PATT27

Technology Education for the Future: A Play on Sustainability

Christchurch, New Zealand
2-6 December 2013

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Associate Editor: Dilani Gedera

Technology Environmental Science and Mathematics Education Research Centre,
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Welcome to PATT27 Christchurch, New Zealand.
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Welcome to PATT27 Christchurch, New Zealand.
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We are very pleased to welcome Technology Education scholars from around the world to New Zealand for PATT 27. We are delighted to have the PATT conference in the Southern Hemisphere for only the second time in its history. This conference, and these proceedings, continue the almost 30 year old tradition of sharing research and ideas in a collegial and inclusive setting. While the conference theme provides a particular focus on considering the future and sustainability through Technology Education, the proceedings also include a broad range of papers which focus on key areas of importance in primary, secondary and tertiary levels of education.

We believe the conference and these proceedings will make a valuable, interesting and significant contribution to the discourses of Technology Education through the introduction of new ideas, the confirmation or critique of assumptions, and the exploration of experiences. This moves our profession forward to rest on a more secure research base and to mature through analysis, interrogation and communication.

We appreciate your willingness to come to Christchurch despite the 2010 and 2011 earthquakes. We hope that you enjoy the city as it starts to rebuild its future. Your presence here is a small contribution to the rebuild so thank you from the shaken and determined citizens of Christchurch.

Wendy Fox-Turnbull, University of Canterbury
P John Williams, University of Waikato
Conference Convenors
November, 2013

PATT
Pupils Attitude Toward Technology

PATT conferences began in 1985 when a small scale workshop on attitude research about technology was held in the Netherlands. Thus began a series of international conferences that continues today. In the early conferences, colleagues from different countries came together to discuss the possibilities and share research about exploring the attitudes of young people to technology, using an instrument that has been developed in the Netherlands, and is still used today. The format of the first PATT conference set the trend for future conferences – no keynote presentations, no parallel sessions and plenty of time for discussion. While the scope of the issues for discussion and the research presented has extended to all aspects of technology education, the conferences have fostered a strong community of scholars of Technology Education, many of whom regularly attend the PATT conferences.

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Contents

Perceptions of Technology Education in the Saudi Primary Curricula (Tertiary Students and Primary Science Teachers)

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ABSTRACT
Over the past 25 years, Technology Education has been present in global curricula. It aims to prepare students to cope with the 21st Century where industrial and technological products dominate international economies. Technology Education has been taught either as a separate subject or integrated with other subjects, particularly with Science, and has been perceived as an area of learning combining knowledge and innovation. This paper identifies aspects of Technology Education which have been embedded in Science subjects in the Saudi curriculum and promotes the concept that it is now time for it to be developed as an independent subject, contributing to the reform of education for C21st learning in Saudi Arabia.

This paper seeks to understand the perceptions of students from different institutes (see Table 1), and Science and Technology teachers in primary schools in the Almahd region about the nature of Technology Education. The goal is to explore the notion of teaching Technology Education either as a separate subject or integrated within Science in Saudi primary schools. A quantitative approach has been conducted for this purpose, with two types of questionnaires for data collection involving students and science teachers. Participants have acknowledged the importance of teaching Technology in primary schools and have offered different perceptions of how this might be achieved.

Keywords: Perceptions, Nature of Technology, Science and Technology, Curriculum.

INTRODUCTION

The purpose of this study is to explore the perceptions of technology which college students and science teachers in primary schools related to technology education in Saudi primary schools.

For the past 25 years, Technology Education has been included in the international educational curricula: industrial and technological products now dominate international economies. Technology Education has been taught either as a separate subject or integrated with other subjects, particularly with Science, and has been perceived as an area of learning combining both knowledge and innovation. Despite the inclusion of technology education in curricula internationally, there has been much debate about whether it should be integrated as one subject or separated (Kipperman, 2006). For instance, in France Lebeaume (2011, p. 77) stated, "Technology education has a long history in the dynamics of design and implementation of compulsory school". There have been numerous tensions about its specific contents and its relationship with scientific school disciplines, especially with physics and chemistry."

This debate has occurred because the boundaries between the two disciplines are not clear. People commonly "talk about 'science and technology' as if it was one thing with a double-barreled name." (Sparkes, 1993, p. 25) It is time to re-evaluate this relationship (Cajas & Gallagher, 2011). Saudi Arabia has not neglected teaching technology as it is considered as an important means for the development of cultural, social, economic and health aspects (Alhogail, 1994, p. 76). Also, educational policy emphasizes the importance of introducing practical and technological studies as a major part in the education programmes to achieve a combination of theory and practice to prepare productive citizens (Alhogail, 1994, p. 96).

However, the boundaries between technology and science have not been determined and the revaluation of the two subjects is necessary to place the distinctive charateristics of technology appropriately within the curricula. It was appropriate to obtain the perceptions of technology education of tertiary students for whom current technological skills might have been affected by their basic education at primary schools. Also, primary school science teachers can tell us about their experiences and perceptions.

Thus, this paper identifies that aspects of Technology Education have been embedded in Science subjects in the Saudi curriculum and suggests that it is now time for it to be either developed as an independent subject or integrated with other subjects such as science, contributing to the reform of education for the 21st Century in Saudi Arabia through understanding the perceptions of tertiary students and primary science teachers that play a key role in establishing technology education.

METHODS

Questionnaires were used to obtain factual and attitudinal information from the participants concerning Technology Education in the Saudi primary curriculum. Two questionnaires were designed specifically for each cohort. The respondents were asked to select a response from five options according to the popular rating scale used in social and science research, known as the Likert Scale. (Sullivan, 2009)

Table 1: Sample profile

Participants	Location of Data Source	Number of participants
Science Teachers	Primary schools within Almahd Province	22
Students	Technical and Vocational Institute in Jeddah	44
	Technology college in Makkah	16
	Technology college in Jeddah	15
	King Abdullah University of Science and Technology in Jeddah.	15

Table 2: Response Rates

Sample	Invited	Responses	Percentage
Science Teachers	40	22	55%
Students	100	90	90%

RESULTS AND DISCUSSIONS

Perceptions of Science Teachers

Findings were analysed and grouped into several themes. This paper includes discussion related to science and technology curriculum themes. This paper identifies three themes generated from the questionnaire distributed to the science teachers. These themes were formulated by collating one or more statements having common ideas which support the important aspects of technology education and the perceptions of participants towards technology.

Theme 1- The influence of the technological revolution of 21st Century on education

No	Statements	Strongly agree	Agree	No opinion	Disagree	Strongly disagree
		1	**2**	**3**	**4**	**5**
1	The technological revolution of the C21st requires governments to review curricula.	15 68.2%	7 31.8%	0 0%	0 0%	0 0%
2	The technological revolution will require schools to develop students' technological literacy.	14 63.6%	8 36.4%	0 0%	0 0%	0 0%
3	It is important that primary students be creative and innovative learners.	12 54.5%	5 22.7%	1 4.5%	4 18.2%	0 0%

This theme represents findings of the statements 1, 2, and 3 from the questionnaire. There was general agreement among the respondents that the technological revolution of the 21st Century has a very strong influence on governments. There was a general consensus among respondents (100%) who strongly or simply agreed that the technological revolution of 21st Century will require governments to review curricula that contribute to develop students' technological literacy. Seventy-three percent of the respondents agreed (combination of strong and simple agreement) that it is important that primary schools should produce creative and innovative learners. A minority disagreed with this notion (22.7%).

Theme 2 - Positive aspects of including technology in primary curriculum

No	Statements	Strongly agree	Agree	No opinion	Disagree	Strongly disagree
		1	**2**	**3**	**4**	**5**
4	Including teaching technology in the primary curriculum will contribute in developing pupils' capabilities to solve technological problems by applying scientific and mathematical ideas.	11 50%	11 50%	0 0%	0 0%	0 0%
5	Including teaching technology in primary schools will help in discovering pupils' professional capabilities.	11 50%	11 50%	0 0%	0 0%	0 0%
6	Without an understanding of technology, students may feel powerless and threatened.	11 50%	10 45.5%	0 0%	0 0%	1 4.5%
7	Primary school pupils would benefit from learning of design of technological products.	10 45.5%	8 36.4%	4 18.1%	0 0%	0 0%

This theme represents findings of the statements 4, 5, 6, 7 and 8 from the questionnaire. The analysis showed that there was a total agreement that there are a number of positive aspects of including technology education in the curricula.
1-developing pupils' capabilities to solve technological problems
2-discovering pupils' professional capabilities
3-removing powerlessness and threat that impede students to dealing with technology

Results show that 81.9 % either strongly agreed or simply agreed that primary school pupils would benefit from learning about design of technological products while 18.1% had no opinion.

Theme 3 - Ability of current developed science curricula to generate creative and innovative learners

No	Statements	Strongly agree	Agree	No opinion	Disagree	Strongly disagree
		1	**2**	**3**	**4**	**5**
8	Current developed science curricula for primary schools can contribute to prepare students who are creative and innovative.	2 9.1%	1 4.5%	3 13.6%	16 72.7%	0 0%
9	Current developed science curricula for primary schools can contribute to prepare students who are technologically literate.	1 4.5%	4 18.2%	1 4.5%	15 68.2%	1 4.5%
10	Current developed science curricula for primary schools include several technological topics.	1 4.5%	4 18.2%	2 9.1%	14 63.6%	1 4.5%

Of the three statements in this block, there was substantial agreement that the current developed primary school science curricula could not contribute to prepare students who are either creative or innovative, or those who are technologically literate. However, there was not quite the same extent of unanimity: 16 of the 22 respondents (72.7%) felt that creative or innovative students would not be assisted by the current curricula, and 15 considered that students who are technologically literate would not be advantaged by the present curricula. Fourteen respondents (63.6%) disagreed with the statement that the current developed science curricula for primary schools include several technological topics and only five either agreed or strongly agreed with such a proposition.

TERTIARY STUDENTS' PERCEPTIONS

The following themes reflect students' perceptions about technology education and the important aspects of teaching this subject in primary schools.

Theme 1-Relevance of science curriculum to technology education

No	Statements	Strongly Agree	Agree	No opinion	Disagree	Strongly disagree
		1	**2**	**3**	**4**	**5**
1	The Science curriculum focused only on environmental issues such as plants and	35 38.9%	29 32.2%	11 12.2%	12 13.3%	3 3.3%

	animals.					
2	The Science curriculum in primary school included a wide range of technological topics.	12 13.3%	16 17.8%	12 13.3%	36 40.0%	14 15.6%
3	Primary science education content includes investigating the properties of materials and their uses in technology.	7 7.8%	20 22.2%	19 21.1%	32 35.6%	12 13.3%

This theme concerned the content of science curriculum in primary schools and the amount of the technological topics included within that curriculum. There was a high level of agreement among the respondents (71%) that the content of science curriculum focused only on environmental issues while 15 respondents (16.6%) either disagreed or strongly disagreed with this perception. Thirty-six (40%) respondents disagreed that the Science curriculum in primary schools included a wide range of technological topics and a further 14 (15.6%) strongly disagreed with this precept. There was little difference between the respondents who took a neutral position on both Statements 1 and 2. Almost half of the respondents - 44 (48.9%) - either disagreed or strongly disagreed that primary science education content includes investigating the properties of materials and their uses in technology, compared to 27 (30%) respondents who either agreed or strongly agreed. 19 (21.1%) respondents expressed no opinion about these aspects in the science curriculum.

Theme 2 - Contribution of the primary curriculum to prepare primary students for further technology study

No	Statements	Strongly agree	Agree	No opinion	Disagre e	Strongly disagree
		1	**2**	**3**	**4**	**5**
4	The Primary curriculum contributed to preparing me to study current technology.	14 15.6%	11 12.2%	13 14.4%	32 35.6%	20 22.2%
5	I learned some of the technological concepts such as: design, creativity, innovation, system, input and output.	7 7.8%	19 21.1%	14 15.6%	31 34.4%	19 21.1%
6	I knew from primary school that technology has positive and negative effects on society and the environment.	19 21.1%	22 24.4%	14 15.6%	29 32.2%	6 6.7%
7	I find that it is easy to understand Technology and deal with it.	24 26.7%	41 45.6%	10 11.1%	10 11.1%	5 5.6

This section concerned to what extent primary education contributed to prepare the respondents - who are currently studying at technological colleges – for further technology study. More than half the respondents showed a high level of disagreement with precepts 12 (57.8%) and 13 (55.5%) that the primary curriculum contributed to preparing them to study current technology and they learned some of the technological concepts such as design, creativity, innovation, system, input and output. In contrast, less than one-third of the respondents either agreed or strongly agreed with the same two statements (27.8% and 28.9% respectively). In terms of Statement 6, namely, what students learnt in their primary education about either negative or positive effects of technology on society and environment, 42 (45.5%) respondents either agreed or strongly agreed with it compared to 35 (38.8%) who either disagreed or strongly disagreed with that statement. As for the last statement (Statement 7) the majority of respondents - 65 or 72.3% - either agreed or strongly agreed with it. They found that it is easy to understand technology and deal with it as a result of that primary education received. Finally, the percentage of respondents who took a neutral attitude towards all the statements relating to this theme, lay between 11% and 15.6%.

Theme 3 - Positive aspects of teaching technology education in primary schools

No	Statements	Strongly agree	Agree	No opinion	Disagree	Strongly disagree
		1	**2**	**3**	**4**	**5**
8	I believe in the importance of teaching Technology in primary schools.	47 52.2%	25 27.8%	4 4.4%	5 5.6%	9 10.0%
9	Teaching Technology in primary schools will help to improve students' ability to understand technology.	57 63.3%	22 24.4%	3 3.3%	3 3.3%	5 5.6%
10	Teaching Technology in primary schools will help to technologically educate students.	48 53.3%	26 28.9%	5 5.6%	4 4.4%	7 7.8%
11	Primary students will benefit much from having Technology taught as a separate subject.	36 40.0%	26 28.9%	14 15.6%	5 5.6%	9 10.0%
12	Primary students will benefit much from learning Technology if it is integrated with other subjects.	33 36.7%	29 32.2%	13 14.4%	6 6.7%	9 10.0%

All the statements in this section reflect the possible positive aspects of teaching technology in primary schools. In regard to Statement 8, a considerable majority of the respondents (80%) either agreed or strongly agreed with the importance of teaching Technology in primary schools while 15.6% took an opposite position. As the largest percentage (87.7% in this section) it reflects the attitudes of the respondents towards Statement 9: teaching Technology in primary schools will help to improve students' ability to understand technology. Only 8.9% of the respondents either disagreed or strongly disagreed with this perception. Between 3.3% and 4.4% of the respondents expressed no opinion regarding these statements (Numbers 8 and 9).

The perception that teaching technology in primary schools will help to technologically educate students was positively received by a great number of the respondents: 82.2% either agreed or strongly agreed with this statement while 12.2% disagreed and 5.6% had no opinion. In regard to Statement 11, the majority of the respondents (62, or 68.9%) either agreed or strongly agreed that teaching technology as a separate subject much benefits primary students, compared to 15.6% of the respondents who either did not agree with that statement or had no opinion.

In regard to Statement 12, it was interesting to note that 62 respondents (68.9%) had a positive perception towards integrating technology with other subjects. This percentage was precisely the same as that of the respondents who had the same positive attitudes towards teaching technology as a separate subject in the previous statement. There was very little difference between the percentages of the respondents who had no opinion (14.4% and 15.6%

respectively); or either disagreed or strongly disagreed (16.7% and 15.6%) with Statements 11 and 12.

DISCUSSION

It was apparent from the results that respondents had a higher level awareness of the influence of the 21st Century on education that pushes governments to review the curricula. This has caused the emergence of technology as a learning area in some of the international curricula, such as in Australia, the United Kingdom, USA, Canada, Europe, South Africa and New Zealand, which consider the importance of teaching technology education to develop students' technological literacy (Jones, 2009). In addition, science teachers were highly satisfied with the positive aspects of including technology education in the curricula that can be used as a rationale for teaching technology in primary schools. These aspects reflect some of the pedagogical, motivational, technological dimensions of technology education that were suggested in Sections 1, 2 and 3. The majority of the teachers do not believe that the developed science and technology curricula produce creative and innovative learners. This shortcoming of the curricula in the Saudi education was also noticed by tertiary students. They had a considerable level of disagreement that science curricula in primary schools support the concept of technology education. The perceptions of both cohorts confirm that there is no connection and interaction between science and technology in the Saudi primary curricula. This has resulted in weakness for preparing the students for learning technology at a tertiary level in future. This is exactly what the students thought: their perceptions showed their criticism of the primary curricula in this stream. It is noted that a substantial number of students indicated that they learnt from primary schools about the negative and positive influences of technology on society and the environment. I think that students' perceptions on this aspect are influenced by the impact of science on society and the environment.

CONCLUSION:

The purpose of this paper was to understand the perceptions of students who currently study at tertiary education institutes and of science teachers in primary schools about technology education in the Saudi curricula. One hundred and twelve respondents to the questionnaires reacted positively towards the concepts of pedagogical, motivational, technological, environmental and social aspects of teaching technology. The findings, in general, confirmed that technology education in the Saudi curricula has continued to position itself under an enormous pile of scientific knowledge generated from science subjects. It is time to introduce technology education with its own characteristics in the Saudi primary curricula to share this experience with the international community during this era that witnesses the technological revolution of the 21st Century. Not only this, but also to prepare citizens who can understand the language of technology and work side by side with people around the world to produce technology that is beneficial to humanity.

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Increasing a D&T Student Teacher's Understanding of Designing through a New Self-Assessment and Feedback Approach

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ABSTRACT
This paper reports on a small-scale project, which looked at the effectiveness of a new self-assessment and feedback (SAF) tool. The tool was designed to develop and monitor the level of understanding of elements of designing carried out by a cohort of six design and technology students studying on a programme training them to become design and technology (D&T) teachers. The study was carried out during two sequential design modules.

Eight self-adhesive post-it-notes in four different colours (one colour per targeted design element) formed the SAF tool used in the project. The post-it-notes allowed students, in a quick, easy but effective manner, to indicate where they believed they had best met each element that had been identified as problematic in the past. Results after their use at the end of the first design project indicated that students had a number of misconceptions about what constituted good practice. The SAF results were discussed with the students and the process was repeated on three occasions during the second project. A questionnaire completed at the end of the second elicited the student's perceptions regarding their level of understanding of specified aspects of designing at the start of their first project, how helpful learning/teaching strategies had been in developing their understanding of designing and how confident they were to teach pupils to design after completing the two projects.

The paper concludes with a discussion concerning the success or otherwise of the new SAF approach in terms of developing capability and more accurately assessing a student's real understanding of designing.

Keywords: designing; self-assessment; feedback; assessment as learning.

INTRODUCTION

This paper reports on a small-scale project, which looked at the effectiveness of a new self-assessment and feedback (SAF) tool designed to develop and check upon the level of understanding of elements of design activity carried out by a cohort of six design and technology (D&T) students studying on a 2-year Post Graduate Certificate of Education (PGCE) programme educating prospective D&T teachers. The study was carried out during two sequential design modules.

The process of designing involves a mixture of concepts and procedures. Understanding is the synthesis of knowing and doing, not the accomplishment of one in the absence of the other (Starr, 2000). A deep understanding of designing is crucial for emerging teachers of D&T if they are to provide pupils with rich opportunities to develop the important transferable skills that genuine design activity can provide (e.g. Atkinson, 2009; 2011; 2012; Lawler, McTaminey, de-Brett & Lord, 2012), rather than the formulaic activity that is found in too many schools today (Miller, 2011). This deep understanding has been shown to be challenging for some students during initial teacher education (ITE) programmes (Atkinson, 2008; 2009; 2011; Atkinson & Sandwith, 2012). For some students already qualified as designers the problems stem from their practice as professional designers where the outcome was the important target and understanding the process played a minor role. For other students it was their design experience during secondary education that led to entrenched misconceptions.

Assessment serves many purposes in an educational setting including enhancing learning (e.g. Mentkowski, 2013). Assessment *as* Learning has been widely researched (e.g. Black, Harrison, Lee, Marshall & Dylan, 2003; Earl & Katz, 2006). It is a process that implements two principles (Atkinson & Black, 2007). The first is that one must start from where the learner is, rather than present strange new ideas to overlay the old and cause confusion. The second is that learning cannot be done *for* learners, it has to be done *by* them, albeit with tutor support. As well as providing appropriate knowledge and apposite activities this support can be provided using various forms of feedback. However, for feedback to be effective it must be motivating (Sadler, 2013) and incorporate active engagement by the learner (Carless, 2013). The SAF approach supported these principles.

The author's past research and observation of those designing has shown that those who do not have tacit design understanding can learn aspects of the process by rote without developing deep understanding of what they are doing and/or why they are doing it. Some aspects of the process appear to be more problematic than others. Based on past research four such areas were identified (see Table 1) and the new SAF tool was designed to help students develop a deeper understanding of these elements and so enable them to teach pupils in the future to design with insight rather than just providing them with superficial processes to follow.

Table 1: Problematic elements of designing identified from past research projects

	Problematic elements of designing
1	Using research to inform design thinking throughout the process
2	Generating a range of creative early ideas
3	Using 3D modelling throughout the process
4	Writing descriptive and reflective annotation

METHODOLOGY

Design Activity

The first minor design project used in this study formed part of the assessment of a 20-credit graphics module while the second major project formed the only assignment in a 50-credit design-and-make module. The minor project brief was to design-and-make a board game, with a theme of environmental issues or sustainability. Students chose between two equally challenging comparable briefs for the major project. One brief involved supporting the body in an appropriate manner for a specific task, while the other concerned a puppet theatre and two puppets for a Primary School with freedom to choose the theme and storyline. Three students chose each brief.

Throughout the minor project design literacy inputs were given covering important aspects of designing. These inputs were re-visited during the major project to overcome any remaining misconceptions. Individuality rather than conformity was emphasized although it was explained that certain key elements needed to be evident in each personal creative journey if students were to be effective designers of functional products.

Assessment and Feedback Process

Several assessment and feedback approaches were adopted. The first three listed below had been used successfully for a number of years.

1. Marks were awarded at the end of each project.

2. A two-dimensional assessment criteria grid developed by the researcher and employed over a number of years was used firstly as a self-assessment tool by the students and then as a tutor-formative feedback/discussion tool on three occasions during each project. Students and tutors used a different colour of pen every time to indicate the student's position on the grid and thereby display progress made.

3. Written Summative feedback was provided for all students indicating strengths, weaknesses and ways forward based on the evidence in the folios, the marked-up assessment criteria grid and the marks awarded.

Recently the researcher had become concerned that although the tools above helped students improve procedural knowledge they did not seem to have helped all students develop their understanding. The new SAF tool was designed based on the principals of assessment as learning (Earl & Katz, 2003), and the belief that discussions with students were required to check whether tutor assumptions made about their understanding based on folio evidence, were accurate (Taras, 2013).

4. The SAF tool used a system of four different coloured post-it-notes to enable students to identify what they considered were the best two sheets in their folio(s) evidencing the following:

    i. using research to inform design thinking (green post-it-notes)
    ii. generating a range of creative early ideas (pink post-it-notes)
    iii. idea development employing 3D modelling (yellow post-it-notes)
    iv. writing descriptive and reflective annotation (orange post-it-notes).

The post-it-notes were used for the first time at the end of the minor project. Once assessment of the projects was complete, summative feedback was provided. This included feedback on the student's placing of the post-it-notes indicating whether in the opinion of the researcher the chosen pages were the best examples to be found in the folio and if not which sheets she would have chosen instead. This was followed by one-to-one discussions clarifying any mismatch between the student's choice and the researcher's choice with the intention of further developing each student's conceptual and procedural understanding.

The SAF system was then used on three occasions during the major project, twice while students were designing and once when all design activity was complete. To aid analysis photographic evidence of the eight folio-pages selected by each student was recorded on each occasion.

Questionnaire

A questionnaire was given to all students after the completion of their major project. Answers provided the student's name, title of their undergraduate degree, and types of creative activity they had encountered during that programme. Other questions asked for each student's perceptions regarding the following: level of understanding of specified aspects of design activity at the start of the minor project; how helpful each learning/teaching strategy had been; how confident they were to teach pupils to design after the two projects.

RESULTS & DISCUSSION

SAF system

Analysis of the placing of the post-it-notes on the first occasion indicated that there were instances in each student's folio where the targeted activity could have been better represented by the choice of different examples. This result indicated that if the researcher accepted that students had accurately identified what they considered were 'best' examples that there was indeed a lack of in-depth understanding of the targeted elements within that first project. This supported the continued use of the SAF process in the major project.

Comparative analysis of SAF system used in minor and major projects

Comparing the first and last time each student used the SAF system allowed an analysis of the level of improvement in understanding of each of the four-targeted aspects of the process.

Using research to inform design thinking: The results indicated that in all bar one student's work, there was considerable improvement in the understanding, use and integration of research into design activity by the end of the major project compared to the minor project.

Generating a range of creative early ideas: The results indicated that even in the minor project half the students understood what was expected in terms of generating a range of early ideas. For the weakest student, his lack of understanding was clearly shown even in his major project when he continued to suggest that the development of his only idea was showing a range of early ideas.

Idea development using 3D modeling: Evidence from the post-it notes showed that in all cases there was more appropriate use of 3D modelling in the major projects compared to that found in the minor projects. It was also the case that by the end of the major project the students' choice of good evidence using the post-it-notes usually matched the researcher's choice demonstrating an improved understanding.

Writing descriptive and reflective annotation: Most students were able to use descriptive annotation in their minor project, however evidence of reflective thinking was sparse. By the end of the major project there had been an improvement in all bar one students use of annotation, this student's explanation was that *"…it did not come naturally"*.

Marks Awarded

For four students the major project mark was higher than their minor project mark, indicating an improvement for the majority of the cohort (see Table 2). A possible explanation for Student-U's low minor project mark and the low major project mark achieved by Student-V are given later in the paper.

Table 2: The marks awarded for each design project and the first-degree programme studied by each student

Student	Minor Project Board Game	Major Seating	Project Puppet T	Undergraduate degree
Z	83%	77%		BSc (Hons) Design and Innovation
Y	74%	80%		BA (Hons) Fine Art
X	64%		78%	BA (Hons) Textile & Surface Design
W	62%		63%	BA (Hons) Creative Practice
V	64%		55%	BA (Hons) Textile & Surface Design
U	48%	65%		BSc (Hons) Psychology

Questionnaire

All six students completed the questionnaire. Data indicated that students had studied on five different types of undergraduate programme, none of which were D&T orientated (see Table 2). Design processes to achieve creative outcomes had been part of four students undergraduate provision. Student-U who had studied Psychology had had very limited design experience. Student-W, who had studied on a Creative Practice degree, believed that she had not used 'formal design processes' as she had been given complete freedom in her approach to creative activity.

Prior to their first design project only Student-X, believed she fully understood all elements of the design process. Students V, W, and Y suggested that they 'understood most of it'. Student-Z and U, both suggested that they had not understood many aspects. Student Z had studied on a Design and Innovation degree, which had been a very theoretical distance learning degree that had not given him the breadth of design skills he believed were required. Student U as already discussed had very little design experience on his Psychology degree.

In terms of which of the four targeted elements of the design process the sample believed they had not fully understood at the start of the minor project, the data indicated that at least one student had not understood each aspect of the process and that five out of the six students had not fully understand one element of the process (see Table 3). When the first post-it-note design sheets were scrutinized it was evident that students had less actual understanding of the elements than they believed they had (see Table 3).

Table 3: Illustrates the number of students who believed that they did not fully understand aspects of the process at the start of the minor project (Column A) and the researcher's belief regarding the students' lack of understanding, based on the first post-it-note evidence (Column B).

Elements of the design process	*A* *Questionnaire data*	*B* *Post-it-note data*
Using research to inform design thinking throughout the process	5	6
Generating a range of creative early ideas	1	3
Writing descriptive and reflective annotation	2	5
The role of 3D modeling throughout the process	1	6

A rating scale was provided for each student's response as to how helpful the six learning strategies used to support the students had been (see Table 4). The data indicated that all students found individual tutorials the most helpful. It is well recognized (e.g. Bols & Wicklow, 2013) that individual verbal formative feedback is important to learners. In this study these tutorials benefited from the additional SAF data that enabled discussions to clearly indicate areas where understanding was lacking. Five students believed that formative feedback given using the assessment grid, which examined the design process they had used, was 'very helpful'. Four students believed that the minor project summative feedback that in this study also indicated how well they had selected their post-it-notes sheets, and the lecturer inputs using past folios were 'very helpful' strategies. Only Student-X who believed she already understood suggested that seeing past folios was only 'a little helpful'.

Table 4: Rank Order of teaching and learning strategies (most helpful = 1, least helpful = 6)

	The Rank Order of Teaching and Learning Strategies
1	Individual tutorials
2	Formative feedback
3	Summative feedback + mark
4	Post-it-note feedback
5	Lecturer inputs
6	Post-it-notes used for the first time at end of minor project

The aspect that gained the least support was when the post-it-notes were used for the first time. However this was to be expected as the activity of placing the post-it-notes on that occasion had been about indicating to the researcher the students' level of understanding and not about helping the student develop their understanding. When asked specifically how useful the SAF system had been five students agreed that having to re-visit the description of what each post-it-note must identify and having to think about where to put them had been very successful in developing their understanding. Only Student-V, did not believe it had helped. Tutorial evidence indicated that she was very resistant to change. Based on past experiences and the minor project she believed she already understood it all and that the post-it-notes were a waste of time. However, her design method even in her major project was to come up with a chosen idea and then retrospectively fill in what she knew should be there. As already indicated her activity had led to a disappointing product with a low major project mark (see Table 2).

By the time the questionnaire was completed at the end of the major project the results indicated that all students felt more confident to teach pupils to design. Student Y with a Fine Art background was the most confident. He believed he could now teach all aspects of the design process. His post-it-note evidence supported this belief. His folios, marks and feedback all indicated that his ability to design and his understanding of the process had improved greatly.

Table 5: A comparison between which aspects of the process the students believed they had not fully understood at the start of the minor project (Column A), which students the researcher believed did not understand at the end of the minor project (Column B) and which students did not feel confident to teach the specified aspects after the two design projects (Column C)

	A	B	C
Using research to inform design thinking	U; V; W; Y; Z	U; V; W; X; Y; Z	none
Generating a range of creative early ideas	U;	U; V; X;	none
Using 3D modeling throughout the process	U;	U; V; W; X; Y; Z	none
Writing descriptive and reflective annotation	U; Z	U; V; W; X; Y	U

As a final analysis the data concerning the four-targeted elements of designing that had not been fully understood at the start were compared to levels of confidence to teach pupils those aspects of the process by the end of the study. The data indicated that five students now felt confident to teach all four elements of the process (see Table 5). Student-U who had not found using annotation easy in his own design activity was unsurprisingly not confident to teach pupils to annotate.

Student-U and Student-V's misplaced confidence in their ability to teach most aspects of the process, was a concern. Evidence of a sound understanding of designing was still missing from both these students' activities. Based on past studies the researcher recognised that two design projects did not provide enough iteration of the process for these students to unpick their beliefs and misconceptions about the process and move forward.

CONCLUSION

The process of designing involves a complex mixture of concepts and procedures. The importance for prospective teachers of D&T of having a deep understanding of the activity has been well supported in the literature. The researcher identified four particular elements of designing that had not been well understood by a number of past students.

This paper, involving a cohort of six students studying to become D&T teachers has reported on the effectiveness of a new, easy-to-use, SAF tool designed to help develop and monitor the level of understanding of these specified elements of designing.

The SAF approach using post-it-notes was designed using principles determined in the literature by assessment/feedback experts. Data collected using the new system and a questionnaire completed at the end of the project, indicated that alongside existing strategies SAF was successful in helping the majority of this cohort to: improve their own design capability; develop a deeper understanding of the process; and feel more confident in their ability to teach pupils to design in the future. It was recognised that further inputs would be required for the two students for whom two design projects were not enough to overcome their misconceptions if they were to provide pupils in schools with meaningful design experiences in the future.

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Technology for a Sustainable Life. Images in Swedish Children's Literature

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ABSTRACT

In the United Nations report Our common future sustainable development is defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". Technology is seen as a kind of enabling force in that endeavour; new technologies are to be the solution to conflicts between growing economic activities and reductions in the use of natural resources. Sustainable development can, however, also be expressed as a set of traditional values that, in a country like Sweden, have been a part of everyday life for many generations. Education for sustainable development has been a goal in the Swedish national curriculum since 1994, not the least in the subject Technology. The teaching can evidently be inspired by both the international discussion on the future world and by the long tradition of how to live locally.

The aim of this paper is to investigate images of technology and how technology is linked to sustainable development in children's literature. Our perspective is that such images represent values that are conveyed to the young generation. We have chosen to study books by four Swedish authors, Elsa Beskow, Inger Sandberg, Jan Lööf and Sven Nordqvist, all of them still read by many children, parents and teachers alike, both in and out of school. Technology is in the examined books portrayed in several modes: as a servant to man, as a deterministic force, as a loyal and "equal" companion to man and as a natural phenomenon in a nostalgic world. Technologies that have a leading role in the examined stories are placed in different kind of contexts, more or less social, more or less utopian or idyllic. In all four author's writings there is an optimistic faith in children's ability to choose the right path. Children are the ones who must take responsibility for the future and overcome the problems the current adult generation have created. From a gender perspective, the message in the majority of the stories is clear: men are the source of technological development.

Keywords: sustainability, technology education, children's fiction, Sweden

INTRODUCTION

In 1987 the United Nations report Our common future (The Brundtland Commission) was published and the elegant definition of the road for the world community to take was established: "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (UNWCED, 1987). Sustainable development has since then been an iconic concept. Technology is given a decisive role as a kind of enabling force; new technologies are to be the solution to conflicts between growing economic activities and reductions in the use of natural resources.

Education for sustainable development has been a goal in the Swedish national curriculum since 1994, not the least in the subject Technology. In the current discussions on the future there are, however, a variety of opinions and uncertainties; sustainable development is a kind of plastic metaphor, which can be loaded with various values, ideas and images. The school has to handle this uncertainty about fundamental future concerns.

The aim of this paper is to study images of technology and how technology is linked to sustainable development in children's literature. Our perspective is that such images represent values that are conveyed to the young generation. Children's literature can be a sharp lens to understand which ideals the adult community wants to consolidate or develop among children and adolescents (Kelly, 1974; Hintz, 2008; Reynolds, 2011). In the Swedish national compulsory school curriculum narratives and fiction are included in the description of the core content of a majority of the school subjects (Skolverket, 2011).

We employ a hermeneutic method, that is, interpretation of the text is based on repeated readings and examination of the illustrating pictures with the intention of identifying themes (Ödman, 2007).

IMAGES OF TECHNOLOGY AND SUSTAINABLE DEVELOPMENT – FOUR EXAMPLES

At the turn of the 20th century Swedish children's literature blossomed with authors such as Selma Lagerlöf and Elsa Beskow. During the 1920s and 1930s children's literature mainly consisted of collections of conventional stories and fairy tales (Westin, 1996; Kåreland, 2008). In the 1950s and onwards there was a pluralism and a desire to broaden themes in Swedish, as well as in British and American literature (Westin, 1996; Pearson, 2011). The current children's literature is characterised by a variety of styles and border-crossing genres, but at the same time of an anxiety to provoke established opinions (SBI, 2013).

Our selection of children's books covers a vast timespan as they represent the literary climate of the beginning of the 1900s, 1960s and 1970s as well as recent decades. The selected authors are all read today. Books by the following Swedish authors have been chosen: Elsa Beskow, Inger Sandberg, Jan Lööf and Sven Nordqvist. We see these four as iconic writers, authors of reference both in daily talks about children's books and in educational discussions about what children may learn from reading. We realise, of course that we by such a small sample, only as best, can illustrate some of the variations that are to be found in the vast literature for children.

Doctor Klokamundus' Invention (1919)

Elsa Beskow (1874-1953) is the foremost name in the field of picture books, which developed in the late 19th century (Westin, 1996). Many of her books have become classics and are continually reprinted and translated. Some of her fairy tales have messages about the expanding modern and urbanised world, including future technology and people's relation to the ongoing technological development.

Doctor Klokamundus' Invention was published in 1919, most recently reprinted in 1996. The story takes place in a fantasy land, Kringelkrokien, which is far ahead technologically. Inventions as the telephone, the phonograph, airplanes and cinemas have existed there for several hundred years. Most tasks are done by the help of machines. But the confidence in technology and science has gone too far and technology is used as a tool to homogenise people. The children (boys) start to misbehave. But instead of seeing the underlying causes, the adults believe that the "problem" can be solved by technology: a high-tech fostering machine. Doctor Klokamundus constructs a machine, which is managed with automated devices. Human coexistence is replaced by interactions with technology.

The story has, as most fairy tales, a happy ending, since the boys escape from the fostering machine and live a "Robinson Crusoe life" in an abandoned castle ruin. By using their creativity they develop their skills and learn how to survive in the wild. The story expresses the consequences of a deterministic view of technology, as people in Kringelkrokien do not realise the dire consequences of their reliance on technology. The implicit message is that in a technological world, there is an imminent risk that people's innermost needs and desires are forgotten. The boys' experiences, however, illustrate that there are other routes to take if technology can be controlled by the one who uses it. Technology can be a tool for conviviality (Illich, 1985).

The Little-Fellow-Star (1969)

Inger Sandberg (born 1930) wanted to write books that spoke directly to the children, books that were not limited by contemporary adult conventions (Nilsson, 1996). In the 1960s, when modernism had stepped into the world of children's books, time had caught up with Sandberg's ideas (Hultén Sonne & Hultén, 1993).

Sandberg's books have a clear educational structure (Hallberg, 1991). In Filurstjärnan (TheLittle-Fellow-Star) (1969) she takes up environmental issues in a kind of space saga. A girl, Barbro, has been sick, and as a comfort she gets a kaleidoscope. Suddenly a space rocket appears in the kaleidoscope. When Barbro shakes the kaleidoscope it breaks and a small rocket lands on her hand. Out of the rocket steps a little spaceman from another star, a "Little fellow" (a "Filur"). He is a space spotter who looks for "stupid and good things that beings on other stars do" (p. 4). Barbro can by the help of magic see and hear what happens when the Little Fellow returns to his star. Barbro discovers a dark world of reckless industrialisation without regard to man or nature.

The story is a metaphor for the current situation on Earth; a dystopian vision. The star is contaminated with purple smoke coming from the cars. All windows must be kept closed and residents are forced to walk around with oxygen tanks. "Little fellows" die of polluted air. Even the rural areas have been affected by pollution, as the factories spew out wastewater into rivers and all vegetation has been sprayed with pesticides. The men in charge ("little-fellows-in-trousers") are responsible for the development. Children and women do not have much influence. In "the house of the deciders" (the parliament) there are only men.

The story shows, however, that the development can be steered in another, positive direction. What is needed is engagement from those who care about man and nature, namely women and children. In the story, the "little-fellows-in-skirts" and the small "little-fellows" go into "the house of the deciders" and start a debate about the environment. The message is that the air, the soil and the water are resources that no one can own. The story is imbued with high confidence in children's ability and wisdom.

Pelle and Uncle Otto's invention (2006)

Jan Lööf (born 1940) is an artist and writer who has written for children during a career which spans several decades. A recurrent theme in his work is technology, especially in the books about the boy Pelle. There are several books in this series but in this paper we focus on Pelle and Uncle Otto's Invention (Lööf, 2006), which is a kind of history of the internal combustion engine and its pros and cons. The book starts with a short introduction to Nikolaus Otto (1832-1891), the alleged inventor. It begins with a short explanation of how the engine works, followed by Otto's own first feelings about having created a noisy and polluting machine. Pelle tells what an Otto engine looks like and continues: "[I]t would change life for people on Earth. But, naturally, Uncle Otto knew nothing about this" (p. 3). This is a recurring theme in the book, the fact that Otto in no way could foresee the problems that his invention would cause over the next century and a half.

Pelle goes on to talk about the initial advantages of the Otto engine compared to the steam engine; the former was small but still comparatively strong. It was so small, in fact, that you could put it on a horse wagon and make it into a car. Although there is no timeline, the narrative must here deal with the early 20th century and a car break-down on p. 8 indicates that it takes place outside of Chicago. This is not surprising since the USA was the first country to adapt this new technology on a grander scale (Hård & Jamison, 2005). The solution was to build smooth, straight roads, with the disadvantage that people went faster and thereby more frequently crashed. Nevertheless, according to Pelle, there were obvious advantages to the Otto engine, for it was versatile and could be used in many types of vehicles. What induced the most change in society was the private car, since it made private transportation so much more flexible.

Uncle Otto's engine could also be put to military use in motorised armoured cars and combat airplanes with machine guns and bombs. Otto was, however, lucky never to get to know anything about all the misery that would come. Lööf here addresses the drawback of the Otto engine – and indeed any technology; the potential for use and misuse, good and evil uses (Kranzberg, 1986; Ihde, 2006).

Uncle Otto would have been surprised had he seen how many cars there are today; far too many: "It is sad to have to say this, but it is time we said goodbye to Otto's fine gasoline engine. Somebody has to invent a new Otto engine without any dangerous combustion gases" (p. 22). The whole book is finished with the following Pelle quote:

> But how to come up with an engine which is as good as Uncle Otto's? I have been trying myself a little bit. First I thought of sun power. You put a solar collector on the car roof. But it doesn't work when it's raining! The best thing would be an engine fuelled by rainwater instead of gasoline! If the engine fails when it's raining you just have to funnel the rain and it will fill up all by itself. A good idea in my view! But as regards the technical side of it – that's up to someone else to solve! (p. 25-26).

The book thus ends on a rather positive note while still acknowledging the complexities of new energy solutions; it is implausible to find energy sources and invent accompanying technologies which are both free, abundant and without any drawbacks.

The world according to Pettson. The sustainable life of the rural bricolour Pettson and his joyful cat

Sven Nordqvist (born 1946) has by now written ten books about the ingenious Pettson and his life on a small farm somewhere in Sweden. We use examples from three of them: The Santa Claus machine (1994), Pettson and the fox hunt (2009), and Findus moves out (2012). (See also the App: Nordqvist and Feldt, Pettson's inventions (2013)).

Pettson is on old man; at least he claims to be, when he takes a nap on his pin sofa thinking on a new construction he will make in his working shed. The days come and go and Pettson does what he always have done - cultivates his garden, goes fishing at the nearby lake (catching perch), makes an invention out of what he has collected in his house, in the attic or things left somewhere in his garden. He listens to the weather report on the radio (a tube radio, certainly) or just quarrels with his cat Findus. It is a world in harmony.

The stories are centred on something that Pettson invents and constructs, an alarm system if the fox should come during the night hungry and hankering for a hen, a new cottage for Findus made out of the old privy house, a machine that can feed the stove with wood sticks, which in reality is going to be a Santa Claus kind of robot. The automatic Santa is a complicated innovation and Pettson must use his entire creativeness. The Swedish eighteen-century engineer Christopher Polhem appears in Pettson's dreams and demonstrates his mechanical alphabet to

Pettson (Lindgren, 2011). Pettson learns how cogwheels and rods should be connected to perform certain functions.

On a basic level children who encounter the books can learn how a variety of tools can be used and different mechanical parts can be connected to make a device work. On a more abstract level they can learn a basic craftsmanship and a workflow when you develop and manufacture technology objects. They can certainly be inspired to a creative way of thinking. On a moral or life style level they can learn that it is possible to manage on the resources that you create yourself.

Pettson's world is sustainable but to the price of being static. There are few if any interactions with the social problems connected to poverty, migration, climate change, and technology development. Nordqvist's books belong to a long tradition in Swedish literature for children in which the story takes place in a pastoral and rural landscape as it once was, or is believed to have been. The most prominent author in this tradition is Astrid Lindgren with for example the books about Pippi Longstocking and Emil of Lönneberga. The time is before urbanisation, consumer society and modern communications technology. The books are read by generation after generation of children (or read to them by their parents, grandparents or teachers). The stories become a bridge between generations; the oldest can experience a reminiscent from their own childhood and the youngest can compare their conditions with how children lived a long time ago.

DISCUSSION

The increasingly technologically driven society during the 20th century is a theme in many stories. A deeply rooted ambivalence towards new technology objects is notable. The authors we have studied give, however, contrasting images of technological development. Lööf's and Nordqvist's books offer a dreamland to readers with a historical interest with their detailed descriptions, especially in the illustrations, of traditional or well-known artefacts and systems. Beskow's, Sandberg's and partly Lööf's books deal with ethical concern connected to the expanding technological systems and its implications for man and nature. It is important to note that although an ecocentric perspective is partly present in the stories, the anthropocentric perspective is still predominant. The stories are presented from a human point of view and the plots revolve primarily around human needs and interests.

The narratives taken together give some noteworthy examples of images of technology and what a sustainable society can be. From an analytical perspective, inspired by Schwarcz (1967), Reynolds (2007) and Applebaum (2010), we identify four main ways in which technology is portrayed:

- Servant mode: technology is a powerful assistant to man and a tool to fulfill needs, wishes and dreams.
- Deterministic mode: technology is something that has come out of man's control.
- Benevolent mode: technology is a loyal and "equal" companion to man.
- Nostalgic mode: "older technologies" are better or more natural than modern (or the latest) technologies and old technology is attributed a higher value.

The technologies that have a leading role in the examined stories are, however, placed in different kinds of contexts:

- Techno-centric context: People use technology to gain control or economic benefits, without regard to consequences for other people or for nature. Alternatively, man has become increasingly dependent on technology. Technology has developed into a threat to man’s creativity, as traditional knowledge and skills are forgotten. The view of nature is anthropocentric; nature can be conquered in the name progress.

- Techno-utopian context: Technology is seen as a positive force to solve human problems and fulfil human needs. But technological advances must be in harmony with the environment and nature. The argument for not emptying earth of its resources leans on an anthropocentric view; we must not destroy for our descendants.

- Urban idyllic context: Technology is placed in an urban world, which has not been flooded by modern technology. Nature is more or less absent. There are references to the welfare society (the Swedish “folkhem”).

- Pastoral idyllic context: Technology is a natural tool in a rural pastoral world. The contact with nature retains morality and balance. Society rests on an ecocentric vision, which means that the ecosystems, other species and the landscapes have intrinsic values, regardless of their importance to man. There is a connection to virtues that, in a country like Sweden, have been a part of everyday life for many generations in many rural and agrarian communities.

The books convey more messages about children, technology and sustainable development: There is a connection between childhood and nature, a belief that has its roots in a romantic tradition. Elsa Beskow, for instance, uses images of the children as “plants”, which should be cultivated to self-sufficiency (compare with Cogan Thacker & Webb, 2002). In all four authors’ writings there is a faith in children’s ability to choose the right path; children must take responsibility for the future and overcome the problems the current adult generation have created (Bradford et.al, 2011). Beskow’s, Sandberg’s and Lööf’s stories illustrate what can happen if humans ignore the negative consequences of the utilisation of technology. Sandberg’s story serves as a positive model for change as it shows how humans, i.e. women and children, can organise to reclaim the development.

From a gender perspective, the message in the stories is clear: men are the source of technological development. They are the ingenious inventors (Pelle and Uncle Otto’s invention) or the inventing bricolour (Pettson). Children and women act as spokesmen for nature and humanity.

In the books of Beskow and Sandberg technology gets the shape of a potentially dehumanising force. In Beskow’s and Nordqvist’s and partly in Lööf’s books the technology landscape consists mainly of older or traditional technologies. The setting is an agrarian society with small towns and villages. The nostalgic dreams are there. The implicit message is that “it was better before”. None of the examined stories presents development of new technology as a positive force that can contribute to sustainability (Lööf takes partly a more nuanced standpoint). A nostalgic world thus rules in many stories for children.

From an educational perspective the books included in this study can contribute to children's better understanding of the technological society they are a part of. Likewise, they open up for discussions about humans, technology and nature and how these interact. The books can also be used in discussions about sustainable development, provided that the teacher/parent actively and consciously questions and challenges the anthropocentric vision conveyed in the stories. A more ecocentric view that highlights the intrinsic value of nature in relation to technological development would promote children's beliefs in ecological sustainability. In this way, the books way have a great potential to serve as a basis for teaching about technology, nature and sustainable development.

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Disruptive Technologies: Engaging Teachers and Secondary School Students in Emerging Affordances

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ABSTRACT
The proposed paper explores a curriculum development project for technology education. The development involves the introduction of the idea of “disruption to the prevailing order” as an aspect of technology into the curriculum.

Reasons for including aspects of disruptive technologies in the D&T curriculum include:

- To help learners in D&T engage in future-thinking
- To engage learners with the ways in which technology leads to change
- To help teachers understand what disruptive technologies offer specifically to D&T education (in addition to what they offer to life beyond schools)
- To begin to equip learners for a world in which whilst many technologies are rapidly becoming more democratised and more available to ordinary people, others are becoming centralised and distant from ordinary people
- To start to unpick, with learners, how new affordances will redistribute social, moral, environmental, financial etc. responsibilities

The paper discusses the concept of disruption in the realm of technology with an example from the past and identifies nine emerging technologies, at differing levels of maturity’ that are considered to be potentially disruptive. For one of these technologies, additive manufacture, the potential for disruption will be assessed and its ability to act as a context for learning explored. The curriculum development model will be described. The paper will conclude by discussing the apparent tension in the technology curriculum between teaching the critique of new and emerging technologies and their use in developing technological capability.

Keywords: Disruptive innovation, Curriculum, Future, Circular economy

INTRODUCTION

This paper builds on a publication by Barlex and Stevenson (2012), which considered the extent to which additive manufacture, commonly called 3D printing, might be disruptive with regard to global transport systems and the design & technology school curriculum. Christensen (2012) is widely referenced in discussions of disruption and views disruptive innovation through the lens of business/commercial activity. We feel that this is limited for our purposes in that we are particularly interested in the way certain technologies as they emerge have significant effects on the way individuals, groups and communities live their lives. These technologies will inevitably have emerged through commercial activity but it is the social impact of these technologies with which we are concerned. Hence while it is important to acknowledge that Christensen's ideas can be used to explain how new technologies emerge we think it is important that in education we concentrate more on the social impact of technology. Our purpose is focused on enabling young people at school to develop a perspective on technology such that they can consider its impact on their lives, and take part from an informed position, in debates concerning whether and how technology should be deployed in the society in which they live. Inevitably social impact and economic impact are intertwined and this view is developed by McKinsey Global Institute (2013):

> The relentless parade of new technologies is unfolding on many fronts. Almost every advance is billed as a breakthrough, and the list of "next big things" grows ever longer. Not every emerging technology will alter the business or social landscape—but some truly do have the potential to disrupt the status quo, alter the way people live and work, and rearrange value pools and lead to entirely new products and services. (P. 13)

In the report *Disruptive technologies: Advances that will transform life, business, and the global economy* McKinsey Global Institute (2013) have identified 12 technologies that have significant potential to alter the business or social landscape:

- Mobile internet
- Automation of knowledge work
- Internet of things
- Cloud technology
- Advanced robotics
- Autonomous or near autonomous vehicles
- Next generation genomics
- Energy storage
- 3 D printing
- Advanced materials
- Advanced oil and gas exploration and recovery
- Renewable energy

This list is to some extent mirrored by David Willets (2013) in his pamphlet Eight Great Technologies:

- The Big Data Revolution and Energy-Efficient Computing
- Satellites and Commercial Applications of Space
- Robotics and Autonomous Systems
- Life Science, genomics and Synthetic Biology
- Regenerative Medicine
- Agri-Science
- Advanced Materials and Nano-Technology

- Energy and its Storage

The following list of potentially disruptive technologies that we think are relevant and potentially engaging to young people in schools was drawn up independently of these reports:

- Additive manufacturing
- Artificial intelligence
- Augmented Reality
- Big Data
- Intelligent matter
- Internet of Things
- Neurotechnology
- Robotics
- Synthetic Biology

Whilst there is not complete one to one correspondence with the technologies identified by McKinsey or Willets there are sufficient similarities to give us confidence that our list is robust in terms of new and emerging technologies likely to have significant social as well as economic impact. We will use the following criteria taken from McKinsey to scrutinize the social impact: These technologies will

- Disrupt the status quo

i.e. they will overturn existing hierarchies and may lead to different and more democratic hierarchies

- Alter the way people live and work

i.e. they may increase or decrease employment opportunities, change the knowledge and skill sets required for employment, impact on education and alter relationships

- Rearrange value pools

i.e. they take part in existing and new commercial activity in ways which redistribute financial gain towards those who are deploying these technologies

To illustrate briefly the kinds of things we mean when we talk about technologies causing disruption, we think an example from the history of technology, that of Kodak (Snyder 2013), is illuminating.

THE STORY OF KODAK

At the end of the 19th century photography was an activity that was pursued by those with expert knowledge, sophisticated equipment, financial resources and time. George Eastman the founder of the Eastman Company changed that. His company developed a camera that was very simple to operate, used a roll of film and, the main feature leading to disruption, a service that took the exposed film and produced a set of negatives and black and white prints. The result was an extremely rapid growth in the use of photography by the general populace. This can be considered In terms of the features of disruption as follows. The company, known by its trademark Kodak, democratized access to photography hence it disrupted the status quo. It altered the way people worked in providing employment for darkroom technicians who processed the film and the way they lived in providing a popular hobby. It rearranged value pools in that it enabled the Eastman Company to be financially very successful in a market that had not previously existed. Ironically the company developed the digital camera and the burgeoning popularity of digital photography led to the demise of Kodak's film photography business. Here we see another disruption involving a shift in the way people live and work - increased use of photography facilitated by digital cameras and loss of employment for darkroom technicians, rearrangement of value pools – away from the film based photography industry to industries supporting digital photography. In terms of disrupting the status quo the role of digital photography coupled with communication technologies has lead to significant global disruption.

The nine technologies noted above have the potential to produce disruptions that are at least as wide-ranging as those produced by Kodak first democratising photography and then reinventing it digitally.

A technology with the potential to have significant social impact

Space prevents us from dealing with each of these technologies in depth so this section will consider just one of these technologies: additive manufacturing.

Additive manufacturing: Additive manufacturing (AM) involves fabricating physical objects in successive thin horizontal layers, according to digital models derived from CAD designs, 3-D scans or video games. Definitions (ASTM 2010, Hague & Reeves 2013, Wohlers Associates 2012) continue to develop. Materials used include thermoplastics, eutectics, foodstuffs, metals, ceramics and glass.

Following Kodama's (1981) account of printing a physical 3-D model, early AM development concerned rapid prototyping rather than product manufacture; capability to make usable products or components emerged only 'within the last decade' (Hague & Reeves 2013). Wohlers & Caffrey (2013) claim that AM is 'going mainstream' but warn that hype exaggerates potential.

Predictions for 'low-end' fused-deposition 3D-printing techniques highlight their potential in emerging consumer design / manufacture markets. Barlex & Stevens (2012) identify online services that print consumers' own designs, and websites which offer print-ready designs. Hobbyists aside, growth in consumer *design* activity will require growth in accessible digital design software (Wohlers Associates 2012:15) such as the MakieLab design App, which enabled the creation –on iPads- of '4,500 (personalized doll) designs within two days of its launch'.

Predictions concerning industrial design and manufacture of finished components by 'high-end' powder-based processes (e.g. selective laser melting/sintering) include:

- Bespoke medical prosthetics and dental implants
- Structural aerospace components for which combining AM with topology optimisation (Hague 2013) offers substantial weight reduction

Current research seeks several prizes: integral printing of structural and functional (e.g. electronic or optical) materials; 'zero waste' of feedstock; parts consolidation enabling an assembly to be made as a single component; AM using multiple materials (Hague & Reeves 2013, Hague 2013, Wohlers Associates 2012, Wohlers & Caffrey 2013).

It is easier to identify potential disruptions than to predict their scale or pace. Table 1 (below) summarises our first attempt to categorise disruptions.

As design tools become more accessible, some niche democratisation and de-skilling of design and manufacture is likely. AM will also enable production of some designs hitherto un-makeable through existing processes (Hague & Reeves 2013). Growing customisability of medical prosthetics will raise patient expectations and outcomes and may localise the manufacture of prosthetics.

AM will strain legal frameworks in several ways. Piracy of copyrighted material will extend to patented products, widening the scope of Intellectual Property violations. Open source designs for dangerous or illegal products could stretch Liability law, as makers and users will have no contract with designers. Who *is* liable when an open source design fails catastrophically in service? Freedom of Information legislation was recently used to defend online publication of a 3-D printable gun design. When *does* design data become contraband? Fears over proliferation of products that threaten security may seed new surveillance goals; states may seek to criminalise some 'maker' community members.

Finished goods are predicted to become the largest application of AM (Wohlers & Caffrey 2013). Workforce reductions will result wherever a sequence of existing processes, e.g. casting-milling-drilling, is replaced by a single AM operation. The affordances (Norman 1988:9) of AM will require designers to 'un-learn' some design skills (Wohlers Associates 2012), and change the attributes required in new designers. Some occupations will be de-skilled, others replaced, eliminated or relocated (e.g. from industrial workplaces in the global 'East' to post-industrial workplaces in the global 'West'). Reduction in transport and warehousing of finished products will not be fully offset by growth in AM feedstock logistics. Meanwhile, 3D design apps will open new leisure markets for AM services, particularly markets associated with toys and games.

What of educational disruptions? Some higher level affordances of AM, e.g. accurate rapid prototyping to check assembly, and greater use by pupils of parametric functions in modelling software, are developmental rather than disruptive. Barlex & Stevens (2012), however, note that AM would enable pupils' 'making' to be outsourced to online 3D-printing providers. This would disrupt teaching and learning where designing-and-making is a central pedagogy. McGimpsey (2011) regards tension between continuity of established skills, and engagement with new technologies, as inherent to Design and Technology education.

A democratisation of design-and-making afforded by 3D-printing could disrupt classroom relations where technology teachers' power relies on gatekeeping access to 'industrial' skills. Difficulties in supervising pupils' online designing and making could disrupt assessment for formal qualifications. Finally, commercial opportunities offered by AM could (disruptively) boost pupil entrepreneurship.

Table 1: Potentially disruptive outcomes of AM

	Disrupt the status quo	Alter the way people live and work	Rearrange value pools
'Niche' democratisation and de-skilling of design and manufacture	✓	✓	✓
AM requires existing designers to unlearn established skills, and	✓	✓	

changes selection criteria for new designers			
AM capacity to make designs previously ‘unmakeable’	✓	✓	✓
Customisability of prosthetics raises patient expectations, improves patient outcomes and localises manufacturing	✓	✓	✓
Intellectual property - piracy of patented products	✓	✓	✓
Legal liability – who is liable when a product based on an open source design fails?	✓		
Use of Freedom of Information rights to protect publication of designs deemed offensive or law-infringing	✓		
State surveillance and criminalization of some ‘makers’	✓		
Job losses resulting from reduction in manufacturing stages and skills, where AM replaces existing processes	✓	✓	✓
Global re-location and localisation of some manufacturing	✓	✓	✓
Reduced demand for product & component logistics, increased demand for AM feedstock logistics	✓	✓	✓
3-D- Design Apps create new leisure markets for AM services,	✓	✓	✓

Curriculum development model

Our model is predicated on the idea that a school curriculum can respond to local conditions and underpinning our approach is collaboration between three parties:

- Those working at a relevant innovation hub within a local university
- Those engaged in initial teacher education, usually based at a local university but increasingly based in local schools
- Teachers in local schools

This collaboration provides the expertise necessary to identify pertinent knowledge of the disruptive technology, to develop appropriate pedagogy and to implement the curriculum so that it can be evaluated from both teacher and pupil perspectives. It will be important that the pedagogy developed allows the pupils to take some ownership of the learning. It is very important that the way it is taught is not seen as a transmission of a body of knowledge but an introduction to some powerful ideas which young people can use a) to develop their understanding of technology and its relationship with society, b) to inform their value positions with regard to specific technologies and c) to enable them to take part in and use such technologies. In order to meet these requirements we suggest that a programme of study concerning a new and potentially disruptive technology should consist of some or all of five parts.

i) An introduction lead by the teacher in collaboration with a representative from the university / innovation hub

The role of universities and associated innovation hubs are crucial to this development and it is important that we do not have unrealistic expectations. We see from a University:

- A contact with a researcher active in the new technology; not necessarily a high ranking academic
- An initial meeting to draw some key features of the technology that could be used to inspire joint work with Science and Design & Technology in secondary schools; the interviewer to go away with a pile of reading links
- A technical review of drafted curriculum materials to ensure that these are accurate and reflect the field
- A school visit to talk briefly to pupils about the new technology in support of a trial.
- Total time: no more than a day.

- We expect the University to gain:

- Support for the widening participation program in HE
- Links to highly experienced curriculum developers
- The development of curriculum resources that highlight the University's role in a leading research field
- Through the curriculum development team, access to schools where materials are used
- Access to the final materials developed with their support
- Full acknowledgement of the University and individuals' roles in supporting the project.

ii) The opportunity for pupils to find out more by their own investigations

There are opportunities here for pupils to use technology enhanced learning The report System Upgrade (Noss 2012) suggests that as ‘semantic web’ tools come on stream, it will be possible to gather meaning from the web, not just information. Investigating the manifestations of potentially disruptive technologies in such a way will provide pupils with new ways of looking at information – turning it into knowledge.

iii) The opportunity for pupils to devise new applications for the technology – an approach developed within the Young Foresight Project (Barlex 2012)

This is a well-established approach within design & technology – designing without making. Despite the initial misgivings of teachers, independent evaluation found that pupils responded positively to this approach and it was incorporated into the National Strategies for design & technology (Department for Education and Skills 2004)

iv) The opportunity for pupils to use the technology

This is perhaps the most problematic part of our suggestions although some of the disruptive technologies we have identified are already part of design& technology curricular e.g. robotics, additive manufacture and internet of things.

v) A final presentation summarizing the worth of the technology and its possible place in a circular economy (Ellen MacArthur Foundation, 2013).

Pupil presentations are now an established part of educational practice and resources concerning the circular economy are becoming readily available from the Foundation.

DISCUSSION

Barlex (in press) has suggested that a technology curriculum can be developed through applying three procedural principles; first, being true to the nature of technology, second developing a perspective on technology and third enabling technological capability. How will this application play out in a technology curriculum that deliberately chose to include disruptive technologies within its remit? Considering disruptive technologies would sit well with being true to the nature of technology as disruption is widely regarded as a feature of new and emerging technologies. Enabling learners to think about this disruption such that they considered future implications and possibilities and began to establish their own personal value positions would certainly be part of developing a perspective on technology. David Layton (1995) was particularly supportive of this aspect of technology education when he criticised an overly functionalist approach to evaluating technology which is limited to "does it work; i.e. do what it is supposed to do?"

> Morality, it seemed, had been jettisoned: providing the thumbscrew, the gas chamber or the bug worked well we are dealing with high quality d&t. (p. 108)

Embedding new and potentially disruptive technologies in enabling learners to become technologically capable is perhaps more problematic particularly if we restrict technological capability to practical activity as envisioned by the phrase "to intervene effectively and creatively in the made world" (Department for Education and Science and Welsh Office, 1988). First there is the problem that some such technologies will not be available in schools and hence learners will not be able to utilize them in their own designing and making. . This is not true for all such technologies and we have seen that in England the government is promoting the use of 3D printing in design & technology lessons (Truss 2013) although perhaps they have not fully grasped the implications of doing this. For those technologies that are unavailable there is considerable evidence from Young Foresight that pupils are highly motivated by activities in which they speculate about possible applications for such technologies (Barlex 2012). Whilst not developing capability in the sense of designing and making such activities are known to enhance pupils design abilities (Murphy 2003).

For those who see design & technology as essentially a practical activity it is easy to become seduced by the attractiveness of making in its own right and give this a privileged position at the expense of the more intellectual aspect of the subject. For those who see intellectual activity, especially that associated with developing technological perspective, as the raison d'être for technology education it is easy to marginalize the important learning gained through practical activity. Devising both resources and approaches to teaching disruptive technologies that maintain both aspects in ways that inform each other remains both the greatest challenge and the greatest opportunity for our disruptive technologies curriculum development project.

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Confidence, Mathematics and Performance of Engineering Studies Candidates at the New South Wales Higher School Certificate Examination

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ABSTRACT
Many New South Wales (NSW) technology teachers continue to express the concern that the performance of their students in the NSW Engineering Studies Higher School Certificate (HSC) examination is compromised by poor performance on engineering mechanics questions requiring mathematical calculations. While concern about the increasingly poor mathematics skills of school students in general has been noted in Australia and internationally, it would appear the issue is far more critical for subjects like Engineering Studies where the capacity to manipulate mathematical equations is fundamental to gaining an appreciation of many engineering concepts and their application. This issue is complex in that while these students do not necessarily require specific skill development in the application of advanced mathematical concepts such as calculus or differential equations they do benefit from the confidence to interpret and then solve engineering mechanics problems involving for example the analysis of graphs, the application of trigonometry and the manipulation of mathematical formulae.

Keywords: confidence, engineering, mathematics

INTRODUCTION
This paper will report on current research which is attempting to identify factors which may be contributing to the perceived impact of mathematics and the poor performance of NSW Engineering Studies students in engineering mechanics. It then suggests strategies which might be implemented by Engineering Studies teachers to both support and enhance their students' mathematical confidence and contribute to their understanding of engineering concepts and as a consequence improve their HSC examination performance.

The paper will be presented in four sections:

1. A statement of the research question and methodology
2. A brief overview of Engineering Studies in NSW
3. A brief overview of some current research – both formal and informal
4. Discussion

RESEARCH QUESTION AND METHODOLOGY
Does a candidate's mathematics confidence impact on their overall performance at the NSW Engineering Studies examination?

Essentially this paper is a non-experimental exploration of the problem. Relevant data was collected from the NSW Board of Studies, research sources and a discussion with an academic colleague working in an allied discipline.

OVERVIEW OF ENGINEERING STUDIES IN NSW

By way of background NSW secondary school students normally present for the HSC examination at the conclusion of year 12 following two years of study. The current NSW HSC Engineering Studies syllabus was originally developed as the subject Industrial Arts and implemented in 1966. It was later revised as the Engineering Science syllabus (1986) and then Engineering Studies (1999). The current syllabus has evolved into an integrated study of the Engineering profession with students exploring a range of engineering application and engineering focus modules over the preliminary course (year 11) and HSC course (year 12). Table 1 summarises the current distribution of these modules over both years.

Table 1: Distribution of Engineering Studies modules

Preliminary modules (year 11)		**HSC modules (year 12)**	
Application modules	**Focus modules**	**Application modules**	**Focus modules**
Engineering fundamentals		Civil structures	
Engineered products		Personal and public transport	
Braking systems			Aeronautical engineering
	Biomedical engineering		Telecommunications engineering

Source: ES syllabus, p.8

Application modules (Engineering Fundamentals, Engineered Products, Braking Systems, Civil Structures, Personal and Public Transport) aim to provide an opportunity for students to develop "knowledge and understanding of engineering concepts and impacts through the study of engineering products" (ES syllabus), while focus modules (Biomedical Engineering, Aeronautical Engineering, and Telecommunications Engineering) aim to provide an opportunity for students to develop "knowledge and appreciation of the role of engineers by studying the nature of the engineering profession and emphasizing the scope of engineering activities in a given field" (ES syllabus). Fundamental to the design of the syllabus is the emphasis on the integration and application of science and mathematics to societal development and change within the context of the engineering profession – a classic STEM subject! Each module then includes content on: areas of engineering practice, historical and societal influences, engineering mechanics, engineering materials, and communication (including graphics).

Enrolments in the subject have varied from an initial candidature presenting at the 1967 HSC examination of 1293 and peaking in 1991 with 5070 candidates. Table 2 outlines recent candidate numbers for 2008 – 2013. By way of observation it indicates a steady candidature of a little under 2000 with about 4% female and an encouraging, if modest recent increase in candidature to 2228 in 2013. The selection of Engineering Studies by potential candidates is influenced by many factors, including for example student career aspirations, perceptions of their own abilities and interest, their sense of the alleged difficulty of the subject, as well as school resources provided to support the teaching of the subject. In addition the availability and confidence of suitably qualified technology teachers is also an important but unfortunate consideration here as well.

The current HSC Engineering Studies examination is based on the most recent 2011 revision of the Engineering Studies syllabus. HSC examination papers aim to measure candidate achievement across syllabus outcomes in each subject. In brief the current Engineering

Table 2: Engineering Studies HSC examination candidate numbers: 2008 – 2013

Year	Male	%	Female	%	Total
2008	1821	95.99	76	4.01	1897
2009	1676	96.1	68	3.9	1744
2010	1889	95.55	88	4.45	1977
2011	1770	95.47	84	4.53	1854
2012	2087	94.95	111	5.05	2198
2013	2137	95.92	91	4.08	2228

Source: NSW Board of Studies

Studies examination specification requires a 3 hour written paper consisting of two sections. Section 1 consists of 20 objective questions while section 2 consists of approximately 7 short-answer questions with parts totally approximately 25 items with at least two items allocated 6 – 8 marks. Significantly candidates may be required to integrate their acquired knowledge, understanding and skills developed during their study of the entire course.

OVERVIEW OF RECENT RESEARCH

While the performance of Engineering Studies candidates varies across all the modules and their content, the perception of their generally poor engineering mechanics performance continues to concern both teachers and the engineering profession. In addition the performance of Engineering Studies candidates when attempting engineering mechanics problems is further complicated by their need to use at least two forms of reasoning: conceptual reasoning and procedural reasoning. They need to be able to understand and apply engineering mechanics concepts while at the same time identifying and applying mathematical problem solving techniques appropriate to the problem being investigated. Whether such reasoning is undertaken sequentially or in parallel may be very much dependent on a number of factors, including for example an understanding of specific concepts as well as the confidence and ability to apply mathematical problem solving techniques appropriate for the problem being investigated.

Bajpai (2006) for example has identified four main steps in the application of mathematics to engineering:

1. Identification of the problem,
2. Formulation of the problem in mathematical terms,
3. Solution of the mathematical problem, and
4. Interpretation of the solution

Taken together the successful implementation of this sequence of steps clearly impacts on the performance and confidence of both expert and learner engineers. Clearly this raises a number of possible underlying factors which may be contributing to this situation. It is certainly not meant to be an exhaustive list of factors but includes the abstract nature of engineering concepts, the relevance of both mathematics and engineering topics, and the performance of candidates at recent NSW HSC Engineering Studies examinations.

While this paper is primarily concerned with HSC candidate performance it should be recognised there has been extensive research investigating why first year engineering students tend to perform poorly in introductory engineering subjects as well. This research is relevant given the majority of first year engineering students have enrolled straight from high school. Karim (2011) for example notes the research reported by Dwight and Carew (2006) and Goldfinch et al (2008a and 2008b) who could not offer any insight into how to effectively deal with the poor performance of these students in subjects such as Statics which involve abstract concepts. In this context however Karim (2011) makes an important observation about the manner in which theory is presented and the consequent desirability to utilise physical models in the teaching of these abstract concepts:

".... it is difficult for students, who are generally beginners in gathering knowledge in engineering, to connect idealised diagrams and examples .... to more complex situations found in the real world." (p. 29)

This observation is supported by the earlier work of Dawes and Rasmussen (2006) in relation to the SQUEAK (Secondary Schools and QUT Engineering Activity Kits) program which aimed to change the perception of Queensland secondary school students about engineering as a vocation. The SQUEAK program aims to engage students and their teachers in contextual based experiential learning that emphasizes the relevance of mathematics and science. Relevance is clearly an important factor here. Certainly in at least one Australian university, students in applied mathematics units where a variety of 'real world' applications of mathematics are explored, have consistently indicated a preference for topics such as coding and game theory in preference to those topics commonly associated with physics or engineering mechanics. This may or may not be simply a reflection of a group of students' sense of identity as mathematicians but it may suggest a wider problem – lack of interest and relevance – with the study of the engineering topics rather than difficulty with the mathematics. In contrast Coupland et al (2008) have investigated the issue of relevance in relation to the mathematics rather than the engineering topic. Flegg et al (2012, p. 719), quoting Booth (2004) suggest engineering students experience three main ways of learning mathematics: a subject of study, a tool for other subjects, and a tool for dealing with real world problems. Coupland et al take this further and assert that when a mathematics topic is not seen as relevant by engineering students three questions need to be asked. Whether the:

1. topic has become outdated,
2. relevance of the topic has been explained, and
3. students require additional experience in engineering to appreciate the relevance of the topic?

It would seem that each of these questions has some validity especially in an education environment increasingly mesmerised by and dependent upon the use of specialised software packages over pen and paper problem solving. In this context Coupland et al quote Love (1995) who emphasizes that 'experts' use software tools as surrogates for their pervious manual techniques. Learners on the other hand do not necessarily have the experience to know when to use such tools and more importantly an understanding of how these tools work. Increasingly this appears to be a major issue with students (learners) seeking instant answers to engineering problems without applying sequentially structured problem solving techniques and then being able to adequately interpret the answer.

A further issue here is what does the data actually indicate about the recent performance of NSW HSC Engineering Studies candidates? Table 3 sets out a comparison how candidates have performed in three HSC Engineering Studies modules: Civil structures, Personal and public transport, and Aeronautical engineering in both engineering materials and engineering mechanics during the years 2008 – 2012. The data is presented as follows:

AUTB: Average upper targeted band
An indication of the intended difficulty band of the question with 2 being the lowest and 6 being the most difficult, set by the examination committee
AM: Allocated mark(s)
The mark allocated to question items by the subject examination committee.
AMO: Average mark obtained by total candidature
%: AMO/AM expressed as a percentage

Table 3 presents a somewhat interesting overview of how Engineering Studies candidates have performed in recent years. It is not meant to be a rigorous statistical representation of their performance. It needs to be interpreted in terms of the mark obtained and the intended performance bands of the question items.

Table 3: Engineering Studies HSC examination candidature performance:2008 – 2012

Module Year	**Engineering materials**				**Engineering mechanics**			
	AUTB	**AM**	**AMO**	**%**	**AUTB**	**AM**	**AMO**	**%**
Civil structures								
2008	6	2	1.10	55.00 %	4.25	8	2.94	36.75 %
2009	3	2	1.27	63.50 %	4.5	8	3.90	48.75 %
2010	n/a	0	n/a	n/a	4.4	10	4.09	40.90 %
2011	3.67	5	1.83	36.60 %	5.5	5	1.90	38.00 %
2012	4	4	2.45	61.25 %	5.25	6	1.76	29.33 %
Personal and Public Transport								
2008	4.5	4	2.14	53.50 %	6	2	0.91	45.50 %
2009	4.67	8	4.25	53.13 %	n/a	0	n/a	n/a
2010	3.5	4	1.06	26.50 %	4	6	2.93	48.83 %
2011	5	4	2.23	55.75 %	4.5	4	0.99	24.75 %
2012	4	4	2.27	56.75 %	4.5	4	0.78	19.50 %
Aeronautical engineering								
2008	3	4	3.33	83.25 %	4.67	7	3.96	56.57 %
2009	5	3	1.45	48.33 %	4.75	8	3.24	40.50 %
2010	5	6	2.35	39.17 %	3.5	4	2.35	58.75 %

2011	3.67	6	2.82	47.00 %	3.67	5	2.17	43.40 %
2012	5	2	0.75	37.50 %	4.67	7	4.07	58.14 %

Source: NSW Board of Studies
n/a indicates no appropriate data available

What may be important here is not so much the comparison between how candidates in general have performed in relation to engineering materials and engineering mechanics items but how each cohort has performed.

Notwithstanding the 2012 cohort's notional performance in Aeronautical engineering, the 2008, 2009, 2011 and 2012 cohorts seem to have performed poorly in engineering mechanics compared with engineering materials, while the 2010 cohort appears to have in general reversed the trend. The reasons for this are no doubt complex and may involve the following:

1. The targeted bands set by the examination committee may not have been met,
2. The allocated mark(s) available to each question item do not offer a significant comparison opportunity, and
3. The academic profile of the candidature is unknown. It may be, for example, the 2010 candidature was stronger mathematically with more candidates studying advanced mathematics.

However the general data trend presented in table 3 seems to be one indicating that overall the candidature performance on engineering mechanics items during this period has continued to be marginally poorer than that of engineering materials.

DISCUSSION

Given both the continued local and international concern expressed about the impact of mathematics performance of secondary and first year university engineering students in general, it would seem appropriate then to investigate strategies which might be useful in addressing this issue. More specifically what strategies should be considered for Engineering Studies classes? One such strategy that should be considered is the use of guided practice.

While guided practice may run counter to the constructivist approach favoured in other areas of technology education, it may provide the necessary scaffolding to support and strengthen the teaching and understanding of engineering mechanics in both the secondary school and first year engineering curriculums. The observations of Sweller (1999), Mayer (2004) and Clark, Kirschner, and Sweller (2012), for example, about the misinterpretation of constructivism as a learning theory as opposed to a teaching methodology are clearly important here. In essence they assert students learn to construct knowledge more effectively when their learning is supported by the provision of knowledge and the modelling of correctly worked examples and processes rather than by unguided exploration. In particular then the potential for developing the confidence of Engineering Studies students in particular to approach, interpret and successfully solve engineering mechanics problems, involving for example the analysis of graphs, the application of trigonometry and the manipulation of mathematical formulae may be more effectively underpinned by the support and deliberate adoption and use of modelling and guided practice problem solving techniques by their teachers.

Guided practice then is a teaching strategy which supports students in their learning with active teacher participation. Ideally guided practice provides an opportunity to develop confidence and proficiency in the concepts taught through their active application. In the context of engineering mechanics students should be provided with an initial scaffold by their teacher-instructor to support both their learning and developing confidence to solve relevant engineering problems. This scaffold should include both a focus on specific engineering mechanics concepts and mathematical techniques for investigating them, the utilisation of appropriate physical and virtual models, as well as an exploration of their relevance to real world situations. Students should then be encouraged to apply this scaffold and explain their problem solving thinking and reasoning to their class peers with teachers providing feedback clarifying the efficacy of the student's approach. In essence the role of the teacher is to both guide and support the student.

Guided practice is by no means a panacea. However this approach provides an opportunity to engage and actively support students in their engineering mechanics learning and more importantly their application of new concepts. Significantly an informal trial of this approach has been recently undertaken at an Australian university with promising results measured by both student confidence and examination performance. The results suggest a more rigorous study would be beneficial and should be undertaken. The outcome of such a study would no doubt have relevance to the manner and effectiveness of how engineering mechanics is taught in both secondary school and first year university engineering courses.

CONCLUSION

This paper has briefly presented an overview of the NSW HSC subject Engineering Studies and examined factors which might be impacting on the performance of candidates in the engineering mechanics component of the subject. Does a candidate's mathematics confidence impact on their overall performance at the NSW Engineering Studies examination? It would appear that circumstantially at least this seems to be the case. The teaching strategy guided practice was briefly described and suggested as a possible means of addressing this matter and improving student learning outcomes and performance.

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Teaching Primary Design and Technology within a Creative Curriculum: An Opportunity Lost or Taken?

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ABSTRACT

Design and technology (D&T) was included as a subject for the first time in the English primary National Curriculum in 1990 (DES 1990). As there was little support given for its implementation and majority of teachers had little understanding of the subject, it was delivered in majority of schools as a separate subject (OFSTED 1995). There were exceptions (e.g. Benson and Raat 1995) and where teachers had a clear understanding of the subject, they integrated D&T into an appropriate theme that was relevant to the children. However there was a move after 2000 from the Department for Education and Skills (DFES) to combine subjects into themes and this was supported by the publication of, for example, Excellence and Enjoyment (DFES 2003). The National Curriculum review that followed known as the Rose review (DFCSF/QCDA 2010) also implied that subjects could be taught through themes or topics. At the same time the term 'the Creative Curriculum' appeared and whilst it does not have one meaning, it was generally taken to mean that schools could be more creative with the way they planned a curriculum that was relevant for their children.

As D&T was incorporated into a creative curriculum, it became apparent that the integrity of the subject was being lost. In an effort to include subjects within a creative curriculum/theme or topic approach, aspects of D&T such as designing were lost and making products that were often inappropriate were evident. A small scale research project was undertaken to determine what happened when schools did incorporate D&T into all their themes or topics. 47 primary teachers from different parts of England attending long award bearing D&T courses were involved and data gathered through questionnaires and semi structured interviews was analysed. In addition a detailed case study was undertaken by 1 teacher as part of her MA ED dissertation (unpublished) and conclusions from this study are also included. Whilst recent educators such as Barnes (2011) and Pollard (2010) have agreed with those over the centuries, for example Rouseau (1913), Dewey (Morrison 1995) and Plowden (1969), that a creative curriculum or cross curricular teaching can be highly beneficial and can develop knowledge and understanding and higher order thinking skills in exciting contexts, the findings of this research will highlight the problems the teachers encountered in keeping the integrity of the subject as part of a creative curriculum.

Keywords: creative curriculum, primary, single subject, cross curricular, technology education

INTRODUCTION

Since the introduction of the National Curriculum in England (DES 1990) there has never been a directive from the Government as to how the whole National Curriculum should be delivered. Whilst there were directives relating to some aspects of the curriculum including literacy (DfEE 1998) and numeracy (DfEE 1999a) it was felt that it should be left to each school to determine how to cover the rest of the content of the National Curriculum. There are a range of options for schools to consider including separate subjects, skills based curriculum, themes or topics, areas of learning, and more recently a creative curriculum. In the non-statutory guidance that was provided for all schools (NCC 1990) it was suggested that design and technology could be taught as a separate subject or through themes and that schools may plan to deliver the subject using both approaches. The National Curriculum Council (NCC) (1993) offered guidance on how schools could develop more systematic approaches to planning including identifying links between subjects. However it was stressed that it might not cut curriculum time needed for each subject if subjects were to be combined and taught effectively. As the National Curriculum was revised, no more suggestions as to how the subject might be delivered within the whole curriculum were included in the documentation (DfE 1995; DfEE/QCA 1999b). It was in response to growing pressure from schools that were concerned about the emphasis on numeracy and literacy rather than a broad and balanced curriculum that there was a move after 2000 from the Department for Education and Skills (DFES) to suggest that subjects could be combined into themes; this was supported by the publication of, for example, Excellence and Enjoyment (DFES 2003). The National Curriculum review that followed known as the Rose Review (DFCSF/ QCDA 2010) also implied that subjects could be taught through themes or topics. A different review – the Cambridge Review (2010) - was also undertaken at this time and offered not only an overview of educational practice past and present but identified that:

> 'simply renaming components of the curriculum 'skills', 'themes' or 'areas of learning' does not of itself address the fundamental question of what primary education is about; nor does it make the primary curriculum more manageable in practice. (p. 403).

At the same time the term 'the Creative Curriculum' became commonly used by teachers discussing the way in which the school was implementing the National Curriculum. A review of some research into the term reveals that it is not just a name for the way of reorganising curriculum content but something that is much deeper. It is about balancing teacher planned and child initiated learning; it is about an inclusive curriculum that will involve and interest all children; it should involve challenges and therefore risk; it should include practical ideas that support the development of social, cognitive and physical development; and it should help to develop a range of thinking skills. (Eisner 1996; NACCCE 1999; Dodge et al 2002; Knight 2002). However, teachers felt their schools generally held a different view as to the meaning of the phrase. Their perception was that schools could be more creative with the way they planned a curriculum. There is no substantial data that can be drawn on to verify this but from the author's data gathered from over a 100 primary teachers attending a variety of CPD during 2010-213, the consensus was that a creative curriculum related to a move away from single subject teaching to the introduction of themes or topics. Two quotes from teachers summed up the general understanding of the term: "…that sounds just like we do but we don't call it topic but the creative curriculum"
" we have moved to a creative curriculum – that means we don't teach subjects now but try to have an overall theme such as Transport and then link different subject content and skills into the theme. We are hoping that the children will find this approach more interesting and they will see the point of undertaking the activities."

Whilst school's planning may include the features identified in the research on the creative curriculum, the teachers did not highlight them as the driving force behind their curriculum planning. Therefore for this study the terms creative curriculum, topic or theme approach are treated as similar approaches to curriculum planning.

It is also imperative for the study that the nature of D&T is defined in order to ascertain if the integrity of the subject is being kept as curriculum planning takes place. It is not possible in this paper to give a detailed and extensive review of research into the nature of D&T; nor is it felt that this is appropriate. For those in the classroom, it is important to have a clear, concise model based on research that enables them to understand the nature of D&T and against which they can make their own judgements relating to the quality of D&T in their school. Since the first National Curriculum document for D&T (DES/WO 1990) there have been a number of changes but the essence of D&T has always been the same. In the 1995 National Curriculum D&T (DFE 1995) capability was defined as designing and making skills combined with knowledge and understanding in order to design and make products. In the 1999 National Curriculum (DfEE1999b) the idea of user, purpose and functionality was more clearly defined and teachers felt that this was helpful in identifying key features of D&T. Based on National Curriculum documents and research into the nature of D&T a group of primary specialists put together a model to help teachers to identify six essential key features to look for in judging good practice in D&T: user, purpose, functionality, design decisions, innovation and authenticity (www.data.org.uk/primary) and it is this model that was used for the course and against which the teachers judged their own understanding, perceptions and quality of D&T in their schools.

THE STUDY AND METHODOLOGY

The purpose of the study was to see if the integrity of D&T was being kept as schools changed to a creative curriculum; of course linked to this was the need to ascertain if teachers understood the nature of D&T, both before and after changes to planning. The creative curriculum/theme or topic approach seemed to be driven by a title such as Transport or Celebrations and content was linked to the title, often it seemed, arbitrarily. The data from the teachers suggested that titles were often picked as the teachers had already a bank of activities that they felt that they could use or there were resources that they could draw on with these titles. No teacher identified that planning started from the skills and content and then a title was linked to these.

This is a small scale study with a sample of 47 primary teachers from different schools and areas in England, all of whom had a responsibility in their schools for D&T. They were attending a long award bearing course (10 days equivalent) for D&T, held in different venues near their schools and all had the support of their heads to be allowed to attend the course. They all had responsibility for planning the D&T curriculum within their schools, but not for the overall structure of delivering the whole curriculum for the school. The chosen sample is best described as non-probability sampling due mainly for the need to keep the sample of a manageable size and because it was not feasible to survey teachers in primary schools in general through conventional probability sampling techniques (Denscombe 2005). The type of non-probability sampling chosen was that of purposive sampling. The sample was chosen explicitly for the research, as the background of the people involved was known, it was felt that they were typical of teachers responsible for D&T in their schools, and they were likely to be able to give data that would link to the research. The size of the group - 47 teachers – was within the suggested boundaries of a small scale research sample where sizes of 30 – 250 cases have been identified (Borg and Gall 1979; Denscombe 2005). There were constraints faced by the researcher including that of time, of no other researcher involvement, and of resources and these should be taken into account when reviewing the findings.

The research strategy that was used was that of sequential mixed methods (Cresswell 2009, Cohen et al 2000, Denscombe 2005). In order to gain some quantitative data relating to the teachers and their schools, the way in which D&T was delivered, and how successful the teachers felt the delivery was, a survey approach was taken. Questionnaires were given out at the start of the course and again at the end. The time for this varied between four and six months depending on how the course was delivered. To capture some qualitative data more open questions were included in the questionnaire and semi structured interviews took place with four-six teachers in a group at the beginning and towards the end of each course. All the interviews were carried out by the same interviewer, partly because there was only one researcher involved but it did help to ensure that the questions were asked in the same or similar way and the interviewer was able to gain an overview and a feeling for the perceptions that the teachers had. In addition the teachers gave in planning sheets for a year to show how D&T was delivered throughout their school and data was gathered through an unpublished MA dissertation (Joyce 2013) from a teacher on one of the courses.

The questionnaire and semi structured interview questions were piloted by three teachers who were not in the sample group to check the questionnaire for any ethical issues that might arise, for clarity, and to ascertain whether the data that was gathered would help to support the research intention. Some minor adjustments were made.

The sections of the initial questionnaire included general background of the teacher and of their school; the way in which the curriculum was delivered in their school; the way in which D&T was delivered; their understanding of the nature of D&T; their perceptions of the teachers' in their schools understanding of D&T; and their perception of the quality of D&T in their school.

Ethical considerations were taken into account throughout the research; all the teachers agreed to take part and understood that they could withdraw at any time; all heads knew and agreed to the teachers taking part in the research; no teacher, child or school would be identified; the research would not be harmful to any participant; the findings would be checked for accuracy using the different data collected; and teachers could obtain the main findings from the research (Gregory 2003; Hesse-Biber and Leavy 2006; www.apa.org/ethics 2002).

FINDINGS AND DISCUSSION

The sample group was 47.

Sex*:* 4 male; 41 female

This is almost the same percentage of male/female teachers in all primary schools in England, where 12% of primary teachers are male in 2011 (www. bbc.co.uk/news/education 14748273) Despite the announcement that there had been a slight increase in the number of male trainee teachers, the percentage was still the same in 2013 (www.telegraph.co.uk/education/educationnews/9849976.)

Age

20-30	30-40	40-50	50-60
15	15	12	5

All the teachers were either subject leaders for D&T or had a particular interest in the subject.

Type of School

All schools were state funded schools.

41 were primary schools – children aged 5-11 years

3 were infant school – children aged 5-7 years

3 were junior schools – children aged 7-11 years

Pre course Findings

The Teachers' Understanding of D&T at the Start of the Course: Majority of the teachers said that they had had some D&T teaching during their degree course but this mainly consisted of a few hours and they could not remember the content in any depth. Making was the main focus of the teaching for those that could remember. Three teachers had taken D&T as a specialism but this was only for one module which again focused on making. Very few (3) had undertaken any D&T Continuing Professional Development (CPD) since leaving University; again these courses were linked to making – electricity and mechanisms. Almost all indicated that they had not focused on the nature of D&T, but on activities that could be undertaken with children.

They were asked to identify six words or phrases that they felt best described the nature of D&T and to put them in rank order if they felt that was appropriate.

Making, knowledge and understanding (including mechanisms and electricity) and designing were considered to be those elements that best describe D&T; evaluating was the next most frequently identified element; whilst user (10) and purpose (8) were identified by only a few teachers. Function (7) and creativity (6) were identified but innovation and authenticity were not included. The idea that D&T was about designing and making something/s for somebody/ies was clearly not at the centre of majority of the teachers' understanding of D&T.

Asked about their staff's perception of the nature of D&T, majority indicated that it would be similar to their own, if the staff understood D&T, which is not surprising as the teachers were leading D&T in their school.

D&T Delivery in the Teachers' Schools: Thirty nine schools had already moved to delivering D&T through a cross curricula approach, calling this the creative curriculum, theme work and topic. It was evident from the data that the approaches were very similar even if the name was different. Schools identified a title such as Celebrations or Transport and then identified different subject areas that could be linked to the title. Only three teachers indicated that if a subject did not fit then that subject would be taught separately. The other eight schools all based their D&T on the Qualification and Curriculum Authority scheme of work (QCA 1998). Four of these schools were looking to change to a themed approached the following year; the other four were awaiting the new National Curriculum before changing their approach.

Quality of D&T in the Teachers' Schools: Majority indicated that they felt it needed improving and some felt it was weak or even very weak. Majority were concerned that D&T was often neglected or left till the end of term. Where staff indicated that there was some good practice, many of the examples did not show a clear user and purpose. For example the children may have been involved in making a book or a card with moving parts, a torch, or a vehicle but they did not consider who they might be for and what the purpose was. Again this was not surprising given that there was not a clear understanding of D&T. A study of each school's planning revealed that majority of schools identified a product to make linked to the title as a way of planning their D&T. A history based topic title proved to be the worst with children making Egyptian jewellery, Tudor houses and Greek temples. Schools that were using the QCA scheme of work i.e. teaching D&T as a separate subject, in the main did identify a user and purpose in their planning.

Post course Findings

Teachers' Understanding of the Nature of D&T: From discussion with teachers throughout the course as they undertook activities that supported understanding of the nature of D&T, it was apparent that their views and understanding of D&T for the majority was changing. As they spent time analysing their schools' planning for D&T they could see that many of the projects were not D&T but at best making projects. Majority thought that the phrase a something/s for a somebody/ies was a focused way that had helped their understanding and that of some of their staffs.

D&T Delivery in the Teachers' Schools: However as the teachers' understanding became clearer it did not always mean that they could influence the way in which D&T was being taught. Out of the 39 schools engaged in a creative curriculum/theme/topic approach only four took time to look in depth at their practice led by the subject leader and were prepared to change D&T activity to ensure that it was authentic. Out of the other 35 schools, 21 indicated that they would carry on until the new National Curriculum was published, even if the quality of D&T was not good. Comments such as:

'the children enjoy what we do – why change?'
'I have my planning sorted and haven't time to change it all'
'we have done this for some years and it always seems to work so let's leave it'
'OFSTED (the inspection service) won't look at D&T so we don't have to worry'
highlighted the difficulties faced by the subject leaders as they tried to implement better practice.

Teachers on the course from the remaining 14 schools indicated that they had some success with some teachers in their schools but not with all. They approached individuals where they could see that a few changes in the implementation of the D&T would be all that was necessary to improve the quality of D&T.

Overall the agent for change was the headteacher or the overall curriculum planning leader in the school and if they did not prioritise a review of the D&T, the subject leaders in charge of D&T had little power to make changes, even where they could see that the quality of practice was poor.
Out of the eight schools still teaching D&T as a single subject based on the QCA scheme of work (1998), two schools were leaving a review until the new National Curriculum was published; six schools reviewed their D&T mainly on a unit by unit basis. This resulted in majority of units now identifying user and purpose.

CONCLUSIONS AND IMPLICATIONS FOR CURRICULUM PLANNING

The conclusions from this study I would suggest are obvious; there has been much anecdotal evidence in the past from, for example, providers of CPD but these conclusions are supported by data collected from a range of schools and teachers. Overall there were no significant differences in the findings relating to the sex, age, or type of school that the teachers came from.
Despite the fact that D&T was introduced to English primary schools in 1990 there is still a body of primary teachers who do not have a clear understanding of the nature of D&T. This may not be surprising as there was never a national programme of CPD as the subject was introduced; teacher training now includes little time for D&T and often this has a focus on making; teachers attendance at CPD is minimal; and there are published resources that do not give a clear message relating to the nature of the subject.
It appears that schools that do not have a clear understanding of the nature of the subject, found difficulties planning authentic D&T activity particularly within a creative/topic/theme approach. Even when the subject leaders understood that changes needed to be made they were mainly ignored unless the head or the school curriculum leader prioritised a review. Those schools teaching D&T as a single subject provided more authentic projects. Unless the key elements of D&T are included in its implementation, important skills such as critical and evaluative thinking will not be developed and from the evidence it was clear that this was not a consideration when planning within a creative curriculum.
An unpublished MA dissertation (Joyce 2013) that has a focus on D&T and cross curricula practice also supports the conclusions. The teacher concludes that:

- where the D&T work is at the heart of the topic rather than marginalised the practice improves as teachers have welcomed the more open approach to planning;
- checking learning outcomes against those in the QCA scheme of work has helped to avoid repetition;
- unless there is quality CPD for the staff it will be difficult to improve practice;
- if the teaching of D&T was not secure in the first place then moving to a theme approach will not improve practice;
- as they moved to a theme approach progression across the school was weakened as teachers planned their theme in isolation;
- unless teachers really understand the nature of D&T there will be little positive impact on the standards of D&T in the school.

The creative curriculum/topic/theme approach seems to have been adopted by many schools. However unless the nature of D&T is clearly understood by the subject leader and all teachers in the school then the integrity of each subject is under threat as schools try to link subjects to titles in inappropriate ways.

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Primary School Teachers' Development of Subject-Specific Knowledge in Technology during a Design Based Research Project

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ABSTRACT

In this study we examine the development of teachers' subject-specific knowledge in technology during a design based research project. In the project a researcher collaborated with two primary school teachers in exploring their students' learning of technology. Throughout the whole project, the teacher-researcher group worked in an iterative and systematic way to explore the students' learning. The data draws from the groups' meetings during the whole project. In order to study the potential learning that was taking place among the teacher team during the course of the teaching project, Practical epistemology analysis (PEA) was used. During the project the teachers' expanding knowledge was based on needs of relations between their understanding of the object of learning (i.e. the capability that the students should develop) and their previous teaching experiences, technical terms and real life examples. An important factor explaining the development of the teachers' knowledge base was the discussion in the group focusing on different aspects, starting with formulating an object of learning, constructing the pre-test, identifying critical aspects and planning and revising lessons. Our study shows that it is possible for primary school teachers to significantly increase their knowledge base in technology and technology education through design-based teaching.

Keywords: Teacher knowledge, design-based research, primary school, technology education, practical epistemology analysis

INTRODUCTION

The introduction of technology education in primary school has meant that yet another subject area has been added to the already long list of subjects to be taught by class teachers at these levels. Several studies show that primary school teachers experience difficulties when teaching technology due to their limited subject matter knowledge and pedagogical knowledge related to technology (Jones & Moreland 2004; Stein et al 2007). But also that subject specific training can increase teachers' confidence in teaching technology (Rohaan et al 2012) and enhance students' learning (Jones & Moreland 2004). In this paper we present a study aiming to investigate how primary school teachers who participated in a design based research project extended their knowledge in technology and technology education during the project.

BACKGROUND

The study was conducted as a Learning study, which is a type of design based research inspired by the Japanese Lesson study. In a Learning study, a group of teachers, in collaboration with a researcher, together explore the most powerful way of teaching a specific object of learning. Based on phenomenographic analysis and a theory of learning, variation theory, they conduct a pre-test, plan a lesson, draw on the student's experience of the object of learning by analyzing the lesson and a post-test, refine the lesson and repeat the cycle one or several times. During this process, the participants learn from each other and gain a deeper understanding of the object of learning in terms of what critical aspects are important to open up for variation (Marton & Ling 2007).

The participants of the study were two primary school teachers, Catherine and Julia (pseudonyms), their pupils and a researcher. The study included two classes with a total of 49 pupils in preschool class and in school year 1 (pupils aged 6–7 years). Both teachers had 7 years' experience of teaching in primary school. Catherine had former training in technology education and a few years' experience of technology teaching, while Julia had neither any training in technology education nor any former experience of teaching the subject. The study was carried out during one semester.

A Learning study takes its starting point from an object of learning that is chosen by the teachers and researcher together on the basis that it is central to the curriculum, and usually it is a topic that involves difficulties for the students. In this study, the capability to construct a linkage mechanism was chosen as the object of learning. The field of mechanisms is part of the core content in the new Swedish Technology syllabus from 2011 (National Agency of Education 2011), and it's also a common content in the existing technology teaching practice.

A vast range of data was collected during the Learning study. In this study we will focus on data from a total of seven meetings with the teachers and the researcher, referred to as the "teacher team". During these meetings all stages of the study were discussed, starting with the choice of object of learning. The meetings also included shared viewing and analyzing video recordings of lessons and pre- and posttests (see Table 1.). Each session was about one and a half hour long. All meetings were audio recorded and transcribed, excepting meeting 5 when the audio recorder accidently was turned off, and notes were taken directly after the meeting in order to sum up the discussion. The transcribed recordings were analyzed.

Table 1: Outline of activities performed during the Learning study.

Activity	Date	Content
Meeting 1	Sept 11	Discussing the purpose of the study and choosing the object of learning
Meeting 2	Sept 25	Discussing and analyzing the object of learning, constructing the pretest
Pre-test		
Meeting 3	Oct 9	Analyzing the pre-test and planning the lesson
Lesson and post-test		Cycle one
Meeting 4	Nov 14	Analyzing cycle one and planning cycle two
Revised lesson, post-test		Cycle two
Meeting 5	Nov 27	Analyzing cycle two and planning cycle three
Revised lesson, post-test		Cycle three
Meeting 6	Dec 4	Analyzing cycle three
Meeting 7	Dec 6	Summing up

METHOD

In order to study the potential learning that is taking place among the teacher team during the course of the teaching project, we have chosen to use Practical epistemology analysis (PEA) (Kelly et al 2012; Wickman 2004; Wickman & Östman 2002). This type of analysis has developed out of a need "to describe actual epistemological practice, that is, how people proceed in action to accomplish certain purposes" (Kelly et al 2012, 285). PEA studies have been performed on students while involved in solving tasks during school work, such as laboratory exercises (Wickman 2004; Wickman & Östman 2002). Learning in the PEA perspective is seen as the creation of relations in the process of accomplishing tasks, and "[l]earning thus necessitates that the participants of a discourse notice the need for new relations" (Wickman & Östman 2002, 605). The analytical tool to study the need for new relations is "gap" (Ibid.). Wickman and Östman have a broad conception of a gap, meaning the potential plurality of interpretations and misunderstandings opened up by any type of act. In their words, "[w]hen people encounter something (utterances, artifacts, natural phenomena, etc.) during talk or in action, a gap occurs" (Wickman 2004, 328). For example, say that you enter a bar, and that you approach the bar counter and say "A pint, please" to the bartender. If the bartender responds to this by pouring a pint of ale to you and if you happily accept this, a gap is said to be "closed". A relation has been created between "A pint, please" and the bartender giving you a pint of ale. In the analytical framework of PEA "a pint" is said to "stand fast", meaning that both you and the bartender take the meaning of this term in the context of a bar for granted. On the other hand, if the bartender hands you a glass of 0.473 litres of beer you may be confused, meaning the gap is not closed, but unfilled. Coming from UK a pint means 0.568 litres and you might end up in a discussion with the bartender about different measurement systems in UK and US and in this gaining knowledge in relation to both metric systems and the meaning of "a pint", thus learning through creating new relations (filling gaps in relation) to the action "A pint, please".

When gaps are not filled, this means that certain relations necessary for action are not solved. Both these types of gaps, filled or unfilled, are of interest in this study. But not all gaps that arouse during the teacher team meetings are of interest to us. Much of the talk during the meetings regarded aspects that did not concern teachers knowledge in teaching technology, such as gaps raised in relation to discussion about new meetings, permits (to film students), small talk etc. In this study we have concentrated on gaps introduced and filled in relation to technical subject matter knowledge and pedagogical content knowledge. However, our intention is not to present the entire learning taking place during the seven meetings, as that would have required a far too extensive article. Instead, we will concentrate our analysis on the main mechanisms through which the practical epistemologies of the teacher team acquired relevant knowledge during the meetings, that is, are there recurrent gaps of certain kinds that seem productive in relation to the task of teaching technology? These recurring themes in the discussion can, from the PEA point of view, be characterized as epistemological habits, as they indicate patterns of inquiry-behaviours that construct knowledge needed to solve the tasks.

RESULTS

In this paragraph we will start by giving a short summary of the meetings, focusing on the first three meetings and illustrating the analytical tools through selected empirical examples. After this we will present what we found to be the most important patterns in the practical epistemologies, that is the way the team managed to solve the task of constructing a relevant teaching for the students.

Starting with meeting one, the first gap of interest for us arise when the researcher states that an object of learning should be determined on the basis of their (the two teachers) past experiences, more precisely on the basis of the problems they think their students have in learning technology.

Researcher: in this first part it's important that we really have talked about what we think is difficult for the students, what they usually have difficulties with, and what kind of knowing we think this is
/../
Catherine: Hrm, but, and it's important that you do the pre-test, the hardest thing, in a way that identifies something that usually is difficult. Then it's like this, <u>usually</u>, <u>usually is difficult</u>, it feels like, you know (laughing), not quite

This gap is not filled as the teachers claim to lack previous experiences. The project could have ended here, simply concluding that the premises for a Learning study were not there. But the group continues and tries to close the gap; that is, choosing an object of learning by trying to construct other relations. One strand in their attempts to close the gap – to decide on an object of learning – is to base the object of learning on the content as specified by the national syllabus. Mechanisms, materials and electricity are areas that are picked up from the syllabus by the team. But this does not seem to be enough to close the gap, partly because the syllabus does not provide enough information about how to proceed in the actual teaching.

In exploring the possible object of learning, the teachers pursue another strand, namely their earlier experiences of teaching using ready-made teaching materials such as LEGO and NTA (a type of "teaching boxes" that include instructions and that build on Science and Technology for Children (STC), a material produced by National Science Resources Center (NSRC)). In this, relations are created between the areas pointed out in the national curriculum, examples given by the researcher and the teachers past experiences. However, some of the constructed relations are broken as they are considered to involve science and not technology (for example certain ways of working with levers). This means that relations of two kinds – both similarities and differences – are created between past experiences, concrete examples given and possible learning objects in technology. Through these new relations, one can say that the team is constructing a deeper understanding of technology education. To take one example, the teacher Julia, who lacks experience of explicit technology training and teaching, comes to the realization that some of her former teaching in fact relates to the technology subject.

Julia: I've made a lot of things with paper fasteners, that you can build [...] I've been working with technology more than I first thought, I think

Another gap that arises in relation to past teaching experiences concerns ready-made teaching materials. The team argues that that such materials are often linked to very specific lesson plans and thus not possible to fit within the framework of a Learning study that demands openness regarding these aspects. One of the teachers tries to close this gap by suggesting that only part of the ready-made materials may be used, and in a more independent way. But the team does not to proceed in further exploring this, and this thus becomes an unfilled gap.

Another recurring theme during meetings one and two are the teachers' search for specific terms related to the object of learning. A gap between the object of learning and the specific technological terms is thus noticed. To take an example of this:

Catherine: what do you call this one? A shaft?
Researcher: lever for transferring a movement
Catherine: you have to have a pivot point for transferring a movement
Julia: lever with a pivot, or?
[---]
Julia: but we can say that then, like a jumping jack, well, what should we call this part?
Researcher: a strip, a paper strip
Catherine: and the technical is? The technical term, what is it?
Julia: the strip (inaudible) (laughing)
Researcher: yes it's a link

Catherine: a link, it sounds professional
Julia: but then this one is also a link, though of a different material

The urge to find suitable terms thus seems to increase the teachers' content knowledge.

Even though certain gaps are filled, this is sometimes just temporarily, as already indicated. During meeting three, it is clear that one of the teachers is not satisfied with how the link to real life examples worked out during the lesson. Despite several new attempts to address this lack of connection to reality, through for example showing the students a pedal bin and discussing it during lessons, the connection to reality ends up as an unfilled, but yet important, gap to the teachers.

Julia: it's important that they get an image, maybe of a seesaw or something, to connect it to reality
Catherine: yes
/../
Julia: some machines /../ a pump to get water
Catherine: they haven't seen those, and a jumping jack is such a constructed toy. Are there any railway barriers?

During meetings three and onwards, recordings of the pupils work with the tasks are analysed by the team in order to further develop the lesson plan. These recordings, together with the fact that lessons are held in between the meeting come to challenge established relations that again have to be closed, etc. In this way, the team developed deeper and deeper understanding of the technology teaching performed.

In relation to the teachers´ expanding knowledge of technology and technology education, we would like to mention three significant and recurring themes of gaps, or "epistemological habits" that have been identified in the material. These gaps regard relations between the teams' understanding of the object of learning and teachers' previous teaching experiences, technical terms, and real life examples.

DISCUSSION

Taking into account the participating teachers' limited experience of technology teaching, they never the less bring in many previous teaching experiences in trying to work out what the Learning study should deal with. Even though not all past experiences are considered to be relevant, many of these experiences contributed in some way or another to develop their common knowledge of technology and technology education. For example, when mechanisms are first suggested as a learning object, one of the teachers connects this to her work with levers in a ready-made teaching material. The discussion in the group deals with how levers and mechanisms are related, and how levers normally are used in primary education to illustrate science, and not technology. Another example is when the researcher shows concrete examples of mechanisms models. The teacher Julia explains that she has indeed worked with these types of constructions but never thought of it as having a technical content. In this process, it is of course important that the group of teachers have some expertise in the field so that the technological content can be recognized. In a Learning study, the researcher often plays this role, and also did so in the present study. This being said, there were several occasions in which the teachers themselves brought new important terms into the process of developing knowledge of the learning object.

We talked about these types of recurring inquiry patterns as epistemological habits as it helped the teachers gaining new knowledge. Another epistemological habit that was discerned in the meetings was that the teachers, especially one of them, again and again comes back to the question of how the teaching is or could be linked to real life examples. As we see it, this relation between the object of learning and real life technology, contributed to develop the teachers' understanding of the object of learning as well as presenting meaningful contexts for teaching. Lastly, also the urge among the teachers to acquire new technically relevant concepts was important for the task of developing the technology lessons during the Learning study.

To summarize, the teachers developed a more specialized approach to technology teaching and learning during the course of the study. An overall factor explaining this is that the team managed to continually elaborate on the technological aspects of the teaching and learning of their students, which is in line with findings by Jones & Moreland (2004). This also means that the Learning study model work for the team despite the fact that the two teachers had no training in either the Learning Study framework or in the theory used, variation theory.

This study is a limited case study with only two teachers participating in a project during one semester. Nevertheless, the results of this study indicate that teachers' knowledge of technology and technology education can be significantly developed by approaching teaching and learning in technology through a delimited object of learning in an iterative way and in collaboration with other teachers. That the team developed epistemological habits can be seen as a sign of what Rohaan et al (2012) have talked about as a positive reinforcement, that is, the team did not settle for solutions or facts but continued to be curious and question whether the teaching they had come up with was best or if it could be improved. These types of habits have been stressed as vital in the modern society where you always have to learn anew and never settle.

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Exploring the Dual Approaches to Technology Education in NZ Secondary Schools

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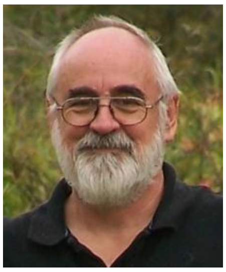

ABSTRACT

NZ secondary schools are able to offer their senior students either industry-based vocational technology education programmes or NZ Curriculum-based general technology education programmes. Each of these approaches is designed to teach knowledge and skills that will help students to successfully transition into the workplace. Through conducting five case studies of recent secondary school vocational and general technology education graduates this research presents data around the perceptions the five students have of their technology education. It focuses on what knowledge and skills were valued by those students, and which pedagogical approaches engaged them.

The research indicated that contextualising learning within a practical project, whether it is a component of vocational technology education or general technology education, seems to engage students more deeply and make learning more meaningful.

Keywords: vocational and general technology education, school to work transition, contextualised learning.

INTRODUCTION

This research presents the findings of five case studies of NZ secondary school graduates who chose to study subjects from within the broad area of technology education. It seeks to provide insight into the question of what knowledge and skills taught in upper-secondary school technology education are perceived as valuable by these students in their transition from school into the labour market or further education. Results are presented in light of the perceived benefits of the dual pathways of vocational and general technology education and how the provision of a contextualised setting in which learning takes place allows students to make meaning within both approaches.

DEFINITIONS

Technology education in New Zealand secondary schools incorporates two approaches, each with a different assessment structure. In this research these two approaches will be referred to as general technology education (GTE) and vocational technology education (VTE). VTE courses and assessment criteria are perceived as emphasising the development of practical capability, whereas GTE is perceived as placing greater emphasis on the understanding and application of theoretical concepts in design and technological practice and developing an understanding of the nature of technology. VTE, in teaching competencies involved in specific trades, tends more to be 'teacher-driven' where the teacher is the expert and imparts his/her knowledge to the student (Bjurulf, 2010). GTE, on the other hand, lends itself more to be 'student-driven'; the student is the investigator, researcher, designer and problem solver, while the teacher is available for guidance and support if needed (Williams, 2006; Jones, Harlow & Cowie, 2004). By definition, GTE is designed to provide benefits to all students; VTE benefits primarily those who are pursuing a specific technical vocation (Williams, 2006). However, both could be said to be grounded in an instrumentalist approach to education with goals related to serving the economic and industrial needs of the nation as well as providing for the economic imperatives motivating an individual to transition from education into an enjoyable, well paid job.

Recent Developments within Secondary School Technology Education

In 2007 the New Zealand Ministry of Education published a new National Curriculum document giving technology education a broad more academic focus. At the time the new Curriculum was introduced Gawith, O'Sullivan and Grigg (2007) described NZ technology education as following an international trend of swinging away from a practical, skills-based paradigm towards an education involved in innovative design and problem-solving in a "critical social context" (p.109). However, this swing has created its own issues and concerns including:

1. Ongoing expectations that GTE would provide students with similar specific manual competencies that had traditionally been taught in craft areas of the curriculum (Williams, 2006; Jones, 2003).

2. Students lacking these basic manual competencies are unable to successfully complete technology projects at school (Hendley, 2002; Evans, 1998).

3. Employers are voicing concern over new employees' lack of these basic manual competencies (Sianez, Fugere & Lennon, 2010; NZIER, 2006).

4. Practically-orientated secondary school students may struggle to find an educational pathway that meets their needs and they may leave school with few or no formal qualifications (Bowskill, Williams & Forret, 2011; Kelly & Price, 2009; Vlaardingerbroek, 2005).

Developing practical competencies and engaging in the process of design and product development are not mutually exclusive, and may in fact be complementary. To this end, the Ministry of Education has recently attempted to rebalance the assessment matrix at upper-secondary school level to include more practical work. 'Teaching and Learning Guides' have been written that draw from subject specific 'bodies of knowledge' outlining specific competencies for each technology subject area (Te Kete Ipurangi, 2011).

In the mean time, VTE has experienced a huge rise in popularity (Dalley-Trim, Alloway & Walker, 2008; Karmel, 2007; Williams, 2006). In New Zealand secondary schools VTE is run effectively as a partnership between schools and Industry Training Organisations (ITOs). The ITOs liaise with industry to ascertain the skills they require and then write and register assessment standards and teaching guides that teachers can use in schools. Schools can then deliver entry level trade National Certificate courses, and students can use these qualifications to ease the transition into trade apprenticeships without needing to complete initial, expensive tertiary training in polytechnics. NZ educators, like their international counterparts (e.g., Karmel, 2007; Malley, Keating, Robinson & Hawke, 2001; Yeomans, 2002) are using VTE programmes to help engage all students in education through the provision of practically focussed programmes.

In spite of the link between industry and schools through ITOs, there is an argument that students would be more successful in transitioning into employment if they were taught more general transferable competencies rather than specific practical competencies (Guile & Young, 2003; Winch & Clarke, 2003). With the fast pace of industrial technological development, secondary school VTE programmes may risk losing touch with the skills needed in industry, teaching outdated techniques on outdated machines. Further, the extensive research that has been conducted to identify the skills that employers are looking for when they hire new employees (e.g., ISC, 2011; NZIER, 2006; Tufnell, Cave & Neale, 2002; Curtis & McKenzie, 2002; Mayer, 1992) identifies core competencies such as basic literacy and numeracy, communication, IT, teamwork and problem solving. These competencies have been suggested as a way of linking the dual pathways of GTE and VTE (Pavlova, 2009; Stevenson, 2003; Williams, 1998) by providing meaningful vocational contexts in which students can "make meaning by engaging in significant activity" (Stevenson, 2005, p. 335). Stevenson (2003) predicts that as vocational education evolves to meet the needs of an industry that "can no longer rely on the predictable tools, equipment, materials, processes and skills that characterised the relatively static jobs of the past" (p. 202), the distinction between VTE and GTE will diminish further.

In light of the changing context within which technology education is delivered, this study seeks to provide some insights into what elements of technology education are valued by and serve young people most effectively in their educational journeys.

METHODOLOGY

Research Participants

Five students were purposely selected with the aim of providing five different stories that could best allow for maximum comparability in terms of Cohen, Manion & Morrison's (2007) 'critical cases'. Three secondary schools were selected that represented different socio-economic status, urban or provincial settings, and large or small student populations. The Head of each of the schools' technology departments was approached and asked to recommend students who had studied technology and finished all five years of their secondary schooling. All participants were aged over eighteen and gave their informed consent to participate in the research. Their confidentiality was assured from first contact and each respondent is identified by a pseudonym. Background information relating to each of the student participants is summarised in Table 1 below.

Table 1: Introducing the five primary research participants

Pseudonym	**School**	**Senior Technology Education Studies**			**Post school Occupation**
		Yr 11	Yr 12	Yr 13	
Emma	Small (<500 pupils) Low socio-economic Provincial	GTE (Graphics)	GTE (Graphics)	GTE (Graphics) VTE (ICT)	University study (Law and Business)
Lorenzo	Small (<500 pupils) Low socio-economic Provincial	GTE (Graphics) VTE (Carpentry)	VTE (Carpentry)	VTE (Carpentry) VTE (ICT)	Semi-skilled labourer in the building industry

Hemi	Small (<500 pupils) Low socio-economic Provincial	VTE (Carpentry) VTE (Engineering	VTE (Carpentry) VTE (ICT) VTE (Engineering)	VTE (Carpentry) VTE (Engineering)	Pre-police training course
Darcana	Large (>1500 pupils) Mid socio-economic Urban	GTE (Materials)	GTE (Materials) VTE (Electronics)	GTE (Materials) VTE (Electronics)	Unemployed
Chester	Large (>1500 pupils) High socio-economic Provincial	VTE (Furniture)	VTE (Engineering) VTE (Automotive)	VTE (Engineering)	Diesel mechanic apprenticeship

DATA COLLECTION AND ANALYSIS

Data were gathered through interviewing the student participants, their caregivers and principal technology teachers. The interviews followed a semi-structured interview protocol aimed at generating qualitative, rich, in-depth data. Thematic analysis based on a variation of the methodology of Marshall and Rossman (1999) was applied to the raw data through a process of listening and re-listening to the interview recordings to initially identify themes and then to extract the thematic data. The variation involved the predetermination of possible themes.

The data were validated through triangulation with the participant's caregivers and teachers. Further validation was achieved by asking the research participants to review their responses through reading the partial transcriptions and seeing the thematic categories the researcher made from their interviews.

FINDINGS AND DISCUSSION

Key competencies and life skills in technology education

As discussed above, the skills and knowledge needed for employment in the future world of work are becoming more and more the general transferable skills needed for life. Technology education is seen as an effective means to develop students' general competencies and dispositions and prepare them for future employment. Key transferable competencies that were identified as common in all the participants' technology education are discussed below.

Cooperative skills: Different students show different inclinations within their technology education; some prefer conceptualising, negotiating and documenting a design process, while others are more interested in fabrication. This research reveals that the pathways and assessment criteria of both VTE and GTE provide opportunities for students to work cooperatively on a variety of projects without appearing to compromise the validity of the assessments.

Hemi and his classmates worked cooperatively on a single project in the context of a Building and Construction ITO (BCITO) competition. Evidence for judging the competition was not solely based on the quality of the build, but also on the students' documentation of the design process and negotiation with their client. While the manual construction skills required for these cooperative projects are assessed under VTE, they are important in GTE programmes. It seems that having students who are skilled craftspeople together with students who are skilled at negotiation, documenting and describing what their team has done, not only reflects real-world practice, but is also the key to success in the competition.

Young (2010) suggests education must challenge students to move out of their 'comfort zone' to discover capabilities that they may otherwise never discover in themselves. In response to this challenge, this research shows that working cooperatively on completing 'real life' projects not only gives students the opportunity to become more aware of their own strengths and value the strengths of others, it also allows them to be exposed to a variety of skills that may well be new and unfamiliar to them.

Problem-solving skills: Responses from the participants in this study indicated a range of pedagogical approaches to problem-solving, with differences between VTE and GTE and also within the VTE pathway. For example, GTE students seemed more likely to encounter unforeseen problems in their work that their teachers also did not immediately know how to solve. Consequently their teachers were more likely to model their own ways of problem-solving rather than just provide an immediate answer. VTE students, on the other hand, were more likely to encounter problems that their teachers had already learnt to deal with many times, and consequently were more likely to provide the student with an immediate answer.

Emma described her GTE graphics teacher as a 'guide', who would help clarify the overall, bigger picture of her project rather than the detail of what she did within that project. She explained that he would work with her to solve problems rather than knowing and providing solutions immediately. Darcana described using the problem solving strategy of researching existing solutions and modifying them to suit the context of his GTE project.

If Chester encountered a problem in the practical tasks of his vocational training and asked the teacher for help, his teacher would not just tell him what to do, but also explain the reasons for doing it that way. Hemi described his two different VTE teachers as having two different approaches to teaching problem-solving. He said he always stopped work if he encountered a problem and asked his teachers to explain what he should do. His engineering teacher would use the problem to model his own problem-solving skills to the whole class, whereas his carpentry teacher would describe the solution directly. Lorenzo tells of asking the same carpentry teacher how to do something and sometimes receiving a hint about how to solve the problem and sometimes a full explanation. Interestingly, Hemi felt he learnt more problem-solving in his carpentry class than in his engineering class. He described how working on a 'real job' and asking for help when he needed it helped him understand when and why certain skills or tools were needed. In contratst, Lorenzo felt that if he had to figure out the solution by himself, it 'stuck in his brain' more easily, but if he was told the answer straight away, he had to try and remember it without having made sense of the problem first.

Vocational 'habitus'

VTE programmes emphasise the preparation of students to transition successfully into trades-based employment through teaching specific competencies around using tools and machinery. However, rather than the research participants indicating that these specific competencies were of themselves the most valuable in their lives after school, they ascribe greater value to the process of acculturation into the values and attitudes needed for success in the practical world of work or 'vocational habitus' (Taylor, 2008) that VTE provided.

Chester described his VTE education involving the skills needed for developing an appropriate 'vocational habitus'; skills that he says will "stay with you forever and set you up for when you work in a real workshop…the tricks of the trade." Similarly, Lorenzo said the specific competencies he learnt in graphics around sketching and drawing plans gave him a "head start" knowing what to do on a building site and successfully communicating with other trades people about specific jobs.

These findings support Dalley-Trim et al.'s (2008) Australian study of secondary school vocational students who perceived their vocational education as providing valuable qualifications and "life skills" that would give them a "head start" in their quest for employment (p. 63). It is also consistent with Taylor's (2008) description of school based carpentry apprenticeship trainees becoming acculturated into the values and attitudes needed for successful employment.

Providing a meaningful context

In a report by the Centre for Education and Industry, University of Warwick (2009), technology education is described as having the potential to...draw out the applications of scientific and mathematical ideas...[to] produce better links between skills, abilities and types of career and be the bridge between academic study and real life activity. (p. 10)

The findings from this research provide evidence that demonstrate this potential, particularly for students who might not otherwise have engaged with more traditional academic study. For example, Darcana described himself as both an academic and practical student. He engaged in, benefited from and succeeded in senior GTE. However, he had difficulty with mathematics and described understanding decontextualised general academic concepts as the "logical side", that is, "more detached…not real…all in your head…existing in a dimension we can't exist in…it just doesn't make the same sense." He reported needing a physical reason or application to actually engage in the learning activity, and then he had no problem working things out even when they involved physics or mathematical knowledge. Darcana believes that education should be about making conceptual knowledge more accessible to students by making links between that type of knowledge and the real world that students can relate to. He was full of praise for his school's VTE programme, which he believed gave students struggling with mainstream education basic literacy and numeracy skills by delivering them in a vocational context.

Hemi described having difficulty with maths assessments compared to his VTE assessments because maths questions did not have any real-life context from which he could draw answers. Chester saw relevance in studying academic subjects only for students who know they want to go to University. He explained that practically-minded students do not see the relationship with what they want to do and what is being taught in many of their subjects.

Emma took GTE in the subject context of graphics. Both she and Darcana described transferring and using knowledge and skills from other subjects, researching when they did not know something, and using conceptual knowledge from maths and science in the process of completing their projects. Emma says of her consideration of costings and the economics of her designs; "[I] guess it was kinda like the real life application of maths."

Contextualised project based learning experiences that reflect real world practice and intertwine theory and practical capability in both VTE and GTE, engaged the students interviewed for this research, and are valued as useful in preparing them for their life after school. The findings support literature that stresses the importance of contextualised learning that provides students a more holistic approach to their education (e.g., Stevenson, 2003; Stevenson, 2005; Bjurulf, 2010; Woods, 2008).

CONCLUSIONS

After analysing the responses made by the participants in the case studies, it appears that it is the general life skills, taught in both VTE and GTE programmes, which were perceived as more valuable than those that are subject specific and specialised. In addition, they more readily recognized their learning as relevant when it was contextualized. Within such contexts students identified their exposure to a variety of knowledge and skills including:

1. the more academic GTE achievement objectives around planning, critical evaluation, design process and societal and environmental considerations in technological development;

2. the more practical goals of VTE to gain competency in the use of tools, machinery and manipulating materials;

3. general life skills around key competencies such as communication, co-operation, perseverance and basic literacy and numeracy.

Many schools do not have the space in their timetable, the staffing, or the student numbers to be able to offer both GTE and VTE as separate subjects. However, teachers do have the ability to provide their students engaging, real-life contextualised projects. In this way teachers are able to focus the learning experiences of their students on preparing them for the reality of the workplace rather than structuring the learning solely around providing evidence for assessment. At senior school level, there is an extensive suite of vocational and general technology assessments available to tie the authentic learning students are undertaking to national qualifications, and provide a range of students with different abilities and interests, opportunities to succeed in their schooling.

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Influence of a University Technological Literacy Course on Career Choices of Undergraduate Students

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ABSTRACT
This study sought to determine if participation in a general studies undergraduate technology education course influences student career choices. Students were administered the *Self-Directed Search Inventory* (1994) as a pre-test and post-test during the semester to compare potential influences the course content and activities had on students' decisions to pursue STEM university majors and/or occupations. In addition, some students who showed interest in STEM fields were interviewed to determine the impact they believe the course might have had on their particular career decisions.

Keywords: Technology and careers, STEM career choices, Undergraduate technological literacy

INTRODUCTION

The need for a technologically literate society has never been greater. Globalization has become a way of life as many nations are now able to compete on an economic and talent- level with each other (Friedman, 2005). Consequently, global demand for qualified talent in the fields of science, technology, engineering, and mathematics (STEM) continues to grow. According to the U.S. National Governors Association (NGA) (2011), STEM job holders will out-earn non-STEM workers, STEM fields have tripled in growth over non-STEM fields, and unemployment rates are lower for STEM workers. Many would believe that this kind of demand for a qualified STEM workforce would be enough to garner interest and support by both students and K-16 institutions to pursue and offer STEM courses of study. However, this is not the case. The NGA (2011) states,

> Although STEM jobs are expected to grow by 17 percent between 2008 and 2018, many higher education institutions—including community colleges, four-year colleges, and research universities—have not made an effort to increase their output of STEM degrees or certificates. (p. 5)

It is also their belief that higher education fails to connect academic outputs to global economic demands. They assert that fields of study and program offerings "must be better matched to the job market to sustain economic growth" (NGA, 2011, p. 23).

Guided by this need, educators are working toward providing students with competitive 21st century knowledge, skills, and attitudes. The hope is that with this new found knowledge, acquired skill sets, and attitude shift, many students will feel empowered and qualified to then become workers in a competitive STEM global marketplace. However, when arriving at universities, undergraduate students often struggle to make or commit to a decision as to what particular field or discipline they will pursue as their desired course of study (McClellan & Moser 2010; Osipow, 1999), and often times, STEM fields are not what they choose. According to Ronan (2005), 50 percent of undergraduate students will change their majors, some by as much two to three times, for a variety of reasons. Influences and variables involved in this multifaceted decision can vary from student to student. Dick and Rallis (1991) assert some of the more influential variables students consider when choosing a career include genuine interest in the field, pay, availability of jobs, and parent and teacher influence. Despite these variables, there are those students who come to higher education with a life's calling and there are students who come in as undecided, looking to find a career interest.

Whether a student has a defined field of study or they are undecided, coursework selections must be made. These courses may prove to be extremely fascinating and impactful or extremely boring to the students, thus spurring additional interest or disdain for a particular subject. But can a course be impactful enough in its content or course activities to spur interest in a particular field, especially interest in a STEM field of study? Can such a course influence a life decision such as career interest? This study was undertaken as an attempt to find answers to these questions.

Technology and Your World

Technology and Your World (STEM 110T) is an example of an undergraduate course students can take to fulfill a technological literacy requirement set forth by Old Dominion University. This course provides students with the opportunity to explore the five overarching categories set forth in *Standards for Technological Literacy* (ITEA, 2000): The Nature of Technology, Technology and Society, Design, Abilities for the Technological World, and the Designed World. In order to develop technological literacy, the course competencies stipulate students will be able to: understand technological principles; develop solutions and achieve goals through the application and evaluation of technology; and be able to communicate their evaluation of technology while collaborating with their peers during their study of the five categories of technological literacy. During the course, students receive an overview of the resources and systems of technology. Emphasis is placed on the impacts that technology has on individuals and society. Students participate in various discussions and activities which explore the evolution of technology, its changes, advances, and effects on individuals and society. This course is also designed to assist students in developing critical and analytic thinking skills regarding the development, selection, and use of technology. Throughout the course, students learn to make reasoned judgments about the effects technological change has on individuals, their careers, and cultures and developing an understanding of basic technological principles (Old Dominion University, 2012).

In addition, students are exposed to various career options in STEM fields while discussing and evaluating the different facets of technology. Guest speakers, videos, and articles highlighting STEM careers are all employed as supplemental course materials. Additionally, students are introduced to the *Grand Challenges in Engineering* (National Academy of Engineering, 2012) and to *Standards for Technological Literacy* (ITEA, 2000). These fourteen challenges and twenty standards serve as a basis for a group project on socio-cultural issues. In addition, students engage in several problem-solving and hands-on activities that require team collaboration during the course. These include the development of a robotic arm made of cardboard to learn about manufacturing technologies, designing a "smart city" that only uses alternative energy sources, designing a solution for moving construction materials in and out of a construction site with buildings all around, and learning ethical issues in the role of bio-technologies and advancements of medicine.

Individually, students synthesize articles on a technology in manufacturing, biotechnologies, information/communication, and alternative energies where they provide a brief summary, discuss the positive and negative implications of the technology, and provide their overall opinion about the technology. In addition, students write and present a report on technological influences in their major or chosen career. This report includes the evolution of technology within their field, current trends and issues, applications of technology in the field today, how the student would apply and evaluate technologies when they begin work in their career, and finally, three current examples of job descriptions for their particular job of choice. At the conclusion of the course, students discuss the various concepts and issues they learned during the course that have helped them work toward becoming a technologically literate citizen.

PURPOSE OF THE STUDY

Benson and Lunt (2011) believe we can develop a better understanding of teaching and learning practices if we study student perceptions of their learning. Researchers (Barak, 2011; Katsioloudis & Ritz, 2011; Lawson, 2012) have reported technology course influences on student learning in the past. This study sought to follow in those footsteps. Undergraduate students who complete *Technology and Your World* should have an understanding of technological literacy and its role in society. In addition, they should have developed awareness for the role science, technology, engineering, and mathematics play in their future careers or courses of study. The question is whether the knowledge developed in this particular course will inspire students to want to pursue careers and courses of study in STEM fields. Therefore, the purpose of this study was to determine if participation in *Technology and Your World* (STEM 110T) influenced students to pursue STEM majors and/or occupations. The following hypothesis and research questions were created to guide this mixed methods study:

H_0: There will be no difference in student career choices upon completion of a semester in *Technology and Your World* (STEM 110T).

RQ_1: If there were student(s) who showed a change, did those student(s) who elected to change to a STEM major/occupation believe technological literacy played a significant role in influencing them to make their particular career decision?

RQ_2: What course content do those student(s) believe influenced their new STEM career choice?

PARTICIPANTS

Two course sections of *Technology and Your World* were given the pre-test (N=59) and post-test (N=58). Students ranged from freshman to senior level STEM and non-STEM fields of interest. Table 1 illustrates the demographics of the two course sections.

Table 1: Technology and Your World Course Demographics

	Females	Males	Freshmen	Sophomores	Juniors	Seniors	STEM Majors	Non-STEM Majors
Students Enrolled	29	20	11	33	9	6	12	47

Note: The number of enrolled students includes two course sections of *Technology and Your World*. Majors reflect student choices at the beginning of the semester.

METHOD

A mixed method approach was utilized to collect both quantitative and qualitative data. At the beginning of the semester, students were administered the *Self-Direct Search Inventory* (1994) or *SDS* to assist in identifying occupations and fields of study that most closely matched their particular interests. These findings were then used by students during the semester to complete coursework and activities aimed at developing technological literacy knowledge and abilities. Students were re-administered the *SDS* at the end of the semester to determine any new interests toward STEM fields. Dichotomous student groups of STEM and non-STEM interest were created at both the beginning and end of the semester. A Chi-square analysis was used to evaluate the data. By comparing the *SDS* results, students who showed new interests in STEM majors and/or occupations could be identified. These students would be interviewed to provide insight into the influence, if any, the course had on their new STEM career/major choice.

Self-Directed Search Inventory

The *Self-Directed Search Inventory* (1994) was used to measure student interest in STEM fields for this study. The *SDS* is specifically designed to measure student interest in varied vocational fields (PAR, 2013). Inventory results can be used to match students with approximately 1,156 occupations which can account for 99% of all workers (Holland et al., 1986). In addition, Holland and Rayman (1986) assert that this inventory is unique in that it not only has established reliability and validity data, but it is both "an assessment of vocational potential and vocational treatment" (p. 57). The *SDS* is based on John Holland's Vocational Preference Theory of six personality traits as vocational preferences. The six codes for the inventory include any three letter permutation of *Realistic (R), Investigative (I), Artistic (A), Social (S), Entrepreneurial (E), and Conventional (C)*. Upon completion of the inventory, students are given a three letter code that reveals their top three career interests. STEM career interest can be indicated by showing either *R, I*, or *C* as their top three choices.

The *RIASEC* typologies and Holland's vocational model have provided both researchers and students with valuable information regarding career selection. They have provided researchers with a way of organizing occupational interest data (Hogan & Blake, 1999) while becoming one of the seminal pieces in career indecision research (Osipow, 1999). This organization and research allows vocational counselors to help students make more informed decisions about career interests. Hogan and Blake (1999) believe that these codes are important because they not only reveal work preference by the individual student, but they also reveal the type of environment and co-workers the student would prefer. Armed with this information, it is believed that students can then make better informed decisions about particular career and field of study interests.

FINDINGS

The sample included 59 undergraduate students who participated in the initial administration and 58 students who participated in the post administration of the *SDS* for a total of 117 scores collected overall. The results of the Chi-square analysis were not significant, $X2$ (1, N = 117) = .922, $p > .05$. Therefore, the null hypothesis which stated there will be no difference in student career choices upon completion of a semester in *Technology and Your World* (STEM 110T) is accepted.

Research Question 1 asked if any student(s) who elected to change to a STEM major/ occupation believed technological literacy played a significant role in influencing them to make their particular career decision. Although the null hypothesis was accepted, two students indicated a change toward a STEM career/field of interest. Both students agreed to be interviewed. One student revealed that the course was very enlightening to her in regards to the impact technologies have on our everyday lives. When asked if the student believed her journey toward becoming a technologically literate individual was assisted by the knowledge gained in the course, the student responded, *"Yes! I was able to see what my [original] career choice entailed. I realized that I would be more comfortable using technologies everyday rather than managing people."* This student went on to convey how interesting the biotechnologies unit was to her. The student stated she always had an interest in the medical field, but never really considered how many career choices were available that were cutting-edge and in-demand. She said her original major was human services, however she would be changing her major to biology. The student indicated that a medical technology job was of great interest to her.

The other student indicated she had not made up her mind as to which STEM career to fully pursue, but science might be a "*forerunner*" for her field of study. Her original major was in recreational and tourism management. She mentioned a biotechnologies video shown in class that had a significant impact on her reconsidering her major. She said, "*I saw that video on growing body parts in a lab and I thought, wow! How awesome is that!*"

For Research Question 2, the students were asked what course content do those student(s) believe influenced their new STEM career choice. They were asked to provide an example of an activity or course topic that influenced their decision. One student stated the career application paper helped her decision because it required her to gain insight into what each career required. This student went on to reveal that as she further researched careers, she felt more comfortable and excited with the requirements and challenges offered in STEM fields. She also indicated the importance she felt technological literacy played in her decision. She felt, *"better prepared to make the right decisions about technology and its impact on my life."* During the interview, the researcher conveyed to the students some variables research (Dick & Rallis, 1991) has indicated are used to make career decisions: genuine interest in the field, pay, availability of jobs, and parent and teacher influence. The researcher then asked the students if they felt technological literacy should be considered an important variable to consider in helping undergraduate students make informed decisions about their future careers. One student answered, *"Yes! Technology is used in our everyday lives. I think it is very important."* When asked if they would pursue more technology education courses in the future, both students smiled and nodded yes. One student said she had already looked at the course offerings for the fall and had an appointment with her advisor to change her major. Both students indicated they would be encouraging their friends to look into STEM career possibilities.

DISCUSSION

Old Dominion University has presented a unique opportunity for undergraduate students to begin development of technological literacy by making select courses a general education requirement. *Technology and Your World* is an example of one course that can be taken to meet this requirement. It seeks to provide an overall STEM experience for students. It provides an opportunity for students to collaborate in conducting experiments like a scientist, problem-solve like an engineer, build technological artifacts and be innovative like a technologist, and apply logic and function to their work through mathematical applications. If one considers Barak's (2011) assertion that "learning is intimately associated with the process of discourse between the learner and other people – teachers, peers, family members and casual acquaintances" (p. 60), then this course can present a collaborative opportunity for students to learn from their peers, active STEM workers, and others about the importance of technological literacy.

The two students interviewed provided an opportunity for the researcher to understand how technological literacy affected two student career decisions. When considering the course competencies and definition of technological literacy set forth by the class in comparison to the student interviews and their course contributions, the two students displayed an understanding of technological principles. In addition, the two students actively participated in development of technological solutions while effectively communicating and collaborating with their peers. The students' development of technological literacy helped contribute to their decisions about career choices, as illustrated in their interviews.

In conclusion, it is the hope of the researcher that this study may lend insight as to the impact technological literacy can have on student career selections, thereby creating a sustainable future for technology education. The qualitative data provided a glimpse of student perceptions on technological literacy and career influences. In addition, the fact that two female students showed an interest toward STEM fields is important as females are underrepresented in these areas. Further research on how technology courses impact and influence STEM career selection is recommended.

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Contribution of Technology Education in Supporting Dyslexic Pupils: A Study on Developing Competencies Building in Experimental Activities

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ABSTRACT

For the law voted in 2005 about disabled people in France, we have known that disciplines such as languages, mathematics, drawing or sports activities are schooling spaces of adaptation for pupils whose disability is not psychiatric origin. Experimental disciplines such as science and technology remain less studied in which some aspects are proposed to help in following "normal" classes. We know nothing about the issue of technology education and about activities used in teaching technology in supporting dyslexic pupils. This contribution shows how dyslexic pupils develop capacities to bypass obstacles they have to confront in experimental activities of technology. This first research reveals that technical languages and artifacts oblige dyslexic pupils go seek in them intact capacities undisturbed by dyslexia.

Keywords: dyslexic, technology education, schooling adaptation, competencies.

INTRODUCTION

Technology education in France is compulsory for all the pupils from 3 to 15 years age. It appears in school disciplines respectively called "sciences and technology" for 3-11 years, "technology" for 11-14, "sciences of the engineer" for the 15-18. It is defined by national curriculums, which specify: objectives, competences, contents and the suitable teaching approach. The teaching of technology in France highlights the problems associated with the logic of design, manufacturing and Assembly processes. It contributes to analyze the needs of the users and to think about the skills of the actors involved. Based on a practical approach of the real (observation, analysis, creation and communication), this teaching participates in the structuring of the knowledge, skills and attitudes.

Beyond words, the technology uses images and graphic areas of realty (Deforge 1980; Ginestié, 1999; Haudricourt, 1987; Lebahar, 2008; Rabardel & Weill-Fassina, 1987). It summons a varied series of technical languages (drawings, cuts, pictures of reality, design drawing, assembly drawing, exploded, schematics, codes, 2D and 3D modeling, ...) poorly known to the general public. Even if, some are widely used in everyday life (drawing assemblies, assembly drawing, exploded, drawing principle ...).

Since the law voted in 2005 about disabled people in France, schools are obliged to register these students in regular classes to get similar education than others. Disabled pupils admitted in the normal school curriculum have no psychiatric disorders or mental disorders. They are categorized “distressed”. Thus the French classes include pupils without handicap with disabled pupils - distressed. Among these troubles, the dyslexia. A study of INSERM (2012) believes that in France, dyslexia (moderate to severe) is 3-5% in primary school. Thus, some 40 000 dyslexic pupils come every year in primary school. It corresponds to a pupil per class at primary. This average is increased because of the number of pupils per classes more important in high school.

Dyslexics are normally intelligent, their reasoning ability is intact. They have not strictly the same difficulties. Dyslexics have specific reading disorders. Their problem of reading is due to lesions of the nervous system (Eden & Zeffiro,1998; Eden & al, 1995; Ramus, 2005; Zihl, von Cramon, 1983). They have a difficulty to connect a pronunciation to a syllable. In other words, they can't easily make the conversion grapheme-phoneme (writing letters, syllables - sound components, sound) and automate it. For these reasons, the dyslexic reading is generally hesitant, slowed, punctuated with errors, times, which may impact the understanding and the time to complete the task. It is especially very expensive from the cognitive point of view and it causes significant fatigue. Dyslexic pupils are distributed into two major trends: those who have severe dyslexia and those who present a slight dyslexia average. For severe dyslexics, clearing and accessibility measures are planned because they are considered disabled (inclusive education individual devices, using auxiliary, appropriate assessments, suitable physical arrangements classroom). The others with lighter dyslexia do not benefit from special facilities. They are the most numerous. They are immersed in normal classes. Regardless of disability, teachers must take into account this diversity of public (Plaisance, 2009). Some perform, for example, a grooming of the instruction or of the artifacts as it is demonstrated in Gombert, Feuilladieu, George, & Roussey, (2008) studies.

Researches about dyslexic students skills are generally focused on reading, spelling and mathematics (Fayol, Gombert, Lecocq, Sprenger-Charolles, Lecocq, 1991). As we know, in France, there is no research about technical skills of dyslexic students in technology. This paper concerns specifically the technical skills developed in technology by dyslexic students - “distressed”.

METHOD

The work is based on an empirical study conducted in France with pupils of secondary school (13-14 years). The study focuses on the cognitive and pragmatic skills developed in situation of study and development of a technical system (wind). We believe that dyslexic pupils, because of their disability, invest experimental activities of technology differently than do regular pupils in terms of cognitive and pragmatic skills.

Classroom observation

The methodological device is to observe dyslexic and non-dyslexic pupil’s difficulties to perform the tasks according to the teaching of technology education in France.

The study was conducted in two classes: one of 22 pupils with 4 dyslexics, another with 14 pupils and 2 dyslexics. The pupils are all between 13 and 14 years old. The sample counts six dyslexic pupils working in pairs with non-dyslexic pupils. Taking a non-dyslexic neighbour is a choice purely pragmatic. It reduces the observation field to a smaller space. The comparison is easier when pupils are seated side by side. Moreover, non-dyslexics are not selected on implicit criteria such as good, wise, caring for others, etc…

Description of the educational system

The sequence is devoted to the design and construction of a wind system. It has several learning objectives:

The first session identifies what is a wind turbine, how does it move and how to understand its working principle. Two intentions build it: Teach pupils to look for information on the Internet and identify the elements that structure the wind site. This is a literature research.

Table 1: Task 1

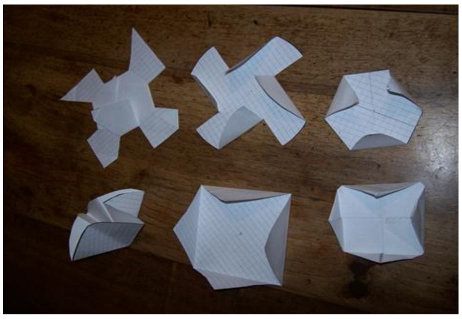
Task 1	Instruction	Equipment available for students
Collect information	- Helped by : http//www.edf.fr/html/ecole énergie », answer questions 1 to 5 of the document 1 « wind turbine and its energy » and fill in the document 2 « Studying the wind turbine working ».	1 Computer 2 Fill in the documents

The website on which pupils must find the answer to questions combines written texts (descriptions and explications) and illustrations (pictures of wind turbine site, drawing in longitudinal sections of wind turbine with roots in the ground).

A second session set a target in developing solutions about the wing system shape from three bases imposed (square, round, triangular).
The objective is to make pupils fully aware of the assembling problems posed by these systems and the multitude of possible choices.

Table 2: task 2

Task 2	Instruction	Equipment available for students
Design	- Draw a square, an equilateral triangle and a circle whose dimensions are 120 mm and 200 mm in diameter or side. - Cut the shapes and provide many solutions to make a pale. - Warning: the center of rotation of the wing system matches with the center of these surfaces.	1 box with a pair of scissors, caps, pins, brads 1 sheet cardboard



Picture 1: examples of pupils' solutions

In the third session, they produce the various systems of wing system in different materials. The goal here is to make them aware that the assembly is dependent on the material properties even for a same shaping. In this session, pupils will also create the system they will have to test in the next session.

Table 3: task 3

Task 3	Instructions	Equipment available for students
Production	- Draw a square, an equilateral triangle and a circle whose dimensions are 120 mm and 200 mm in diameter or side. - Cut the shapes in each sheet available (paper, plastic) - Shape it with the equipment available	1 box with a pair of scissors, caps, pins, brads Two sheets: One in paper, the other in plastic

The various systems of wing system created (squared, triangular or circled base in paper, cardboard or plastic) are tested in a fourth session to control the efficiency and the working of each system.

Behind the experimental aspect, the teacher points out to the pupils that all assemblies are not suitable (because some produce friction), all materials are not suitable (because of the different properties, some materials are more able to resist to windy conditions than others), moreover, derived forms of triangular and rounded bases are not good technical solutions.

Table 4: task 4

Task 4	Instruction	Equipment available for students
Test	Test each wing system with the experimental support available for Note the results in a two-entries table.	1 experimental support on which the wing system will be fixed, All the wing system that children built, 1 document to fill in for each kind of pale (triangular, rounded or squared bases). Pupils have to indicate the following details: fixation number, attached or detached pales, diameter, indicator state (on/off), effective movement (turning or not)

Data collection

Two types of data are collected: those related to cognitive skills and the others linked to practical skills, both to carry out the various tasks assigned.

Table 5: Criteria of observation of child's action

Observation of the child's actions		
Criteria	Action indicator	Present /Absent
Understanding of the instructions	Moving quickly into action	
Organisation/ Information management	Suppleness in accomplishment	
Planning/Chronology	Relevant organisation of the action and chronologies	
Autonomy	Working from action rules the pupil determined himself/herself	
Self-confidence	Working continuously, without giving up	
Summary	Meeting data to solve the problem	
Speaking	Getting or giving information	
Executive time	When the student starts to work on the task	
Reading supports	Reading and understanding some texts, graphics or schemas.	
New words	Using of new words met during the task.	

A referential for each student, previously established, can allow checking the presence or absence of these indicators during the task fulfilment.

RESULTS AND ANALYSIS OF THE SITUATION OF TEACHING-LEARNING TECHNOLOGY

Task 1 - Collect information

Dyslexic pupils have more difficulties than non-dyslexic in searching for and returning information found on the Internet on a writing document as showed in the following table:

Table 6: Number of difficulties in finding information for both groups of pupils

Total dys	Total non dys
30	19

On the 11 observed skills, the dyslexic pupils group has a score of 30 against only 19 difficulties for the non-dyslexic students group. In particular three students in the dyslexic group who bring together much of the difficulties encountered: They have 26 on the 30 observed difficulties. As for non-dyslexic students, only a pupil displays 6 on the 19 observed difficulties. The figure below shows the distribution of difficulties skills.

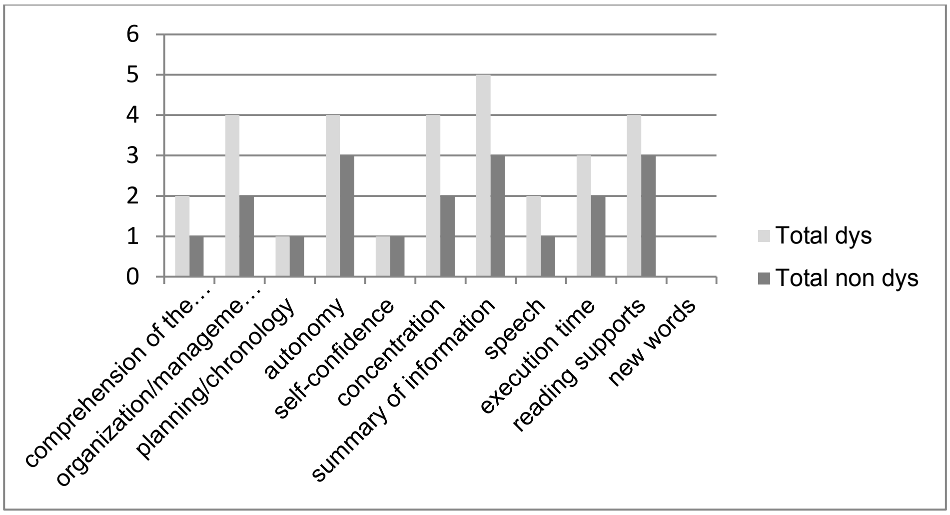


Figure 1: Number of students in difficulty against the competencies in information retrieval

This graph shows that it is harder for dyslexic pupils to manage the information, synthesize it and communicate, and they have more difficulties to focus on this type of task than their non-dyslexic mates. In compensation, reading on a website is about as problematic for both categories of pupils: only a few more troubles can be noticed for dyslexic pupils. Planning a task and self-confidence work exactly in the same way for both categories.

Task 2 – Design

Here, the students had to reflect the design of a wing system. This activity does not handicap dyslexic; their scores are almost identical to non-dyslexic.

Table 7: Number of difficulties in designing a pale for both groups of pupils

Total dys.	Total non dys.
22	21

On 11 skills observed, the group of dyslexic pupils score appears almost identical to non-dyslexic students score (22 against 21 of difficulties in the non-dyslexic group). In each class, it is noticeable that only a pupil has 6 of the 22 difficulties observed in the dyslexic group and 6 of the 21 in the non-dyslexic group.

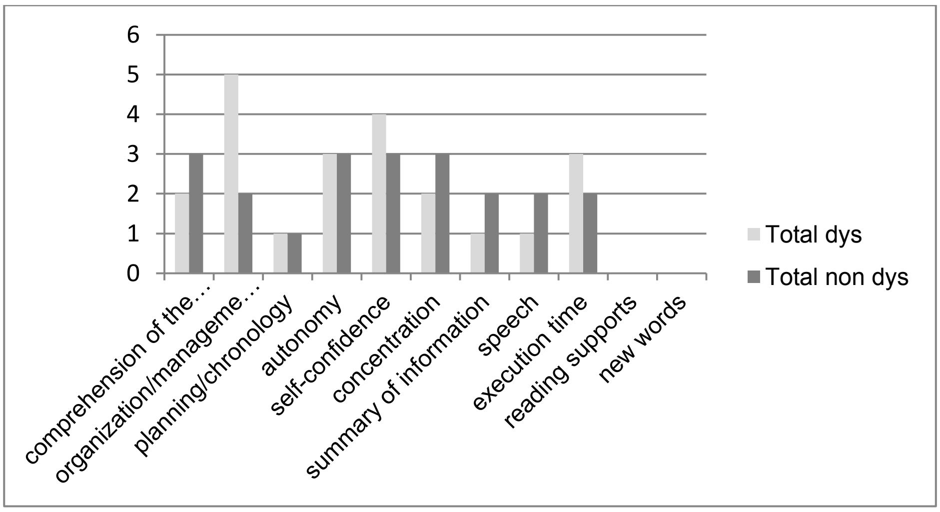


Figure 2: Number of students in difficulty against the competencies in design

Dyslexic pupils do understand better the instructions and their concentration is also better than for non-dyslexic pupils. Self-confidence and the ability to do the work in time are slightly more problematic for dyslexic pupils. The organization of the task is much more difficult for dyslexic pupils. Thus, dyslexics have twice more difficulties than others. However, timing and planning abilities as autonomy and speaking denote the same results for both groups of pupils.

Timing and planning results can be surprising. Indeed, dyslexics are not able to do the grapheme-phoneme conversion. Now, this conversion is precisely a question of planning and building chronologies between syllables and words: One of their biggest handicaps. However, the figure 2 shows that they do not have much more difficulties in planning than non-dyslexic pupils. Chronology and planning this task don't depend on the literacy. It depends on graphics. Graphical representations mobilize their intact abilities and help them develop planning skills they usually do not have.

Task 3 - production

The production of technical systems is very good to the development of skills for dyslexic pupils as shown in the score table below.

Table 8: Number of difficulties in producing a pale for both groups of pupils

Total dys.	Total non dys.
7	20

This table shows a significant ease in the production phase for dyslexics. They have two-thirds less difficulties than the non-dyslexics (7 difficulties for the dyslexic group against 20 for the other). The difficulties distribution among the group is homogeneous in both categories. Contrary to what has been said previously about difficulties in searching information and designing a technical system, no student in the group is more in difficulty than another.

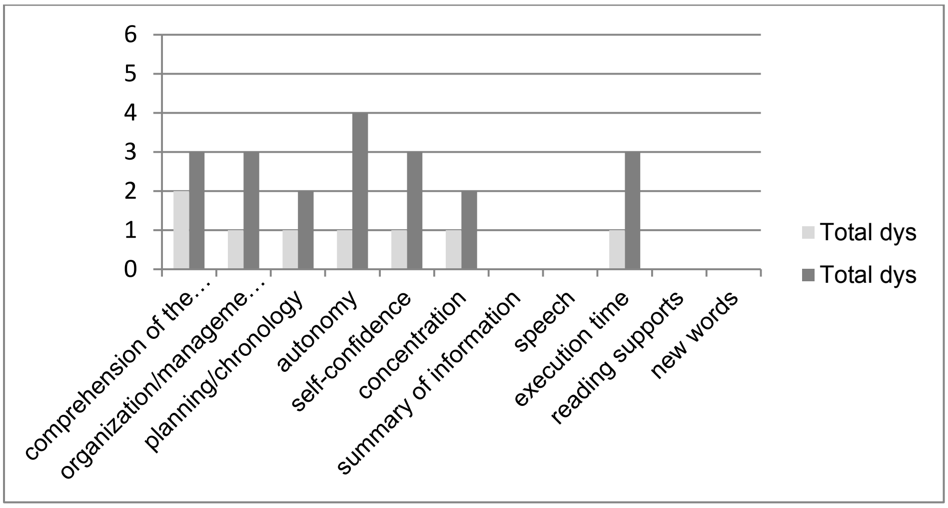


Figure 3: Number of students in difficulty against the competencies in production

The production of artefact appears much easier for dyslexic than for others as shown in the Figure 3. Dyslexic pupils apply seven skills on eleven better than other students. The four remaining are equal. Concerning the self-confidence, the time or the organisation, dyslexic pupils have three times less difficulties than others. Moreover, dyslexic pupils have half less difficulties in focusing or planning than ordinary students. To understand the instruction, dyslexic students have a third less difficulties than others. No difficulty was noticed to summarize, to speak, to read different kind of supports and to use new words whatever is the category of pupils. Indeed, production activities do not solicit synthesis. And also, the fact that pupils need to lead concrete action and to conduct the task (i.e. they are quite busy, they speak little and remain focused on their task) can explain the results.

This type of activity, based on the concrete and controlled action, is particularly favourable for dyslexics who unlike their conventional counterparts are used to self-discipline their work constantly. This incorporated habit in dyslexic person remains underdeveloped in others who operate with fewer rigors on the pretext of acting more easily, and yet this type of activity is a rigorous methodology, continuously monitored. Ordinary students difficulties can also be explained by the manipulative nature of the activity and the perception (right or wrong) they have.

Task 4 – Test of wing system performance

In this task the pupils tested the pales they produced previously and recorded the results in a table. This activity as previously enables to set up a slight advantage for dyslexic in terms of facility.

Table 9: Number of difficulties during experimental activities on a wing system for both groups of pupils

Total dys.	Total non dys.
15	23

The group of dyslexic pupils encounters 15 difficulties while the non-dyslexics group are confronted to 23 difficulties, i.e. ¼ more than dyslexic pupils.

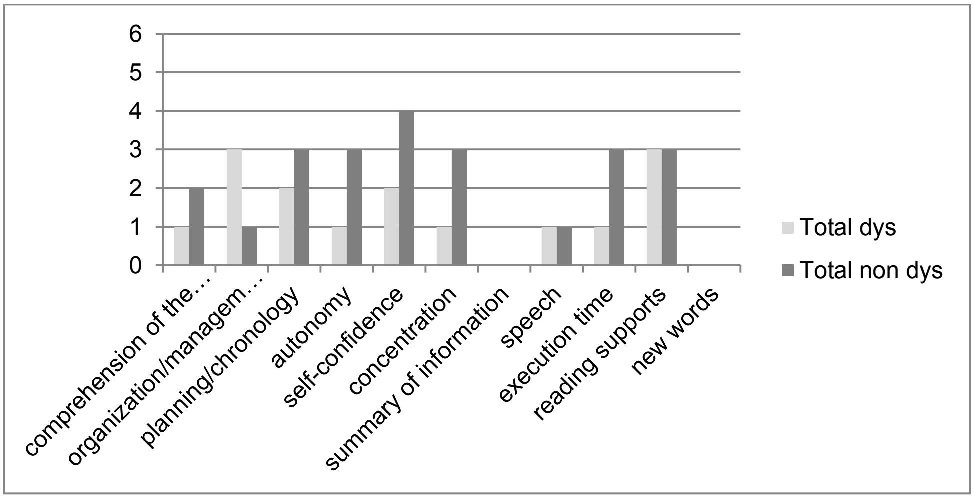


Figure 4: Number of students in difficulty against the experimental competencies

Like the previous task, dyslexic pupils have less trouble than ordinary students to perform this controlling and experimental task. The graph shows that on the eleven observed skills, dyslexic have less difficulties on six of them: understanding the instructions, planning and timing, autonomy, self-confidence, concentration, the execution time. Among students who have difficulties with autonomy, concentration and execution time they are three times less present. Among pupils who have difficulties in understanding the instruction and self-confidence they have half less troubles and they have equal difficulties in reading and speaking. In return, dyslexics have more difficulties to manage and organize the activity. As previously synthesizing and using new words do not cause any difficulties for anyone.

The nature of the task that is part of a rigorous methodology and must be constantly monitored explains in part the results. As previously, the completion of this task allows dyslexics pupils used to self-control to mobilize these skills to achieve this task. This is not the case of current pupils who are most likely to charge into action without precaution.

CONCLUSION

The conclusion of this first study is centred on two points:

Firstly, the tasks requesting the grapheme-phoneme conversion (Internet research, communication) have been less successful for dyslexics than non-dyslexics. This is not surprising given their disorder specificities.

Secondly, in contrast, dyslexic students had less difficulties than non-dyslexic for the 'planning' task, 'production' task, and 'control test' task. That was unexpected. To explain the results of the two first tasks, dyslexic students report capacities in planning and reasoning in the design and production of wing system. These capabilities have been properly mobilized because the grapheme-phoneme conversion does not hamper them. We think dyslexic students have intact planning and reasoning capabilities that were expressed because the proposed task needed their mobilization.

Dyslexic pupils developed competencies to control their actions in order to compensate the difficulties, as proved in their writings or reading. This ability is very important in technology and in experimental situation. It will be very interesting to investigate a task dedicated to control and verification of technical system.

Some tasks of technologic education proposed to these pupils helped them to mobilize and develop reasoning skills, design skills and planning skills that can hardly be expressed in highly literary disciplines. The question of the choice of the task in assessing the skills of dyslexic pupils raise: depending on the task, a same competency can be gained or not. Our intention is to give to all these results the status of hypotheses for a future research on a larger sample to consider a possible generalization.

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Early Year's Activity in Sciences and Technology Education in France: Analysis of the Design of Artifact

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ABSTRACT

In France, for very young pupils (3 to 5 years), starting to learn about technology starts with activities based on the use, observation and creation of technical objects/aids in the context of real life situations in the classroom, games for building things, production workshops and many more besides. The Plan of Restoration of the Teaching of Sciences and Technology in Schools (PREST in French) of 2000 insists on the need for making more effective the teaching of sciences and technology in school and to assign, as much as possible, an experimental dimension. These orientations are still strong and start at pre-school (3 to 5 years old pupils). In fact, teachers are advised to define teaching sequences that consist in posing a problem whose solution leads to the invention and the manufacturing of a technical purpose while knowing that there exist obstacles related to the driving and intellectual capacities of the young children. This is far from the French teacher's practices that privilege the entertaining aspect of the activity that depends on the cognitive and educational aspect. The development suggested to the children is not precisely focused on the result but on the constraints, the choices and the rigor of the technological approach.

The aim of this contribution is to present an analysis of the effective activity of pupils during a sequence of design activities in a class of 23 pupils (aged 4-5) in the last year of pre-school in France. The sequence is devoted to the investigation of an articulated puppet. The analysis conducted here, distinguishes three types of activity: Use activities, observation activities manufacturing activities.

The analysis shows the interest of the pupils for technical activities. Indeed, the effective activity generates, beyond curiosity for the artifact, a specific behavior, making pupils aware of constraints related to the activity of designing an artifact. We also note that the types of activities covered in this sequence (theory and observation) are obtained after repeated interventions of the teacher.

Keywords: activity, sciences & technology, education, learning,

INTRODUCTION

The role of pre-school education in the construction and the development of each person is a real challenge in contemporary societies. It prepares with autonomy, the communication with the others and the control of the environment when they will be adult. Practicing a technological education for the preschool pupils in France starts with activities based on the use, observation and manufacturing of an artefact realised in class according to the institutional instructions (BOEN, 2002). With these activities, pupils are able to question about the artifact with the point of view of man-product ratios. These design activities seem a powerful mean for increasing the pupils' capacities of reflection, argumentation and judgment. Indeed, learning how to have doubts, to organize them and to solve a problem will engage pupils in an effective training approach as showed in various researches of Benson (2009); Chatoney (2003, 2009); Fleer (1992); Rogers and Wallace (2000), Welch, M. & Hee Sook, L. (1997). Other publications, for example those made up around the operation "the hand with the paste" or those of Nuffield Curriculum Centers for the elementary school, have the advantage of specifying the didactic challenge, the teaching invariants or the specificity of an approach suitable for the discipline.

When design activity is mentioned, a human activity is evoked. This human activity is based on an objective that can be attached to a biological need (to feed, to dress…) but also to a goal such as, for example, improving an existing system (Dewey, 1934/2005; Darse, 1994). In order to do a design activity, the subject uses cognitive, psychological, technical instruments (Rabardel, 1995) that will help him to think. The language(s) that makes possible to communicate about an artifact or illustrated representations of the artifact (codes, models, drawings…) are instruments which will allow to organize the thought of the designer (Vygotski, 1985; Mounoud, 1970, Lebahar, 2007). All imply the competence of the designer (Weill-Fassina, 1979). In design activities, the specifications play a significant role. This document makes references to the constraints prescribed by the silent partner. These constraints relate to technical sides and/or functional specifications to the problem to be satisfied. The specifications precede the process of design (Eastman, 1970) and determine the representation of the initial state of the problem by formulating functional or physical specifications (Ullman, Dietterich, & Stauffer, 1988). The constraints given by the specifications are impossible to circumvent and independent from the designer.

Are design activities forced by specifications some occasions to develop the 4-5 years old pupils' capacities to act and think?

This paper aims to present an example of a teaching sequence for which interest with the cognitive plan was attested in the first research (Chatoney, 2009). The sequence of teaching is not centered on the result (finalized artifact) but on the constraints, the choices and the rigor of the technological approach (the process). In addition, it takes part in the development of knowledge about teaching practices in this field as soon as the preschool. We will question the role of the teacher and the efficiency in the choices of implementation.

METHOD

Observation of a sequence addressed by 23 pupils in their last year of pre-school (aged 4-5) and devoted under investigation of a puppet articulated. It is organized in three successive meetings from 15 to 20 minutes, distributed in the week. The unit video is filmed. At the end of the sequence the researcher recovers the traces of the activity produced in classroom (drawing of the pupils, models, joining's, specifications, summary…).

The analysis of the design activity is into two parts: A description of the teacher's strategy. Objectives, spots, organization, means are the principal indicators. The analysis of the traces of the activity produced in class is connected to the choices of implementation of the teacher and thus makes possible to analyze the efficiency of design activity.

Images of the traces of the activity will be presented as the description of the sequence.

DESCRIPTION OF THE SEQUENCE

Objectives of trainings and organization

- It is initially a question of leading the pupils to return in a project determined by constraints. This constitutes in our point of view a central and specific element of the technological teaching whose anthropological value is undeniable. The pupil will acquire here the conscience of his choices.
- It is secondly a question of being interested in knowledge whose anthropological value (mechanisms) is largely attested as well by the place that many curriculum vitae grant as by the interest that many researchers and pedagogues give (Fleer, 1992; Merle, 2000, Nonnon, 2001; Parkinson, 1999; Rogers & Wallace, 2000; Schoultz, 1997).
- It is finally a question of being interested in training likely to generate a capacity of action and an awakening of the constrained process for the realization of an artifact. However, the conditions of realization are arranged and reconsidered so that they are used fully as engines with the discovery in question.

The pupils are divided around 4 tables from 5 to 6 pupils.
A school assistant assists the teacher. They share the work of individualized follow-up. Each one deals with 2 tables (a dozen pupils).

Strategy of implementation and associated traces of the activity

1) A first intention is to put the pupil in a project situation and to make him carry out the specifications of his puppet.

Teacher starts with a history (an adventure with 3 girls and 3 boys). They wear either a skirt or pants and a sweater characterized by a color.
The handling of a puppet representing the main character "Mimi" animates the history. It's small (15 cm in height) and 3 mobile components constitute it: a head (of boy or girl), a chest, legs (skirt or pants).

Table 1: Instruction of the design task by the teacher

Activities	Instructions	0rganisation	Accessories
Engage the pupils in a project.	*Mimi is going to find his friends (last sentence in the album). We are all going to make puppets of them.*	Group and oral work	the model of specifications (Mimi = girl, red sweater, blue skirt).
Choose a character in the story in order to draw and make a puppet.	*Draw the puppet that you want to make. You can make a little boy or a little girl. You can only use the three colors that are on your tables.*	Individual work	White piece of paper by pupil. Pots containing three colors of felt pens.
Define the constraints (clothes, color, gender) in a specification chart	*You are going to fill in a chart, like the one for Mimi that I have put here, to explain what your puppets are going to be like.*	Individual work	Colored drawings Specifications table to fill in Model specifications placed on the desk

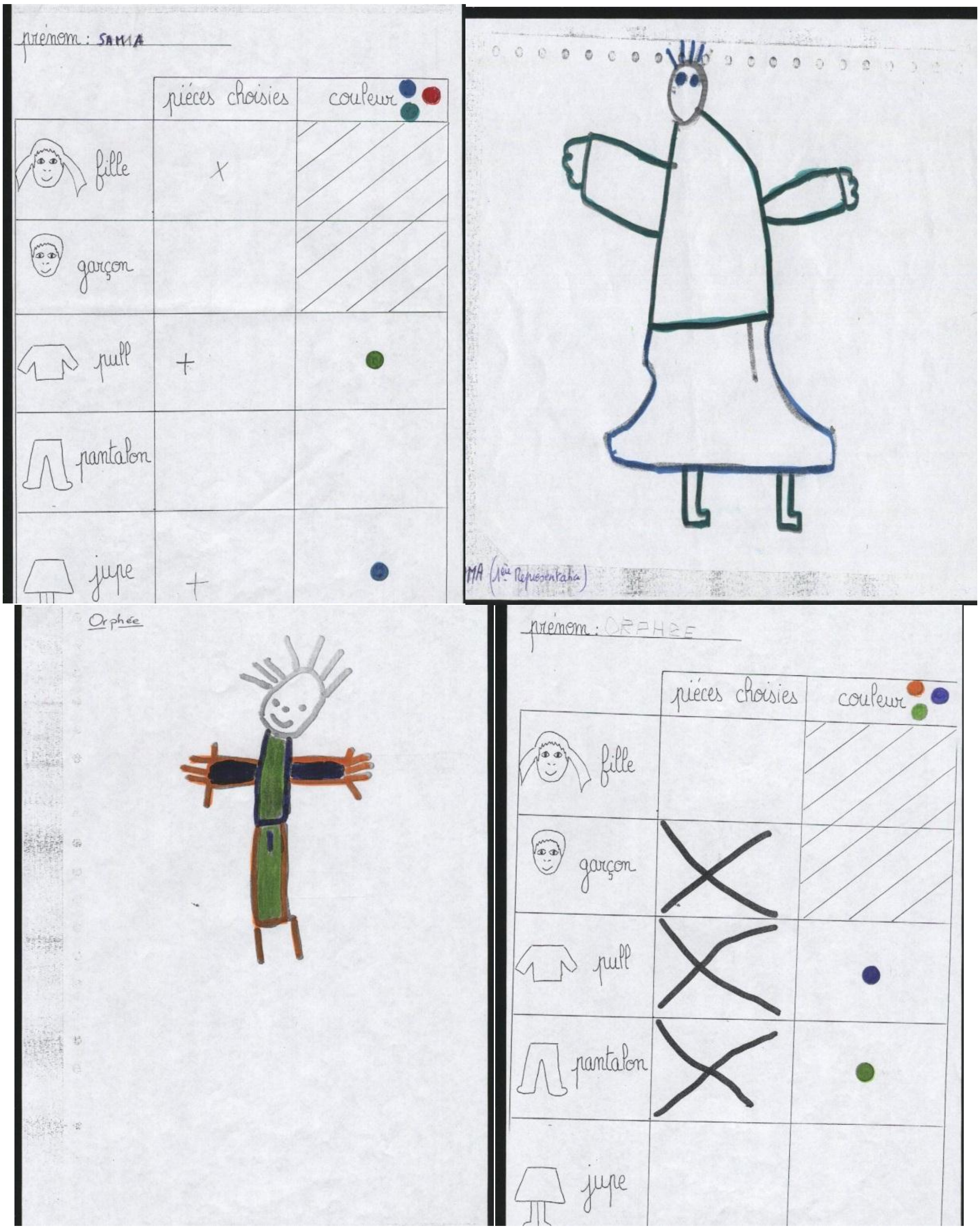

Figure 1: Examples of pupils' drawings and charts

2) One second intention consists in identifying the engineering problems (positioning of the parts and the connection between the parts) and suggesting solutions

In this phase, the pupils will have to distinguish the shapes of the parts making up the puppet, and position them correctly while keeping to the project guidelines. They must then suggest possible ways of putting the puppet together using all available materials, before finally comparing them and choosing the most suitable system.

Table 2: Definition of two types of technical problems to be solved by the pupils

Activities	Instruction	0rganisation	Accessories
Choose the three parts that correspond to the pupil's project, position them all together correctly and give them the correct color detailed in the specification. In other words: « build the puppet from scratch »	*I've put forms/shapes on your tables. You are going to choose those that correspond to your puppet, and then stick them to your piece of paper. Then you have to color them in using the colors you decided upon for your puppet*	Individual work	All the pre-cut shapes made out of white paper (a girl's head, a boy's head, a pullover, a skirt, trousers), a glue stick, felt-pens, a sheet of white paper, their drawing and their « specification » chart.
Find systems allowing pupils to put the parts of the puppet together, and compare them in relation to the anticipated result (head and lower body movement in relation to the chest).	*We want the puppet to move. How are we going to do that? We've got sticky tape, string, nails and brass fasteners ». « Now that you have found a solution, you have to fill in the chart.*	Individual work Travail and then collective by table.	Paper shapes, string, nails, sticky tape, brass fasteners, a chart for 6 people to fill in.
Check whether each of the solutions has the two conditions allowing the parts to move (to turn and to stay still) then chooses the most suitable assembly method.	*We're going to see whether it turns and stays in place. The string? The nail? The brass fastener? The sticky tape?*	Class work	the charts completed by pupils, the models put together, a table serving as a summary chart, to be filled in as and when pupils make suggestions.

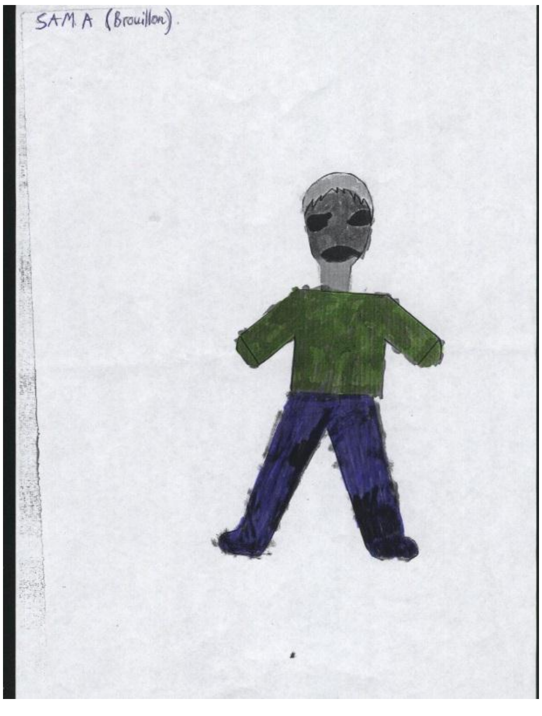

Figure 2: Example of a pupil's sticking together of their puppet

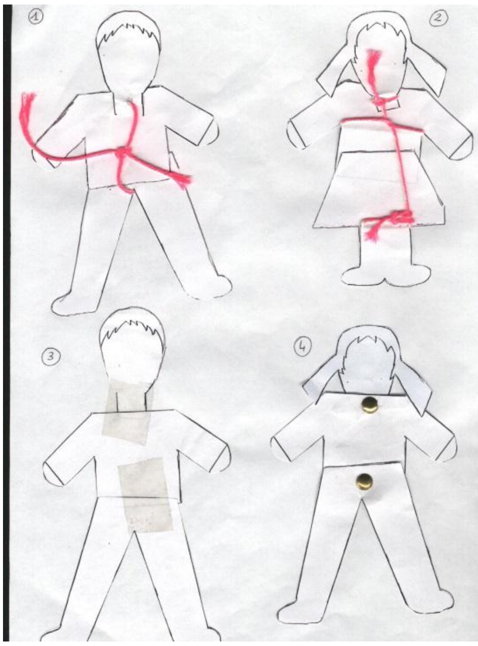

Figure 3: puppet - building solutions suggested by one group of pupils

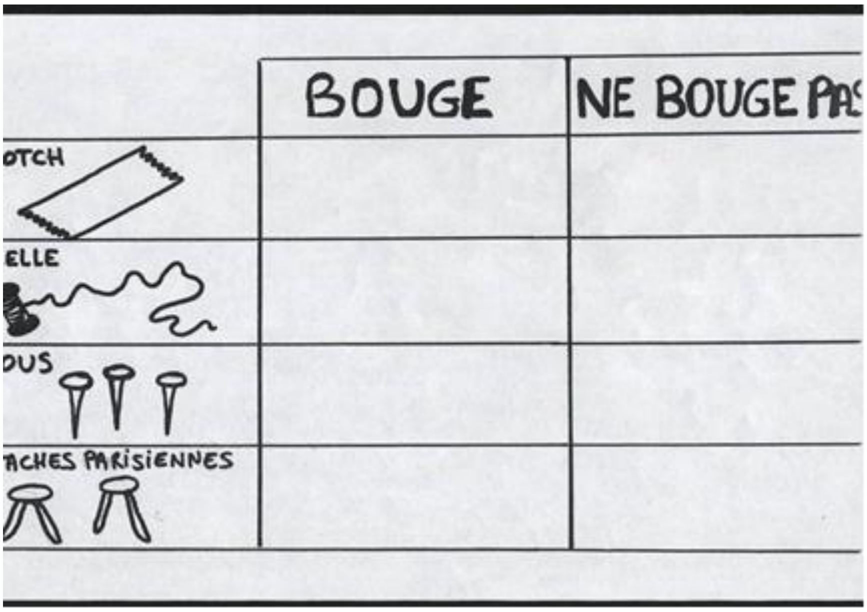

Figure 4: Table: comparing solutions

3) The third intention is devoted to the production of the puppet

This phase has two aims. Firstly, every pupil has to produce their puppet independently and then make sure that it complies with the original plan outlined in the « specification » chart. Each phase lasts for ten minutes.

Table 3: Creation of the puppets

Activities	Instruction	0rganisation	Accessories
Producing your own puppet.	*From the shapes available here, you are going to choose the ones that*	individual work.	All the shapes are available in all colours on a table, along with a box of

	correspond to your plan, then put them together and draw your character's face		brass fasteners and four die cutters.
Check that finished puppet corresponds to the choices made and noted in specification chart	*With the help of the « specification » chart, check that your plan complies with what was outlined at the beginning.*	individual work.	Specification chart, finished puppet.

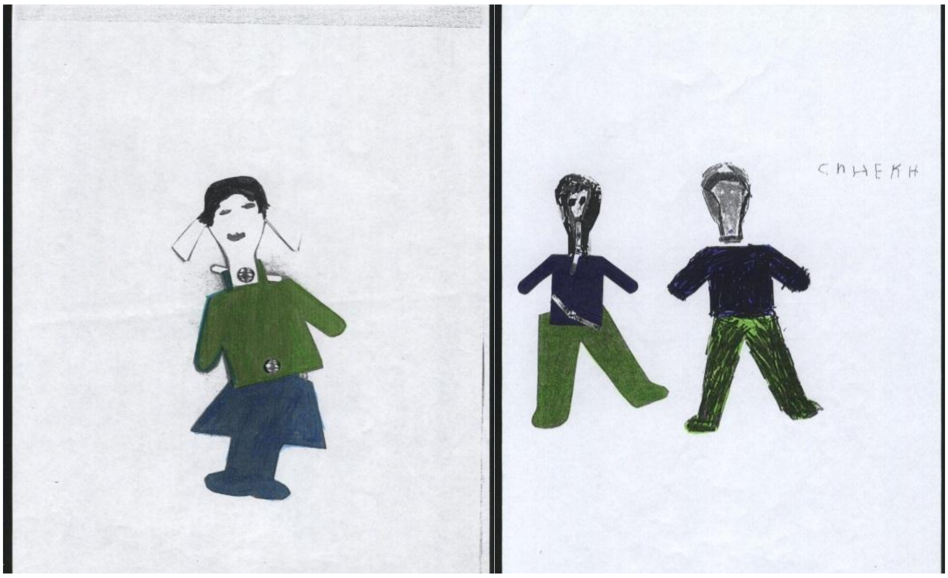

Figure 5: End products highlighting difficulties linked to the notion of back and front, or above and below

ACTIVITY OF DESIGN IN CLASS ANALYZES

The design activity is analysed based upon the teacher's strategy, the kind of tasks given to the pupils, marks from the activity and a summary evaluation of the sequence drawn up by the teacher after the event.

The trigger of the design activity

The first report that we can make is that pupils readily participate in the activity.

However, choosing a character causes pupils a major problem. Not all pupils remembered the colours of the clothes for the characters in the story. Only three memorised the types of clothes described in the story, and set about drawing their character immediately. The other pupils had to memorise the characters again in a group, then choose their character.

The entry into design activity is done starting from sketches carried out by the pupils. The drawings are done conscientiously and with lots of care. All types of human representation are seen together. Thus, we find drawings of stick men, potato men and more 'detailed' men. The vast majority of pupils directly define the colour of clothes by drawing a line, or by colouring in parts representing the limbs. Six pupils trace the character outline with a felt pen and then colour it in. One pupil improves the colouring in of the entire body of their character by re-drawing the pullover outline in the right colour. This task does not present any major difficulties. Hence, all pupils manage to accomplish the task, each in their own way, as shown above in illustration 1.

Problem solving and search of solution in the design activity

In the design activity, the first part is devoted to the problem solving and to the search of solutions to position one element with another.

This meticulous examination of the systems/methods put in place and the paper model enable pupils to make « technical » suggestions, for example: turn the paper model around in order to pass the string around both sides, so that it stays in place, make a hole in a set place in order to put the string or the brass fastener through, twist the ends of the brass fastener or knot the string to make it hold firm, as shown in illustration 4.

The pupils learn that there are two kinds of attachments between parts: fixed and moving joints and that they are named as such. They learn that in both cases, several technical solutions exist and that some of them are more suitable than others. The nail, for instance, has the advantage of having a sharp point to pierce a hole in a paper. However, it allows the parts to move but it does not hold them in place. The brass fastener has an advantage over the nail, for example, because it allows the parts both to move and to stay still.

Production of the artifact

The nursery helper aids the teacher in putting the puppets together. They pierce the holes so that the pupils only have to place it on top and build it, thus solving the neck problem. Knotting the string and piercing with the hole punch do not prove possible for everybody. As happened previously, these new « technical » difficulties are dealt with by the teacher, who will make a hole in the place where she is asked to do so, or tie a knot as instructed to do so. Ten pupils put the parts together perfectly. All the others do not anticipate the fact that the puppet has a back and a front. Hence the attachments appear on the top of the puppet, but they should be behind. So brass fasteners are introduced from bottom (back) to top (front), making the attachments appear at the front. The question of the front and back of the parts brings us back to spatial problems (in terms of rotation on a plan, in space, symmetry, reading, noticing things...) that pupils of that age are yet to acquire.

The addition of facial lines is systematic and marks the end of the production activity. The pupils willingly dwell on this and talk. They show their puppets and play with them.

The conformity test works, with all pupils checking that the right shapes and colours are ticked. Only five pupils made mistakes in the choice of available parts. Two of them take the initiative to change a wrong part for one that works, while the other three wait for instructions from the teacher.

Two difficulties are noted which the teacher did not sufficiently anticipate: the sharing of work in groups of six, and the problem of objects having a front and a back. Both these points can be easily being improved.

Organising work in groups of six is justifiable at nursery school, because the teacher and the helper only have two groups each to look after. This is a justifiable argument. In this case, it would have been better to give the material corresponding to an attachment method to every pupil in each group (rather than having a lot of material) two identical systems explored in the group. That way, all the pupils could have tried things out.

Concerning the spatial problem, it would be useful to look at these differences in order to look at the problem areas, and turn learning towards the matter of aesthetics of placing parts on the top or the bottom. This would allow the puppet to be given a front and a back and for them to be established.

DISCUSSION AND CONCLUSION

From a learning point of view, the pupils succeeded in working on their own personal project. Indeed, for a large majority, their choices did not vary with the activity change (drawing and creating). It can be noticed that only three pupils changed their mind in the middle of the task and considering the frequency of verifications based on the specifications, they realised quickly and modified their drawing or product by themselves.

The specifications chart given is an extremely useful instrument. Pupils are able to remind what they did, to help them taking responsibilities and to give them an opportunity in taking decisions. In these design activities, the specifications refer to the prescribed constraints. The silent partner, in our case the teacher, defines them.

These constraints relate to technical and/or functional sides specific to the problem. Here, the specifications are a sort of educational contract that pupils (like designers) cannot avoid. The constraints linked to these specifications are data of the problem. Thus, according to the constraints, the pupils can plan what the final state might look like (the puppet). So that, the pupil is responsible for the design process. Obviously, at their level, the teacher constantly assists pupils but they keep a large part of autonomy in design process to solve the problem posed.

Consequently, the most important thing to take from this study is the cognitive importance of the tasks set for pupils and of the teachers' teaching strategies. The cognitive activity from beginning to end is conducted with the introduction of new experimental sets. Planning seems to be a form of functional organization of their own cognitive activity.

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Who Makes Better Use of Technology for Learning in D&T? Schools or University?

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ABSTRACT
University teacher training departments have many functions in their role as Schools for Initial Teacher Education (ITE), these include accrediting qualified teacher status, teaching subject knowledge and pedagogy, and influencing change in a school subject's content and pedagogy. This paper discusses this latter area.

It can be easy for teacher training in universities to become ivory towers, modelling new ideas for curriculum delivery and content in a 'bubble' away from the real world of the school classroom. A centre of design and technology (D&T) education at an English university has undertaken research-led developments in the use of web 2.0 technologies and technology enhanced learning (TEL), modelling how they can be used in the classroom. The research examined in this paper is the next stage of the centre's curriculum development to ensure the relevance of the university curriculum content and practices.

Anecdotal evidence suggests that the use of TEL in secondary schools is inconsistent and sporadic with D&T teachers using TEL, with minimal awareness of research available, which could inform their practice. This impacts on the centre's trainee teachers as they begin teaching in schools during their final year of the course, with a possible unrealistic expectation of how TEL is used in schools, based on their university experiences.

To discover if their university experience is useful for both undergraduates and graduates of the course when they are teaching in schools, the research questions in this small comparative research project are:

1. How is TEL used by the university within the D&T subject knowledge modules of the course?
2. How is TEL used in D&T lessons in some local secondary schools?

The analysis of this data will be a comparison of the use of TEL across these two fields. The aim of the subsequent discussion and conclusion is to ensure that the subject knowledge taught and modelled in university about TEL in D&T is relevant and forward thinking, preparing trainee teachers for their future employment.

Keywords: collaboration, congruent teaching, teacher education, technology education, technology enhanced learning, web 2.0 technology.

INTRODUCTION

A centre of design and technology (D&T) education at an English university has undertaken research-led developments in the use of web 2.0 technologies and technology enhanced learning (TEL), modeling how they can be used in the classroom.

The research examined in this paper is the next stage of the centre's curriculum development to ensure relevance of the university curriculum content and practices. To ensure their university experience is useful for both undergraduates and graduates of the course when they are teaching, the research questions in this small comparative research project are how is TEL:

1. used by the university within the D&T subject knowledge modules of the course?
2. used in D&T lessons in some local secondary schools?

The analysis of data will be a comparison of the use of TEL across university and three Nottinghamshire schools. The aim of the subsequent discussion and conclusion is to ensure that subject knowledge taught and modelled in university about TEL in D&T is relevant and forward thinking, preparing trainee teachers for future employment.

DEFINING TEL: A D&T TOOL OR A D&T TEACHING STRATEGY?

The phrase 'Web 2.0' is regularly used to define web-based technologies, which include blogging, social media platforms, photo and video sharing websites. These examples, amongst others, display content publicly for sharing and collaboration beyond the confines of a single classroom. In education, web 2.0 can 'open channel(s) for exploring the value of social and collaborative production, including peer learning' (Fitzgerald et al., 2009, p.29). Related terms include 'blended learning' and 'TEL', this latter term is appropriate for this paper as if focuses on teaching and learning activity and less on the technology as a D&T tool. This paper compares the use of how technologies (primarily web 2.0) are used to support teaching and learning on a D&T ITE course and D&T lessons in schools.

TEL: THE POTENTIAL FOR LEARNING

The TEL research programme spent over four years developing systems and software for use in schools. An outcome of the project was identification of twelve TEL themes (Noss, 2012), which have implications for the use of technology in all school lessons. In this paper we focus only on three themes, selected for their relevance to our topic of web-based technology: 'connect', 'share' and 'know'. Selecting these for relevance to our topic. They have been chosen based on our use of TEL and the literature review conducted for this paper in the context of secondary schools and D&T. We will explain these three themes in the context of our research question only and illustrate themes in D&T lessons with examples from literature.

'Connect' is the first theme, and web 2.0 creates opportunity to connect informal and formal learning through the use of social media, blogs and wikis for example. Mobile technologies such as tablets and phones can also be a crucial component of connecting and supporting asynchronous and peer learning (Garrison & Vaughan, 2008; Poore, 2012). According to Poore (2012) social networking tools (e.g. Twitter, Facebook) and the use of video/ instant messaging (e.g. Skype, Facetime) support real-time communication with people outside the classroom, such as between students and teachers.

'Sharing' is the second theme, it has clear links to connect however 'connect' focuses on the relationship between communication and location of learning, whereas 'sharing' focuses on collaboration. Social media and wikis are web 2.0 technologies that can support collaborative learning (Davies & Hardy, 2011; Hardy and Davies 2013; O'Leary, 2008). Research by the authors (2011) exemplifies how collaborative learning can take place through the use of wikis during design and technology activity. A group design project used a wiki to record decisions made using individual research, which was then posted on the wiki for the whole group see and subsequently use.

‘Know’ is the final theme, where information available online is made meaningful either by the teacher, the individual or peers and becomes meaningful knowledge through the way it is presented and understood (Noss, 2012). Salmon (2000) describes this process as a development where the knowledge is made personal through the engagement with others through the use of technology. The authors previously reported on the use of eportfolios as a way individuals use images of their own work, to make meaning of their own knowledge development in the use of D&T materials and processes (Hardy, Tinney and Davies, 2012).

RELATIONSHIP BETWEEN ITE, SUBJECT CONTENT AND PEDAGOGY

University teacher training departments have many functions in their role as providers of Initial Teacher Education (ITE), we suggest these include accrediting qualified teacher status, teaching subject knowledge and pedagogy and influencing change in school subject’s content and pedagogy.

In England the eight prescribed teaching standards (Department for Education, 2012) are central to ITE course’s content in their role as accrediting centres (Ofsted, 2012). Two of these standards require teachers to ‘demonstrate good subject and curriculum knowledge’ and ‘plan and teach well-structured lessons’ (p.6-7). This should influence the teaching of subject content and pedagogy during taught components of an ITE course. Consequently, Williams’ argument takes on more significance that what trainee teachers learn is as important as how they learn (2009). However, care must be taken not to focus on content over pedagogy. Swennen, Lunenberd and Korthagen propose solving this through congruent teaching; that is (1) modelling, (2) explaining the choices made while teaching (meta-commentary) and (3) linking those choices to relevant theory (2008, p.531).

D&T teacher training departments, and therefore D&T teacher educators, have a role influencing the modernization of D&T’s subject content. Examples include projects led by or involving Dr David Barlex (Nuffield D&T project), Jenny Dein (Technology Enhancement Programme Millennium Projects) and Bill Nicholl (Creative Problem Solving and Inclusive Design). There is a key role to play in modernizing D&T pedagogy by teacher educators, key texts such as Spendlove (2008), Owen-Jackson (2002) and Barlex (2007) evidence this by their inclusion on D&T ITE course reading lists in England.

MODERNIZING THE D&T CURRICULUM WITH NEW TECHNOLOGIES

Ofsted’s (2011; 2013) definition of modernising D&T subject content includes employing new technologies, such as new materials and processes. However, we argue for a wider definition of new technology which includes web 2.0. We (Hardy and Davies, 2013) suggest that learning to use web 2.0 technologies develops pupils’ creative design skills, and is a component of modernising D&T subject content. Looking at the use of technology from pupils’ perspective we know it is a ubiquitous part of their lives; they are digital natives (Prensky, 2001) using technology instinctively and intuitively so why not include it in the D&T curriculum. It is a fine line between technology as a tool for teaching (i.e. pedagogy) and technology as a strategy for designing and making (i.e. subject knowledge).

The ITE functions detailed above should produce effective teachers who will shape future D&T. Consequently, D&T ITE needs to ensure that pedagogy and content enables this.

METHOD

There were two participating groups who provided data for analysis about TEL in D&T lessons/lectures:

Group 1: university lecturers from the D&T teacher training course.

Group 2: D&T teachers in local schools.

Both groups were involved directly and indirectly in shaping ITE and the school curriculum through school/university partnership meetings. The sampling is purposive as research was conducted to inform curriculum development at this one university. Three of the university participants are also authors of this paper and are mindful this involvement could affect data and interpretation. As a significant percentage of the university's D&T ITE graduates are employed locally (44% of 2013 graduates); university lecturers were mindful to develop the ITE curriculum based on local expectations. Although schools within an 80 mile radius provide teaching placements for the university, for ease of access those within a 10 mile radius were selected for interview.

The investigation used three data collection methods: online surveys, face to face interviews and follow up emails. Two online surveys were set up with similar questions for each group but contextualised to either a school or university setting. The surveys had two parts. The first part focussed on the 'big four' four (Poore, 2012): (1) social networking, (2) blogs, (3) wikis and (4) podcasting, audio and videos. These were identified from literature and our own practice as being the most commonly used web 2.0 technologies, for engaging and enhancing learning. The second part asked about the use of other technologies which may not have seemed so obvious for enhancing learning in new ways. The headings in the questionnaire's came from current literature and those same headings were used in the structured interviews which took place at both the university and the local secondary schools.

The teacher survey had 20 respondents and the university survey four (a maximum of five was possible). From these surveys, initial data analysis was carried out and participants who had indicated willingness to be interviewed from both surveys were contacted for a follow up interview. Three lecturers and five teachers were interviewed face-to-face. Structured interviews allowed for exploratory questions and discussions about the participants' examples of TEL in teaching and learning (Powney & Watts, 1987). Appropriate questions were developed for the different groups, based on the survey analysis.

After analysing the interviews participants were emailed and asked for further examples of how they used specific web 2.0 tools such as podcasting, Dropbox.com, tablets and mobile phones. This was because the examples given in the interviews did not focus on enhancing learning.

FINDINGS

Part One: The Big Four

Social Networking: Eleven of the surveyed teachers used social networking in their teaching and learning however only one teacher gave a specific example of using this tool when interviewed. All of the interviewed lecturers said they used social networking in their teaching and learning. Both the teacher and one lecturer use Twitter to post web links to information relevant to the students' in class work. The same lecturer also has Twitter conversations with students about taught sessions and gave a specific example of using Twitter during a session when tweets were sent during a student lead seminar to a designer who was being discussed in the seminar.

Table 1: Summary of use of 'big four' technologies to enhance learning in D&T lessons/lectures

	Teachers		Lecturers	
	Survey data (n=20)	Interview data (n=5)	Survey data (n=4)	Interview data (n=3)
Social networking	55.5% (11)	20% (1)	100% (4)	100% (3)
Blogs	30% (6)	20% (1)	100% (4)	66.6% (2)
Wiki	30% (6)	0% (0)	100% (4)	100% (3)
Podcasting, audio videos	65% (13)	80% (4)	75% (3)	33.3% (1)

Blogs: There was no evidence of teachers or lecturers using blogs during lessons/lectures to enhance learning from either the survey or interview. One person from each group gave an example of how blogs were used outside of lessons both formally and informally. The teacher uses a blog to provide an update on topics and give feedback. The lecturers' have a department blog and one lecturer had asked some students to write posts about their learning in session; this recognised as a promotional and awareness raising exercise not for direct enhancement of learning.

Wikis: In the survey 30% (n=6) teachers indicated they used wikis in lessons; we did expect at least one interviewed teacher to give an example but none did even when a follow-up email was sent asking for any further examples. All of the lecturers interviewed and surveyed said they used wikis in lessons to enhance learning and this has been reported at previous conferences.

Podcasting, Audio and Videos: Four teachers interviewed stated they used podcasting, audio and videos in their teaching and learning. One teacher gave an example of where they have created their own videos to be used as food demonstrations to pupils.
Whilst three of the four lecturers surveyed said they used podcasts, audio or videos in their teaching and learning, when interviewed only one gave a specific example: 'I made a YouTube video about setting up a machine for the students to refer to'.

Part Two: Other Technologies

Online Video Sharing: This was comparatively high with both teachers and lecturers. Three teachers spoke about using 'YouTube' clips and 'BBC iPlayer' in their teaching as an information source, these resources are not created by the teacher but selected for suitability:

'Philipe Starck had a TV programme called 'Design for Life'. Pupils were given access to this via iPlayer and had to make notes answering specific questions. Philipe Starck was the designer that pupils had to research for their exam so this was an introduction to him. Pupils in groups watched different sections and then shared their information with other groups.'

Table 1: Summary of use of other technologies to enhance learning in D&T lessons/lectures

	Teachers		**Lecturers**	
	Survey data (n=variable*)	**Interview data (n=5)**	**Survey data (n=4)**	**Interview data (n=3)**
Online video sharing	94% (15/16)	60% (3)	100% (4)	66.6% (2)
Video Messaging	27% (4/15)	0% (0)	75% (3)	33.3% (1)
Cloud storage	94% (15/16)	60% (3)	75% (4)	100% (3)
Image sharing	43% (6/14)	0% (0)	50% (2)	66.6% (2)
ePortfolio tools	86% (12/14)	0% (0)	50% (2)	100% (3)
Note taking	33% (5/15)	0% (0)	100% (4)	100% (3)
Apps on mobile devices	63% (10/16)	20% (1)	50% (2)	66.6% (2)
Mobile devices	60% (9/15)	20% (1)	75% (3)	33.3% (1)
Email	100% (17/17)	100% (5)	100% (4)	66.6% (2)
Interactive voting poll	73% (11/15)	20% (1)	50% (2)	0% (0)

- Not all respondents answered each question

Cloud Storage: Used by both the teachers and the lecturers but with different web tools given as examples. Lecturers referred to Dropbox.com when giving examples whereas teachers talked about the VLE as cloud storage. Two teachers spoke about using Dropbox.com to share resources with colleagues.

Email: Teachers interviewed said they used email in their teaching and learning, but only one gave a specific example related to pupils and this was with older students as a means of communication to discuss coursework. Lecturer results indicated use of email as a part of their teaching and learning to follow up after tutorials and to keep students aware of any changes to sessions.

Eportfolio: There is a large contrast between the use of eportfolio tools used in teaching and learning. It is a part of a university policy that these tools are used in formative and summative assessment. All of the lecturers interviewed stated that they used these tools in their teaching and learning, whereas none of the teachers used this tool. One teacher stated that exam boards do not accept this format for coursework and there is no need to use this tool.

DISCUSSION

From the data collected, the university appears to make more use of web 2.0's capability to support sharing and collaborative learning. The lecturers said TEL supported peer-to-peer learning, sharing knowledge and information, and collaborative work. In the interviews with teachers, it was clear that they enjoyed using technology formally and informally and saw the benefits including:
'Increased pupil engagement and access to materials'
'It's created a situation where pupils can access information outside of the classroom'
'Pupils engage so much more as its real for their lifestyle'

The lecturers used more tools than the teachers, which may be explained by the obstacles teachers mentioned in the interviews: training, set up time, appropriateness of tools for school use, and awareness of the tools available. School policies were also seen as an obstacle, such as restrictions of mobile phone use, discouraging pupils and teachers bringing their own devices into school. Unsurprisingly lack of confidence was another hurdle to using technology. However, one teacher did say that as a result of the interview they would experiment further with technology in their lesson, in particular Twitter.

Both groups did use TEL for asynchronous learning, for example the use of a VLE, blogs and Twitter. Teachers commented that using social networking in school raised fears about internet safety. The university lecturers use these tools more frequently but do not have the same responsibilities with respect to cyber bullying and child protection due to their students' age.
It is interesting to note the discrepancy between the survey and interview data from the school teachers, the survey scores tend to be higher than the interview scores. This may be due to them over-compensating on the survey, completing the survey quickly or time in the interviews to clarify the teacher's understanding of the technical terms. In addition, we wonder if they may have misunderstood the focus on the use of these tools to enhance learning.

Referring back to the three themes of 'share', 'connect' and 'know', both groups used technology for all three. The data does not allow us to make a fair comparison of the effectiveness of the school use in supporting developing pupil knowledge with the university.

As mentioned by Loveland (2012) and Poore (2012) constructivism, specifically social constructivism, is learning through collaborative and interactive process. We believe the technologies discussed in this paper support this due to their ability to facilitate collaborative learning in D&T. Although this research has highlighted some of the differences and obstacles for schools, the arguments for using TEL outweigh these, which in turn have led us to the following recommendations to influence our own practice as educators:

- Develop the meta-commentary about scaffolding the use of TEL within design practice
- Explain the benefit of using web 2.0 technologies such as wikis to developing pupils' D&T capability
- Be explicit about the use of technology to enhance learning but also as tools for professional development and planning
- Work with our students to be aware of the wider implications of using social media with school aged children.

CONCLUSION

This is a local research project working with the partnerships between this one university and local schools in the training of D&T teachers, and does not claim that generalisations could be extrapolated from either the data or its analysis. However, we hope by sharing our findings it may support other colleagues in how they engage with developing pedagogical uses of technology in D&T teacher training. It would be interesting to discover if the ways in which this university uses TEL within D&T ITE is unique to them, or if there are similarities with other D&T courses. This would give an opportunity for universities to work collaborative to develop TEL in D&T pedagogy.

FINAL NOTES

The research for this paper was led by a student on the ITE course funded through the university's undergraduate research programme. The authors worked collaboratively to plan, analyse and write using a wiki.

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Sustainability and Technology in New Zealand: Exploring Students' Environmental Awareness as a Result of Curriculum Shifts

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ABSTRACT

In this paper we discuss how the components of technology education in New Zealand have been theorised as having the potential to enhance student understanding of sustainability and in turn, underpin student technological literacy. As part of a wider research project focused on the development of student technological literacy we explored the student data for evidence of environmental awareness. These findings suggest that when technology programmes provide opportunity to develop awareness and knowledge about environmental aspects, as well as opportunity to apply these in their own technological decision making, the curriculum potential appeared to be realised in classroom settings. That is, over the two year technology learning programme, sustainability became an increasingly observable and informed feature of student technological literacy. We posit this supports the role of technology in ensuring students move from tokenistic references to sustainability, towards a more robust and meaningful understanding of the construct and its implications across a range of contexts.

Keywords: Environmental awareness, sustainability, technological literacy.

SUSTAINABILITY IN THE NEW ZEALAND CURRICULUM

Technology as a learning area in New Zealand is currently aligned to the New Zealand Curriculum (NZC) (Ministry of Education, 2007). The NZC (Ministry of Education, 2007) has been positioned within a contemporary curriculum theory perspective whereby it can be thought of as a 'code of practice' from which teachers work as professionals, rather than a prescription to adhere to in a more technicist manner. To work as professionals, teachers are expected to have sound general educational understanding and, particularly in the case of primary teachers, an increasingly deeper understanding of all the learning areas and the similarities and differences between them. It is also expected that an essential component of school and classroom curriculum design would be the incorporation of the needs and interests of individual students, and an understanding of both school and the wider community's, social, cultural and political perspectives.

Sustainability is positioned in the 'Principles' and 'Values' sections of the NZC (Ministry of Education, 2007, pg 9 and 10). The 'Principles' section outlines the "foundations of curriculum decision making" and relates to "how the curriculum is formalised in a school" (Ministry of Education, pg 9). Sustainability is listed as a significant future-focus issue in this section, and this is explained as "exploring the long-term impact of social, cultural, scientific, technological, economic, or political practices on society and the environment" (Ministry of Education, 2007, pg 39). In the 'Values' section, values are described as "deeply held beliefs about what is important or desirable. They are expressed in the ways that people think and act." (Ministry of Education, 2007, pg 10). Within this section it is stated that all schools should encourage students to value "ecological sustainability, which includes care for the environment" (Ministry of Education, 2007, pg 10). Teachers are encouraged to develop learning experiences that provide students with opportunities to both learn about values and develop value-related capabilities. As both these sections are part of the overarching structure for all school and classroom curriculum development, each of the eight learning areas, including technology, has a responsibility to ensure the principles and values form a coherent part of the general education experience of all students. The NZC (Ministry of Education, 2007) therefore, clearly provides a curriculum imperative for sustainability to be a part of all students' general education.

SUSTAINABILITY THROUGH TECHNOLOGY

The technology learning area within the NZC (Ministry of Education, 2007) has the aim of ensuring all students are provided with opportunity to develop a broad, deep and critical technological literacy (Compton & France, 2007). This concept of technological literacy is in keeping with that discussed as the common international 'goal' of technology education where there is a focus on developing technological literacy that supports an informed and critical citizenship for the future (Dakers, 2006) where notions of sustainability are central (Elshof, 2011). Elshof suggests that 'technology education will be relevant to the degree it catalyses' the energy and inspires the creativity of young people to invent what amounts to a 'new' sustainable world' (Elshof, 2011, pg 150). He sees a clear need for technology to 'step up' if it is to play this role successfully. This requires the development of technology programmes that make explicit decisions regarding the means of development, what outcomes should be developed, as well as decisions around consumption and disposal (see Dakers 2006 and de Vries 2011 for various author discussions relevant to these dimensions).

The NZC (Ministry of Education, 2007) presents three strands and eight components as key to technology programmes. (For a full description of each component, see Compton, 2010). Each of the components have eight progressive levels (level 1-8) which are used to guide teachers and students in their learning across year 1 to year 13 (approximately age 5 through to 17). Each component develops understanding of, or draws upon, sustainability in an explicit attempt to add meaning and depth to the construct and therefore ensure it has more than a tokenistic presence in technology learning programmes. Emphasis on sustainability shifts across different levels as described below.

The Nature of Technology strand provides opportunity to *raise awareness* of sustainability, as both a driver and an impact of technology, and discuss issues associated with it at a philosophical level. For example, learning opportunities related to Characteristics of Technology (CoT) should progress student understanding of the past, current and future role of sustainability in technological decision making. At early levels this is focused primarily around environmental awareness. That is, at level 2 there is a clear and explicit expectation that students should understand the relationship between the made, natural and social world, be aware of positive and negative impacts of technology on the environment, and identify environmental issues that may have influenced practices and/or outcomes. At level 3 they should be able to describe *how* technology has impacted on the natural world, and *how* environmental issues can influence people's decisions about what to make, how to make it, resource selection and testing. Learning opportunities related to Characteristics of Technological Outcomes (CoTO) should progress student understanding of the fitness for purpose of technological outcomes across people, time and place, and to make informed predictions about future technological directions based on social and personal values associated with sustainability. While some understanding of 'good design' is required at level 3, the more explicit links to sustainability are made at level 5 and above.

The Technological Knowledge strand provides opportunity to *develop knowledge that will inform* understanding of the construct of and requirements for sustainability. For example, learning opportunities related to Technological modelling (TM) should progress student understanding of how the social acceptability of design ideas and prototypes can be determined. Links between sustainability as a factor in practical reasoning based decisions are a clear requirement at level 4, with level 6, 7 and 8 being very focused on risk identification and mitigation including those associated with environmental, social, political, and economic impact. Learning opportunities related to Technological Products (TP) should progress student understanding of material properties and how and why they are selected in the development of technological outcomes. As early as level 2 students are required to develop knowledge of why different materials have been selected and at level 3 they are asked to link material properties to the social acceptability of technological products. Environmental impact of materials, e.g. renewable source, ability to be re-used or recycled, are clear examples of factors to be taken into consideration with regards to social acceptability. At level 7 and 8 students are explicitly required to apply material knowledge to issues of maintenance and disposal. Learning opportunities related to Technological Systems (TS) should progress student understanding of how components work together in increasingly sophisticated systems. As with TP, at level 2 students are required to develop knowledge of why different system components have been selected and at level 3 they are asked to link system understanding to the social acceptability of technological systems.

The Technological Practice strand provides authentic opportunity for students to *apply their understanding* of sustainability. For example, learning opportunities related to Brief Development (BD) should progress students' practice in determining how sustainability is understood and valued by themselves and others and how this will influence the outcome to be developed and its specifications. Learning opportunities related to Planning for Practice (PfP) should progress students' practice of resource management in ways that consider caring for the environment as they develop capability to manage resources efficiently and make ethical decisions around sustainable development. Learning opportunities related to Outcome Development and Evaluation (ODE) should progress students' practice in developing a range of creative and innovative ideas to be taken to various stages of development appropriate to the context. Such a focus allows students to arrive at a 'no go' decision when there is no defensible reason to use resources for a particular purpose. Decisions underpinning the selection of particular outcomes for further development, rely on extensive reflective and critical analysis of what is of value and why. The exploration of materials in terms of functional and aesthetic value against environmental cost should be undertaken as extensively as possible in order to interrogate designs and resourcing prior to the selection of materials and the development of any final outcome. All three components of Technological Practice provide opportunity for the application of sustainability-related understanding from level 1 through to 8. The more developed students' awareness of sustainability is (through the Nature of Technology components), and the more informed the students' concept of sustainability is (through the Technological Knowledge components), the more central sustainability should be to students' overall technological practice.

Based on these curriculum components, along with the principles and values directive from the NZC (Ministry of Education, 2007), students in technology should be provided opportunity to: develop a multifaceted and informed understanding of the concept of sustainability; make decisions and undertake practice in accordance with this understanding; and ultimately develop a critical awareness of its growing importance to not only the technological world, but human existence itself. That is, from a curriculum perspective, we argue that technology in New Zealand has 'stepped up' and as such has the *potential* to play the role Elshof (2011) believes it should. What is less clear is whether this is translating into classroom programmes that allow the realisation of this potential. Data presented below will be used to shed some light on this.

DATA SOURCE AND CODING

The research project providing the data presented below was the *Technological Literacy: Implications for teaching and learning* (*TL: Imps*) project. This was a New Zealand Ministry of Education funded research project with the aim of exploring how the components of the technology strands support the development of student technological literacy (for further details of the research see Compton, Compton and Patterson, 2011). Data was collected from a total of 1543 students over a two year period. Students were invited to participate in the research if they were involved in the research teachers' technology programme in 2011. The students ranged from year 0 (average age of 5) through to year 13 (average age of 17 year). Baseline data was collected in early 2011 from 1368 students, spread across year group as follows:

Table 1: Students Providing Baseline Data by Year Group

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13
#	5	68	80	124	127	130	126	126	108	138	178	72	47	39
%	0.4	5	5.8	9.1	9.3	9.5	9.2	9.2	7.9	10.1	13	5.3	3.4	2.8

Final data was collected at the end of 2012 from 1057 students. Of the 1057 providing final data, 978 had participated in a two year technology programme. These students were spread across year group as follows:

Table 2: Students Providing Final Data (Two Year Programme) by Year Group

Year	1	2	3	4	5	6	7	8	9	10	11	12	13
#	4	62	73	108	106	114	44	100	48	144	112	37	26
%	0.4	6.3	7.5	11	10.8	11.7	4.5	10.2	4.9	14.7	11.5	3.8	2.7

During the analysis of data, judgments were made on the student's awareness of ethical, environmental, economic and legal aspects as they wrote or discussed answers to questions related to their learning in technology. Codes used in the environmental awareness judgment were as follows:

0 No mention of the environment at all.

1 Mentioned in passing – simplistic/wrong understanding. Reference to environment only made once in all data collected during the phase. For example, 'plastic can hurt the environment so it is bad'.

2 Strong emphasis – simplistic/wrong understanding. Reference to the environment is made at least twice. Examples included such comments as 'all plastic is bad for the environment', 'technology wastes resources', 'this is not fit for purpose because it is not environmentally friendly', and/or 'this doesn't use electricity so it's environmentally friendly'.

3 Informed and relevant to context. Examples included such comments as 'if something is a good design it should be sustainable, which means it should be made of renewable resources and the original design should take into account how it can be disposed of in a safe and environmentally friendly way' or 'my design would be quite environmentally friendly because I have tried to use materials that are from renewable sources (the wood) or have only used plastics which are recyclable. This will make it more popular as people these days like things to be better for the environment'.

Findings related to student environmental awareness from the baseline and the final data are presented below.

FINDINGS

The baseline data showed that of the 1368 students providing data, the majority of students (1243 or 90.9%) made no mention of the environment, and 114 (8.3%) mentioned the environment in passing. Nine students (0.7%) showed a strong but simplistic emphasis, and only two students demonstrated an informed and relevant environmental awareness. After participating in a technology programme based on all eight components of technology clear shifts in environmental awareness were noted. Of the 978 students providing final data, four students provided insufficient data for an environmental awareness judgment to be made. Of the remaining 974 students, the number of students that made no mention of the environment had fallen to 489 or 50.2%, with 177 students (18.2%) mentioning the environment in passing. Forty students (4.1%) showed a strong but simplistic emphasis, and the number of students demonstrating an informed and relevant environmental awareness rose to 268 or 27.5%. This shift is illustrated in Figure 1.

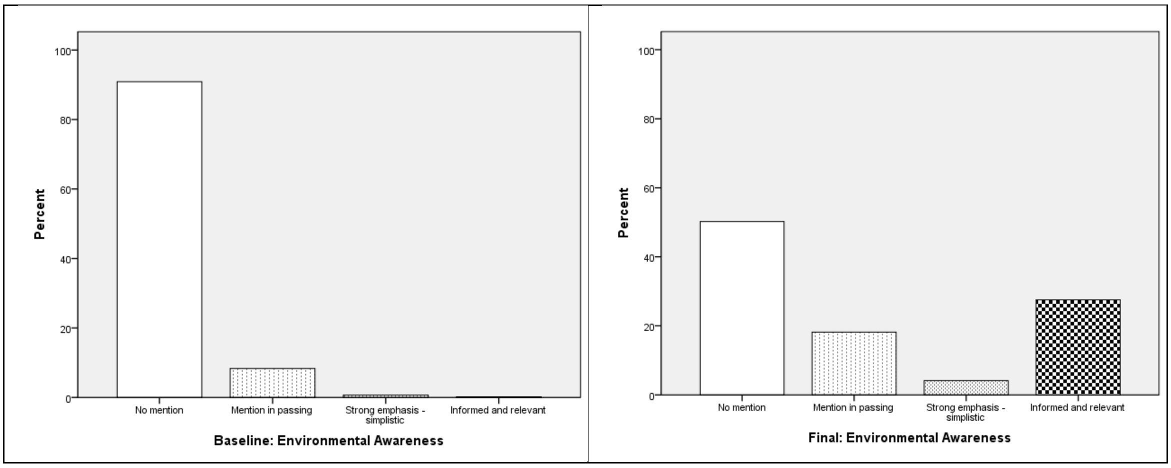

Figure 1: Environmental Awareness in Baseline and Final Data

When explored by year group a shift in environmental awareness occurred in all year groups, with at least two students showing an ‘informed and relevant awareness’ from year 2 upwards. This shift is illustrated in Figure 2.

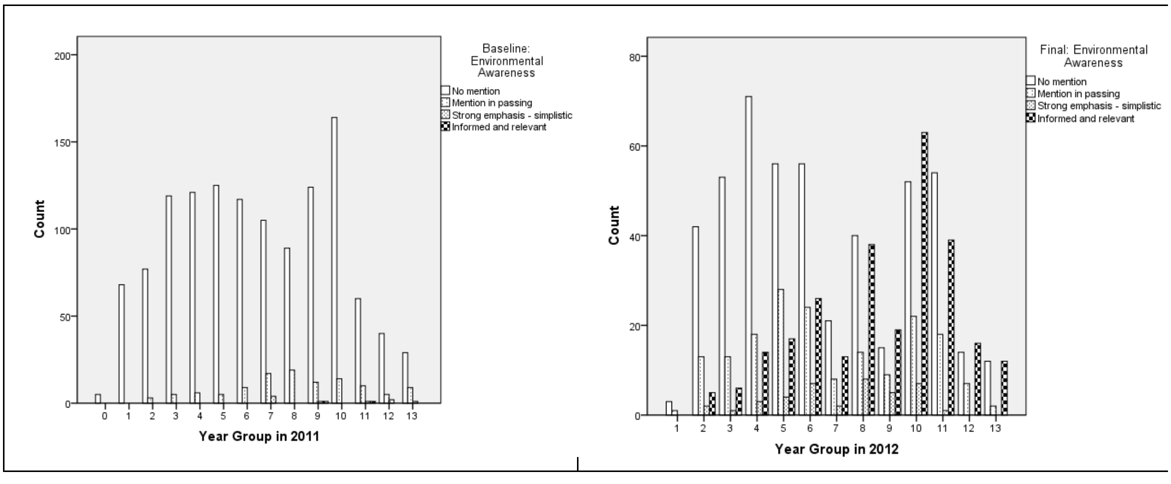

Figure 2: Environmental Awareness in Baseline and Final Data by Year Group

Over the two years, these students also showed an increase in their overall technological literacy as measured against collective achievement across the eight components. That is, in the baseline data, 955 students (69.8%) showed pre-level 1 technological literacy, 389 students (28.4%) showed level 1, 23 (1.7%) showed level 2 and only 1 (0.1%) student showed level 3. In the final data, only 43 students remained at pre-level 1 (4.1%), with 419 students (39.6%) now showing level 1 technological literacy, 445 students (42.1%) showing level 2, 128 students (12.1%) showing level 3, 18 students (1.7%) showing level 4 and four students (0.4%) showing level 5.

When the data related to student level of technological literacy and environmental awareness was explored for any correlation it was interesting to note that the baseline data showed a very weak correlation (spearman's rho = 0.114 sig to 0.01 level). The correlation between environmental awareness and year group was slightly greater, although also very weak (spearman's rho = 0.153 sig to 0.01 level). This suggests environmental awareness was impacted on by factors other than the students' level of technological literacy, such as age/years at school. In the final data however, the correlation between student level of technological literacy and environmental awareness showed a moderate correlation (spearman's rho = 0.447 sig to 0.01 level). This was much higher than the correlation between environmental awareness and age/year group (spearman's rho = 0.256 sig to 0.01 level).

DISCUSSION

The findings presented in this paper suggest that the potential provided by the NZC (Ministry of Education, 2007) and particularly technology as a learning area, appear to be capable of successfully realising an increase in student environmental awareness. Whilst not suggesting environmental awareness is synonymous with understanding sustainability and undertaking one's own sustainable practices, it does provide a good starting point for sustainability understanding and implications within a technological framework as outlined above. We consider that starting with a partial but manageable aspect of sustainability (such as a focus on environmental impact and implications for decision making) may be an important step towards shifting from a 'fashionable' but largely tokenistic element in student thinking and practice (as would underpin a strong emphasis – simplistic judgment above), to one that is more 'informed and relevant'. We were therefore pleased to see a much greater number of students moving to the 'informed and relevant' category, than the 'strong emphasis – simplistic' category after participating in the two year technology programme.

These students had only experienced two years of technology education based on the eight technology components of the NZC (Ministry of Education, 2011). Prior to this, any technology learning experienced by these students would have focused on technological practice alone reflecting the earlier 1995 technology curriculum. The baseline data therefore indicates that opportunity to *apply* sustainability understanding through the student's own technological practice is not enough. Rather, the inclusion of the Nature of Technology and Technological Knowledge strands, in providing clear guidance on developing awareness of and informed knowledge about environmental issues, is critical if sustainability is to become a fundamental feature of student technological literacy.

We propose that this initial exploration provides support for the idea that technology programmes focused on progressing all eight components of the NZC (Ministry of Education, 2007) may well be able to fulfill a role in developing future citizens with a meaningful, critical and robust construct of sustainability. Such programmes may also serve to ensure those students who go on to become future technologists undertake their professional responsibilities in a manner informed by a sophisticated and practically-oriented understanding of sustainability. That is, where sustainability becomes a fundamental feature of their future technological thinking and intervention practices.

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Did the UK Digital Design and Technology (DD&T) Programme Lead to Innovative Curriculum Change within Secondary Schools?

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ABSTRACT

Design and technology (D&T) requires teachers to continually update their knowledge and skills, with regard to new technologies, appropriate to the needs of the time (Design and Technology Association, 2011). In 2011, Ofsted identified the need for "England to keep pace with global technological change" (Ofsted 2011, p.5), in the report 'Meeting technological challenges, a survey of schools from 2007-2010'. Following the report, the UK government funded a national programme called Digital Design and Technology (DD&T). The programme set up a network of regional support centres to provide up-to-date Professional Development (PD) courses on modern D&T subject knowledge.

The purpose of this paper is to analyse the data gathered from teachers that attended the e-textiles training element of the DD&T programme during 2010-2012, in order to elicit information about the impact of the training on developing e-textiles curriculum back at school. This paper contributes to the current debate on modernising the D&T curriculum and will support tutors of D&T PD with guidelines to improve future programme design.

The data was collected in three stages, using a mixed methods approach. Quantitative and qualitative data were collected at each of the three stages using: (1) end of training, teacher evaluation; (2) online, follow up survey; and (3) one-to-one semi-structured phone interviews (Creswell, 2009, Burton and Bartlett, 2005). The data identified that changes occurred in the schools in three ways: (1) through the sharing of new subject knowledge learnt during PD; (2) by developing links with systems and control (S&C) staff in the school; and (3) by (a) adapting curriculum to include e-textiles or (b) developing new e-textiles curriculum.

The e-textiles training within the DD&T programme has made a difference: to teacher's professional practice, based on positive feedback from their pupils; and encouraged teachers to develop elements of integrated curriculum in their school, based on supportive departmental cultures. However, the study also highlighted the difficult nature of curriculum change.

Keywords: e-textiles, curriculum change, professional development, secondary education

INTRODUCTION

Design and Technology (D&T) requires teachers to continually update their knowledge and skills, with regard to new technologies, appropriate to needs of the time (D&T Association, 2011). In 2011, Ofsted identified the need for "England to keep pace with global technological change" (Ofsted 2011, p.5), in the report 'Meeting technological challenges, a survey of schools from 2007-2010'. The report acknowledged Professional Development (PD) as the route to up-to-date subject knowledge and recommended teachers access this where available.

Following the report, UK government funded a national programme called Digital Design and Technology (DD&T). The Department for Education (DfE) made funding available for secondary teachers to develop their professional knowledge via a programme run through the Design and Technology Association. DD&T Support Centres were set up across England to provide up-to-date PD courses on modern D&T knowledge. A popular element of the programme was the teacher training events designed to support knowledge around the integration of electronics and textiles, often referred to as e-textiles courses.

The purpose of this paper is to analyse data gathered from teachers that attended the e-textiles training element of the DD&T programme during 2010-2012, in order to elicit information about the impact of the training on developing e-textiles curriculum back at school. The authors believe, (along with Guskey and Yan, 2009) that there is merit in critically evaluating PD training to ensure that programmes achieve intentional aims.

This paper contributes to the current debate on modernising the D&T curriculum and will support tutors of D&T PD with guidelines to improve programme design.

LITERATURE REVIEW

E-textiles are an exciting area within the engineering field (Buechley, 2006). The definition of e-textiles includes electronic and computational technologies that are imbedded into textiles. E-textiles can be applied in a variety of ways, including clothing, interiors, medicine and car industries. Braddock and O'Mahony (1999, p.6) argue that e-textiles are "narrowing the gap between the world of art, design, engineering and science". This is important for D&T curriculum, as Hughes, Bell and Woofe (2011, p.58) argue for teachers to design activities, which relate to "technological, scientific and mathematical principles" and to "consider the perceptions of pupils" about the "utility of the subject".

E-textiles are an example of 'real-world' technologies and have the potential to contribute to modern curriculum for D&T. The Ofsted report, discussed in the introduction, identified that electronics should be taught in "combination with new materials" and pupils should be taught how to "apply control systems in all aspects of the subject". The new National Curriculum for England and Wales that will be taught from September 2014 also advocates an integrated approach across material areas.

An argument put forward by Buechley (2006) with regard to e-textiles, is that this field of study has the potential to not only 'narrow the gap' between subject disciplines but to appeal to a "different class of user". The authors along with Buechley are excited by the possibilities of this field of study inspiring learners and attracting girls into a generally male dominated field. Statistics shown by Kirkup et al. (2010) cited in Bell, Hughes and Owen-Jackson (2013) identify that only 5% of UK working women have careers in science, engineering or technology (SET). This has economic consequences for the UK and signifies the need for DT teachers to deliver curriculum that at least encourages pupils contributions to developments in technology regardless of their gender (ibid).

To support D&T teachers with curriculum change, regular PD is needed, which allows them to 'feel confident with new processes (and) materials' (Burton and Bartlett (2002, p.240). Teaching new processes and materials can be difficult for teachers as new forms of curriculum might cause problems (ibid).

It is important to recognise that change in the classroom is complex and to recognise that the journey will not be smooth. Teachers need regular feedback from their pupils on the effects of the change and on-going support (Guskey, 2010). 'Good' schools are recognised as effective and they provide time and opportunity for teachers to learn within and outside the workplace (Day 1999, p.20). However, not all schools may be termed as 'Good', and a teacher's capacity to write, talk about and do the things they learn at a PD event (Eraut 1994, p.25), will be influenced by the local culture of their school and department (Helsby (1996), cited in Burton et al. (2002, p243)).

Guskey et al. (2009) argue that research into effective PD is limited, which highlights the need for designers of professional development to evaluate current practice.

METHODS

The data was collected in three stages, using a mixed methods approach. Quantitative and qualitative data were collected at each of the stages using: (1) end of training, teacher evaluation; (2) online, follow up survey; and (3) one-to-one semi-structured phone interviews (Creswell, 2009, Burton and Bartlett, 2005).

The online survey and one-to-one interview questions were piloted, to check for ambiguity and validity (Cohen, Manion and Morrison, 2007). Feedback from the pilot led to changes in the wording of the online questionnaire to ensure clarity and the online tool needed to be adapted, due to technical issues.

Twenty teachers completed the end of training evaluation, collected from one DD&T support centre, after an event in March 2012. Twenty-two teachers completed the online survey from a field of over 140 teachers that attended training during 2011/2012, across England. The one-to-one interview sample was identified during the online survey and based on a teacher's willingness and availability. This sampling method is referred to in the literature as an opportunity sample (Bell, 2010) or a nonprobability sample (Creswell, 2009). The one-to-one interviews were conducted over a one-week period. The sample was 100% female.

The research followed British Educational Research Association (BERA) guidelines for 2012 and met with the authors' University ethical clearance procedures.

The data was collected and analysed using Guskey's (2002) model 'Five Levels of Professional Development Evaluation'. The 5 level's build on one another and success at each level is dependent on the level before. The levels include (1) Participants' Reactions to the PD activity (in this case one day training), which evaluates overall enjoyment of the course and is collected at the end of the event. (2) Participants' Learning from the event, which focuses on checking to see if anything has been learnt during the training. (3) Organisation Support & Change, which shifts the evaluation to the organisation (school) in order to see how PD has been transferred to the teacher's workplace. (4) Participants' Use of New Knowledge and Skills, evaluates how new knowledge has made a difference to the teacher's professional practice and curriculum within school. (5) Student Learning evaluates how the PD training affected pupils learning in the classroom.

FINDINGS

Participants' Reactions

Data from the end of training questionnaire identified that 15/20 teachers enjoyed the training and cited strengths of the course to be: range of activities; hands-on elements; new knowledge; resources and level/style of course teaching. One participant responded negatively citing that the course had not provided new knowledge. Only 16/20 teachers answered the training evaluation question.

Participants' Learning

Data from the end of training questionnaire also identified that: (1) 20/20 of the teachers felt that the training had developed their subject knowledge, built confidence in delivering modern textiles and built confidence in developing activities that integrated skills, to a satisfactory or above level; and (2) that 19/20 of the teachers felt they had gained ideas for curriculum development from the training.

Organization Support & Change

Data from the online survey identified: skill levels; cost of resources; time; and the teacher's job type as potential barriers to curriculum change. 6/21 teachers developed links with systems and control (S&C) staff to address the gap on skill level.

Data from the phone interviews supported survey data by identifying that time was an issue for one teacher who cited that time available for the e-textiles activity was "restricted" by "delivery at lunchtime" (extra-curricular activity) which could "put (pupils) off if they wanted to go outside" at lunchtime. Two of the teachers also cited examples of the role that a teachers job may have in potential for change. One teacher identified that if the teacher had responsibility for a curriculum area within D&T, then they were free to make decisions about resources and curriculum for that area. However, another teacher felt that developing curriculum was "not my role" and felt that she "couldn't change curriculum" although she could "add on" (to existing curriculum). One teacher interviewed also felt that she needed more scientific knowledge and support with how to make links to S&C staff within her school.

The phone interviews also identified data about the culture of the school/department. One teacher commented that she "knew the head of department (HOD) wanted (her) to take it (e-textiles) forward" and another cited the support of senior leadership. A different teacher spoke about how her department felt "no benefit" in the change and another discussed how initially sceptical attitudes of her colleagues changed once they saw successes and then they "got on board' with change.

Participants' Use of New Knowledge and Skills

Data from the phone interviews identified that all three teachers shared their knowledge learnt on the training day during department INSET and one teacher explained that new links were created with the science department. The teachers also integrated e-textiles into their school curriculum. The data identified changes to the curriculum at KS3 (11-14 yr. olds), through: (1) adaptation of existing (Bag) schemes of learning; (2) a lunchtime club (extra-curricular) and (3) a new (Lantern) project. The teachers discussed the use of: (1) bought in battery kits; (2) soft circuits; (3) LED lights; (4) conductive thread; (5) soft switches; (6) sensors and tilt switches and (7) pre-manufactured components (e.g. press-stud, hook and eye). One teacher discussed the integration of hard circuits, which needed "to be soldered".

This echoed the data collected from the online survey showing that 22/22 teachers shared their new subject knowledge with colleagues in the department and 11/22 developed curriculum that integrated electronics and textiles. Again the trend for KS3 teaching was evidenced through 5 citations that discussed KS3 activity. The online survey also revealed that teachers showed the technology to pupils "for choice within projects" at KS3 & KS4 (14-16 yr. olds) and that some teachers led extra-curricular activities with KS3 & KS4. There was no mention of KS5 (16-18 yr. olds) activity.

Student Learning Outcomes

Data collected for this level came from the teachers' perceptions of pupil learning within their classrooms and was collected during the phone interviews. One teacher mentioned how pupils "enjoyed" the scheme and another commented about how pupils learn about e-textiles. Two teachers mentioned how pupils "didn't make connections" with S&C learning from other lessons and one of these teachers felt that in her opinion the pupils "struggle to transfer knowledge from one material area to another" and "they don't tend to draw on their S&C knowledge when in textiles".

All three teachers discussed how an integrated curriculum could change pupils' perceptions about the subject. One teacher cited that pupils "now see S&C as part of textiles" and another commented that "e-textiles had the potential for pupils to see technology as a combination of material areas, with links to other subjects and a gateway to breaking down gender stereotypes within the subject". This was echoed by one teacher's comment about how "boys see textiles as (a) girls subject" and that because the "boys like science", this type of activity (which combines the two areas of the curriculum) could get the boys "hooked" on textiles. The same teacher also went on to comment "girls don't like electronics" and explained that she felt "this is wrong" and "once they are into it, they enjoy it". The teacher felt that e-textiles (along with smart/technical textiles) have the capacity to increase General Certificate of Secondary Education (GCSE) take up of textiles.

The data also identified that one teacher thought the technology was "too modern for pupils" and not linked to the 'real-world' ('Lady Gaga' given as an example – "too gimmicky"). Another teacher cited that she worked hard to create projects that would appeal to boys and girls, with a combined science & fashion theme.

ANALYSIS AND DISCUSSION

Our original research question was: Did the UK Digital Design and Technology (DD&T) programme lead to innovative curriculum change within secondary schools? From the data gathered we could elicit information about the impact of the training on developing e-textiles curriculum in schools. The change occurred in the schools in three ways: (1) through the sharing of new subject knowledge learnt during PD; (2) by developing links with S&C staff in the school; and (3) by (a) adapting curriculum to include e-textiles or (b) developing new e-textiles curriculum.

All of the teachers from the online survey and interview shared their knowledge with other colleagues at school. The e-textiles training allowed the teachers to develop confidence in the new (subject knowledge) learning by providing a platform for contact with new processes and materials as discussed by Burton et al. (2002) earlier.

6/21 teachers, from the online survey and one teacher from the interviews developed links with the S&C staff in their school. This was a disappointing finding, as on-going support (Guskey, 2010) followed up in a teacher's school (Day, 1999) is a key component to curriculum change success. It was interesting to note that one of the teachers interviewed identified a need for further support with how to work with her department (S&C) staff as this implies that D&T departments don't currently support work in an interdisciplinary way.

Actual curriculum change occurred with all three interviewed teachers and with 11/22 of the online survey teachers. The curriculum change occurred through (1) timetabled lessons or (2) lunchtime clubs (in the proposed initial stages). It was positive to see these changes that involved the teaching of electronics in combination with textiles (Ofsted, 2011). Evidencing the adoption of modern curriculum (D&TA, 2011), which reflects the interdisciplinary nature and exciting developments in the current engineering and textiles industry (Braddock and O'Mahony, 1999 & Buechley, 2012).

Barriers to change

From the data we can also see that the teacher intentions for curriculum change (19/20), didn't match the reality (11/22). Something changed once the teachers returned to their school, their capacity to action change became more complex (Guskey, 2010). Teachers felt that either their job, did/or didn't permit them to implement the changes. Based on status, time or support from the school/department. An example of this was the teacher who described her department's initial scepticism, and how she could only teach the new curriculum to her pupils, through a voluntary lunchtime club. This evidences the commitment and tenacity required of individual teachers to ensure change, when the path is not always easy. Burton et al. (2002) point this out to us, when they observe that "sticking with the norm" is safer in an age when teachers are constantly being monitored. This highlights the importance of local school culture in any change (Eraut, 1994 & Burton et al, 2002).

When the school culture was "good" (Day, 1999), it was positive to hear the experiences of teachers about how pupils had reacted to the new curriculum content. Teachers saw positive changes in their learners' attitudes towards the subject and its possibilities for integration with other material areas. They commented on "breaking down gender stereotypes within the subject", supporting the arguments put forward by Buechley (2006). The teachers also talked about pupil enjoyment and new learning with regard to modern textiles.

The classroom experience for the pupils is as important to curriculum change as the department culture. Teachers need feedback from their pupils (Guskey, 2010), to decide if the change will stand or fall. The data evidenced that in one school (lunchtime club), after positive feedback from the pupils, the local culture changed and "initially sceptical" teachers decided to adopt the new curriculum across the department. In another school the new curriculum was dropped after one period of teaching. This was decided due to the teacher's observations, that her pupils, thought the content was "too modern" and "gimmicky". It is interesting to note that the teacher felt unable to explore more 'real-world' applications for the technology as part of on-going PD, within the workplace (Day, 1999).

Teacher's also discussed the difficulties around the transference of electronics knowledge from one material area to another. The data was unclear about whether the teachers were saying this had changed through the integrated curriculum or was still an issue? Future research could focus on the correlation between pupil knowledge transference from electronics into textiles (and vice versa) in the lessons of teachers that developed links with S&C staff within their school.

CONCLUSION

It appears that the e-textiles training within the DD&T programme has started to make a difference to teacher's professional practice and encouraged teachers to develop elements of integrated curriculum in their school. The study has also highlighted the difficult nature of curriculum change.

Work still needs to be done to support teachers with implementing curriculum change once back in their school and to allow teachers to work in an integrated way at a department rather than individual material level. Integrated planning has the potential to support pupils with the desired knowledge transference across material areas. The authors have already referred to the complex nature of change and the importance of the school culture. If a modern curriculum is the desired outcome, then D&T departments need to re-evaluate their attitudes towards integrated approaches to D&T delivery.

The study has evidenced that teachers were encouraged to develop the new curriculum when they saw positive reactions from pupils. The response from the interviewed teachers was overwhelming in regard to pupil enjoyment and changed attitudes around the utility of the subject e.g. the potential to support girls with electronics and boys with textiles. This was a small-scale study, however, the authors feel confident that positives can only come from this type of activity, which allows teachers to design curriculum with the potential to encourage pupils regardless of their gender.

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Modeling in Technology and Engineering Education

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ABSTRACT

In a survey on basic concepts in technology and engineering education, modeling was found to be among the most prominent concepts by a group of experts in philosophy of technology, technology education and engineering education (K-12). Modeling does feature in many technology and engineering education activities, but as a concept is does not get much attention. Not much is known, anyway, about what could be the content of teaching and learning about modeling. This can be one of the areas where recent developments in the philosophy of technology offer relevant ideas for technology and engineering education. In the paper the following issues are addressed:

1. What is the nature of modeling in technology and engineering what types of modeling would be relevant to distinguish in technology and engineering because they would contribute to a better understanding of the nature of technology and engineering;

2. What preconceptions may be held by K-12 pupils/students concerning the nature of models and modeling;

3. What functions of models can be taught and learnt in technology and engineering education and what might be useful strategies for that.

This paper could serve as an agenda for future educational research into the teaching and learning of modeling as an element in technology and engineering education. This could open a whole new area of research that can support the introduction of 'the nature and functions of models' in technology and engineering education.

Keywords: modeling, engineering, philosophy of technology, preconceptions

INTRODUCTION

Technology education has gone through important paradigm shifts in the past three decades. In most countries it emerged from a craft-oriented school subject and moved towards a more concept-based subject. In the past pupils were taught to make artifacts based on drawings that were prepared by teachers or that were taken from textbooks (this can be read in various contributions to Section I in the International Handbook of Research and Development in Technology Education, edited by Jones and De Vries in 2009). Nowadays technology education still has a practical flavor, but pupils also learn theoretical concepts that they use in design activities. This shift has caused technology educators to ask themselves what the key concepts in technology are. In a recent Delphi study among approximately 30 experts in technology and engineering education and philosophy of technology, one of the concepts that was identified as important for teaching technology was modeling (Rossouw, Hacker and De Vries, 2011). This is reflected in books that offer an Introduction to Engineering. "Modeling" is usually one of the chapters in such a book (see, for instance, David et al. 1971 for a classic book and Brockman 2007 as a more recent example, where modeling is even in the title of a book that introduces engineering in general). Given the important role of modeling in engineering and in industrial practice, this was not a surprise. But it was the Delphi study researchers' impression (expressed orally during a review meeting) that this outcome is quite in contrast with much of current technology education practice. This concern was already expressed by Gilbert et al. in 2000 and it is still valid. Although many activities in technology education theoretically can be labeled as 'modeling', this does not necessarily mean that pupils and students learn explicitly about what modeling is and why it is so important in engineering and technology. Pupils may make lots of drawings and scale-models and use all sorts of simulations, but they are not challenged to reflect on the nature and function of those models. This is a very limited approach to learning about modeling. If modeling should be an element in the technology education curriculum, then its nature should be made explicit. This papers discussed some of the difficulties and possibilities for that. It is not a usual research paper that presents an empirical research study. It has more the character of a position paper, in which a need for development is identified and proposals are presented for addressing that need. The paper combines insights from philosophy of technology and engineering and educational research outcomes.

AIM AND RESEARCH QUESTIONS

The aim of this paper is to propose a possible content of *Modeling* as a part of a technology and engineering curriculum, based on outcomes of studies in the philosophy of technology and engineering. The following questions will be addressed:

1. What is the nature of modeling in technology and engineering what types of modeling would be relevant to distinguish in technology and engineering because they would contribute to a better understanding of the nature of technology and engineering;

2. What preconceptions may be held by K-12 pupils/students concerning the nature of models and modeling;

3. What functions of models can be taught and learnt in technology and engineering education and what might be useful strategies for that.

THE NATURE OF MODELING

In the first place it is important that pupils realize what modeling is. Modeling is the process of developing a simplified version of reality. There are two methods in doing that. Abstraction means that we leave out aspects of reality. We may, for instance, leave out air friction to produce a model for a free fall motion. Idealization means that we make small changes to simplify the representation of reality. We may, for instance, replace a wobbly curve of measured values into a smooth one that fits a simple mathematical formula. In both cases we have to realize that the model is no longer identical with reality itself and this should be taken into account when using the model for decision making about reality in its full complexity.

As always in education, we seek a conceptually attractive way of presenting the nature of the subject content. Modeling is a very complex and varied activity and for education it is necessary to develop a simple typology of models and modeling-related issues (the same need for a typology was expressed by Boulter and Buckley 2000 for science education). One option for teaching the various types of models that are used in engineering is the following typology (taken from Bertels and Nauta 1974):

a. Concrete models. These consist of materials. Examples are: replicas and mock-up models.

b. Conceptual models. These consist of concepts. Examples are: a flowchart model of steps in a design process and a system representation with material-, energy- and information-flows.

c. Formal models. These consist of symbols. Examples are: formulas and CAD models.

Both objects and events can be modeled. The modeling of events is what happens in simulations. Abstraction and idealization can be used both in modeling objects and events. Other distinctions that can be relevant are: qualitative versus quantitative, static versus dynamic, and deterministic versus stochastic (Boulter and Buckley 2000).

Another important issue in modeling is the different function models can have. Here, too, we seek a simple typology. This is one that has been derived from the Boston Museum of Science, which has an excellent exhibit on models and modeling (see http://www.mos.org/exhibits/making-models). Some functions were added (based on Bertels and Nauta 1974) to reach the following list of functions:

a. Support development of theories and artifacts (see Boon and Knuuttila 2009 for an elaboration of this – epistemic – function of models). This can be done is two ways

   i. Manipulate. An example of this is a model airplane that is put in a wind tunnel to examine the air flow around the wings in order to develop the real airplane, or a LEGO model that is used to try out a certain construction before the artifact is made out of cardboard or wood.

   ii. Explore mentally. An example of this is a system representation that helps designers determine the proper structure of subsystems, or the sketches that are used by a design team to discuss possible solutions for a design problem.

b. Communicate about theories and artifacts. This can be done for (at least) two reasons:

   i. Educational. A model of a molecule is used in chemistry education to explain the structure of, e.g., DNA, or a model of different types of transmissions that is used to explain the principle of transmissions.

   ii. Procedural. An example of this is a CAD model of a house that is used by the architect to communicate with the customer or to show his/her qualities in designing houses.

PRECONCEPTIONS ABOUT MODELING

The American Association for the Advancement of Science (AAAS) has set up a website in which they present research into ideas that pupils and students have about models and modeling (see http://assesment.aaas.org/topics/MO). They identify six categories of modeling-related ideas: (1) the term model refers to a representation of something in the real world, (2) models can represent objects, (3) models can represent events of processes, (4) geometrical figures, diagrams, sketches and maps can be used as models, (5) number sequences and graphs can be used as models and (6) oral and written descriptions can be used as models. For each category numerous misconceptions were identified with pupils and students. Many pupils, for instance, think a model is always a three-dimensional object. Pictures and graphs are not recognized as models. Many pupils believe that only objects, not events and processes, can be modeled. Another misunderstanding is that a model is always better the more it resembles reality. It is clear that it is by no means to be taken for granted that pupils and students have a good understanding of modeling. It is a challenge for technology educators to make them understand this for technology and engineering. Little research has been done into possible misconceptions about modeling in technology. Yilmaz, in a 2010 article on civil engineering students' misconceptions about structural modeling, showed that even at tertiary level, students have difficulties understanding the nature of models and modeling, which makes them fail often in developing correct models for structures (Yilmaz, 2010). This justifies the expectation that at secondary and primary level, pupils and students will definitely have problems understanding the nature of models and modeling also.

MODELING IN ENGINEERING AND TECHNOLOGY EDUCATION

The typology presented in section 2 is very general and not based on reflections on technology and engineering specifically. It is, however, not difficult to recognize that all three types of models feature in this domain also. Let us examine the three categories one by one.

Concrete models are probably best known for technology. Probably most of the artifacts pupils produce in primary technology education are small-scale models rather than full-scale objects. They do not make real moon bases, cars and houses, but models. This model-nature of their products is, however, probably often not made explicit. In a way this fits well with their level of development, as they are used to have a fuzzy boundary between their toys and the original objects that are modeled in those. A toy car for a child is a car. It would be good, however, to start raising at least some awareness that the toy car can only do certain things (like flying) due to the fact that it is not a real car, but a small-scale representation of a real car. This small-scale representation is useful, because it allows us to do exactly those things that we cannot do with real cars. Allowing manipulating is one of the possible functions of a model. In secondary education, this basic awareness can be extended into recognition of the various differences between the model and reality. When making a paper airplane, for instance, pupils can be challenged to reflect on the value and the limitations of doing flying tests with those models for learning about real flying behavior (this example is also mentioned in Zawojewski et al., 2008).

Conceptual models can be found mostly in systems engineering. Systems are then represented in a picture consisting of different connected sub-systems, all represented as rectangular boxes. These are an a high level of abstractions as all the details of the device are left out of the picture. Another example of the use of conceptual models in engineering is the electrical diagram in which concepts like resistance, power supply, connecting wire, are all presented by certain pictorial representations. In a similar way, in chemical engineering a chemical process can be modeled by showing different concepts (valves, mixers, drums) by different pictorial representations. In architecture, bubble or relation diagrams are used to show the relations between different parts of a building. Concepts like 'bedroom', 'kitchen' and 'living room' are presented as bubbles, connected by lines that represent relations (either functional or spatial).
Formal models probably are the most important type of model in engineering. This type covers a wide range of models, mostly in the form of formulas and computer models (like CAD and FEM models). Often these are dynamic models and used for simulations. They can be found in every branch of engineering.

Two ways of abstraction as a method for modeling are specific for technology and engineering (De Vries, 2010). These are related to the nature of technical artifacts. Such objects have both a physical/structural nature and a functional one. As abstraction means leaving out parts of reality in the model, there are two options here for abstraction: leaving out the physical/structural nature and leaving out the functional nature. The first option is used for instance when developing a system representation. In such a representation all physical/structural information is left out and only functional blocks are included in the model. In making a mock-up model of an artifact, most of the functional aspects are left out and only the physical/structural aspects are included in the model. Such distinctions help pupils and students understand the technology-specific aspects of modeling in technology education.

The evaluation of the appropriateness of a model also has some technology-specific aspects. For models in science what counts mostly is relation between the model and experimental data. The model has to have ‘truthfulness’ in that it fits with the data within in a certain limit (because the model will never fit the data exactly, given the fact that it is a model and not reality itself). For engineers, not only this is important but also the effectiveness of the model. Here is a similarity with engineering versus science knowledge: in science truth is the main criterion, but in engineering effectiveness is often more important. Another important issue in modeling in technology is the efficiency of the model. In product development time and money are important constraints and this has consequences for the modeling also. Models need to be good enough to prevent errors in product development, but they also need to be time- and cost-efficient.

As models in engineering are mostly used for making decisions about the development and implementation of new products and systems, it is important that the model does not move away too much from the full complexity of reality. In that respect, engineering sciences can be called ‘sciences of the particular’ rather than ‘sciences of the universal’ (De Vries, 2010). One consequence of the need to stay close to reality is that often models in technology do not only contain a hardware and software dimension, but also a ‘humanware’ and ‘socialware’ dimension (Franssen, 2010).

As models in technology are often used to make decisions about future interventions in reality with possible important impacts, there is an ethical issue in this. The model necessarily simplifies compared to reality. The intervention, however, is about all aspects of reality. Aspects that are left out from the model may appear to be important and if overlooked can cause great problems. An example of this is up-scaling from a model to a real production facility (Zwart et al. 2006 present an nice philosophical reflection on the ethics of up-scaling). Although this will not easily play a role in classroom projects, the issue is important for real-world engineering and if we want to create a realistic image of technology and engineering, it is good to make pupils and students aware of this ethical dimension in modeling in the case of technology.

CONCLUSIONS AND RECOMMENDATION: MODELING IN THE TECHNOLOGY EDUCATION AND STEM CURRICULUM

Coming back to our research questions, we have seen that:

1. The nature of modeling in engineering is that it produces simplified representations of reality. Given the misconceptions we can expect pupils to have, the aspects of abstraction (meaning that staying as close as possible to reality is not a priority), the different types of models (not only 3D, not only objects), the different functions of models (not just to manipulate) and the ethics of modeling (probably completely absent in pupils’ intuitive ideas) are worth having in the curriculum.

2. Misconceptions that have been found in general studies and that probably also appear present in pupils’ ideas about modeling in technology and engineering are: models are models of objects, are always 3D models; the closer models resemble reality, the better; and the way models are developed is unclear for them.

3. Functions of models identified in literature are: supporting development (by allowing manipulation and mental exploration) and supporting communication (by supporting explanation in an educational setting and by supporting steps in the process of development in which different parties are involved).

The examples shown in section 5 show that modeling is a widely spread activity in technology and engineering. The answer to question2 shows that it is probably not well understood by pupils. The answer to questions 1 and 3 show that there is certainly theoretical substance for teaching about modeling in technology and engineering, in spite of the fact that in the philosophy of technology and engineering, not much attention has yet been spent on this issue.

Modeling can be a learning line in the primary and secondary curriculum. In the primary curriculum, pupils can be given first experiences with the use of (mostly concrete) models. At this level, the nature of modeling can only be dealt with in a rudimentary form of course (for instance, by making them aware of the difference between toy cars and real cars). In the secondary school curriculum more attention can be given to the formal aspects of modeling (the types of models and the functions of models).

An example of how modeling can even be the basis for a curriculum in engineering is the Small Group Mathematical Modeling for Improved Gender Equity Project, described in Zawojewski et al., 2008. This project was for tertiary level and therefore goes beyond what is feasible in primary and secondary education. Yet it illustrate that modeling has so many facets that it can be all over the technology education curriculum if one chooses to do full justice to its important in real-world technology and engineering.

The combination of modeling and design activities are particularly interesting from a STEM perspective. Elsewhere (De Vries, 2012) the author has argued for designing as a connecting element between science, technology, engineering and mathematics. Here modeling is mentioned as a second element of such a kind. Modeling is often done with the purpose to build a bridge between a practical situation and the analytical tools of mathematics. In order for mathematics to be applied, a modeled version of reality is needed. This is the case both when understanding reality (in science) and manipulating and changing reality (in technology and engineering) is at stake.

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Learning Robotics Online: Teaching an Online Robotics Course for Secondary School Students


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ABSTRACT
This document outlines a research project to explore the use of an online robotics site for senior secondary school students in an urban New Zealand (NZ) school. The importance of this issue is discussed by analysing the needs for quality resources to assist schools in providing students with appropriate online learning experiences and knowledge. This is to enable them to make informed choices with respect to technology careers. There is a shortage of students pursuing technology careers and that in turn influences the NZ economy (Baron & McLaren, 2006, pp. 8, 35).

The purpose of the study is to explore the use of an online environment to support the teaching of robotics with respect to student achievement. The author will plan, implement, monitor and review an online course in robotics through an action research approach using formative evaluation methods to determine the effectiveness of the individual action research cycles. The study will also identify best practise in online learning to improve the quality of the learning process. Qualitative methods will be used to analyse online discussions, participant's reflections, classroom observations and discussions and one-to-one interviews with the students and the classroom teacher. This study will investigate how an online robotics course can be used by classroom teachers, to teach a course in robotics.

Keywords: Robotics, online learning, effectiveness of an online learning site, school, action research, qualitative research, technology education

Definition of terms

Robotics is the science of studying and creating robots. A robot is a machine that gathers information about its environment (senses it) and uses that information (thinks) to follow instructions to do work (acts).

Technology has a complex definition and it depends on the context. De Vries (2005) uses philosophy as a foundation for exploring various meanings of technology. These are:

- Technological artefacts – The product or the outcome (de Vries, 2005, pp. 13-27).
- Technological Knowledge – What the person needs to know to create the product (Background knowledge)(de Vries, 2005, pp. 29-48).
- Technological process – The methods used to create the product in an orderly flow (de Vries, 2005, pp. 49-65).

- Technology and the nature of humans – How human behaviour and needs influences human interaction with technology and product outcomes. This includes moral issues influencing our use of technology and the aesthetics of technology products.(de Vries, 2005, pp. 68-103)

Technology Education is the term used for subjects to do with development of real life products and systems. These subjects can be to do with wood, food, textiles, graphics, digital technologies etc.

Educational Technologies means products like Web 2.0 tools, computers, robots and tablets used in teaching.

Effectiveness in this context is the degree in which learning outcomes are achieved and the extent to which problems and issues are solved.

NCEA: The National Certificate of Educational Achievement. The New Zealand national qualification for senior secondary students (New Zealand Qualification Authority, n.d.).

Secondary school is the term used for schooling covering Y9 to Y13. This is normally age 13 to 19 years. Senior Secondary School is the term used for students from Y11 to Y13 who normally work through levels one to three of the NCEA certificate.

INTRODUCTION

This article outlines a research project under way that explores the use of a course website to support the teaching of robotics in the senior secondary school. It includes the planning, implementation, monitoring and reviewing of an online course in robotics. Throughout this process the researcher will identify best practise in online learning to improve the quality of the learning process.

The main reason the researcher decided to pursue this topic was due to the trouble recruiting appropriately qualified technical people whilst working as a manager at a major electronics firm. One of the biggest problems she had was to recruit experienced technical people with appropriate knowledge and skills. Many of these had to be recruited from overseas. Numerous other countries have similar issues with not enough students in technical areas. The author believes that robotics is one way to expose students to technology and teach them 21st Century skills.

Employers continue to request degrees that cover science, technology, engineering and mathematics but students are still not choosing these subjects (Hill, 2012). Many students view the scientific and mathematical subjects as boring and irrelevant and they don't understand why they are important (Chandra & Fisher, 2009). The reason may be because there is a shortage of teachers with the skills to teach specialist subjects like science (Picciano & Steiner, 2008), robotics and other technology subjects, especially in rural areas (Stevens, 2011).

Students need to make informed choices about careers in technology (Baron & McLaren, 2006, p. 17). If they do not get exposure to technology, how can they make valid informed choices? Further to the need for more students in technology careers are the requirements for 21st Century Learning (Bellanca & Brandt, 2010). The knowledge and skills students need to succeed in their future are not currently addressed by traditional means of teaching (Snape & Fox-Turnbull, 2011). Technological development happens so fast that we do not know what is possible in the future. Therefore, we do not know what knowledge and skills will be required by the students of today in their future careers (Bellanca & Brandt, 2010). We need students to develop into confident, connected, actively involved and life-long learners who can participate successfully in society (Ministry of Education, 2007). Students need to be able to think critically and solve problems, know how to use language, symbols and text, be able to manage themselves as well as participate and contribute effectively in groups (Pearlman, 2010) and society. Currently the majority of schools still cater for industrial age teaching but to address the Knowledge Age society, changes need to be made (Snape & Fox-Turnbull, 2011) (Bellanca & Brandt, 2010). The traditional meaning of knowledge is changing and educators need to understand how it has change and how to address it (Gilbert, 2005).

Technology education creates an opportunity for teachers to create truly 21st century learning experiences for students. Innovatively combining technology teaching with an online learning site will provide the students with tools to improve their own learning and develop 21st century knowledge and skills through self-directed learning (Chandra & Fisher, 2009). Robotics is a part of Technology Education because robotics covers the design, development and implementation of robots. These are key elements of technology learning (Ministry of Education, 2007) Using robotics technology, students are able to explore new knowledge and skills through a constructivist learning approach (Ostashewski, Reid, & Moisey, 2011).

The purpose of this study is to find out how an online robotics course can be used for teaching robotics and engaging students to develop knowledge and skills. This study will look at aspects of on-line course design to determine their success in teaching robotics as well as the types of online learning experiences that provide a positive outcome for students. This study is not to prove that robotics learned online is better but that it can be used as an alternative or to support face-to-face teaching. The following sections of this article include a brief review of current literature, methodology, research questions and methods deployed.

LITERATURE REVIEW

This section reviews the literature that informs the study. Articles related to online learning, the effectiveness of online learning and robotics are reviewed. The author also gave attention to articles and text books discussing how to develop an effective and appropriate online learning course. This was to ensure that the research can be based on a more accurate real-world experience taking into account current accepted practices.

Course Websites to Support Learning

Carmichael and Farrell (2012) sited various researchers who discussed the fact that students are not as technologically competent as we believe. The students' technological knowledge does not help them with their learning. In creating school learning sites with comprehensive courses we can teach students the technological skills required to take responsibility for their own learning.

Johnson and Anderson (2011) stated that teachers can use similar strategies in online teaching and traditional teaching by ensuring that students have targeted learning outcomes and specific resources that focus on the content. With the Word Wide Web (WWW) there is so much information that students can get overwhelmed and teachers may not always have the skills to help the students make sense of this information or to decide if it is a relevant teaching resource. It is therefore important that teachers have precise learning goals for their students and evaluate websites before the students use them or provide guidance to students when choosing appropriate websites.

Effectiveness of Course Websites

How well students learn are the main criteria when developing an educational course. This shows how effective that course is in ensuring students meet learning outcomes. In recent times, online learning has been seen as the "solution" to many problems, and the direction we should be taking in new learning (Wright, 2010). However, various researchers have noted that there is not enough valuable research done into the effectiveness of online learning (Langenhorst, 2011) (Jaggars & Bailey, 2010) (Ostashewski et al., 2011).

Although Ostashewski et al. (2011) showed that online learning is an effective way to teach, Carrol and Burke (2011) found many case studies that showed no advantage using online over face-to-face courses. Chang (1999) argued that is because they do not use the appropriate measuring tools. Chang (1999) described a web-based learning environment instrument (WEBLEI) to capture students' perceptions of web-based learning. This instrument is used to evaluate the effectiveness of online learning across four categories:

- Access has to do with ease of access to the Internet and how students felt in control of their own learning
- Interact with peers and teachers has to do with reflection, feedback and collaboration
- Response has to do with how the students feel about the course
- Results relates to how well the course structure and activities supported achievement of learning goals

There are two ways to evaluate the effectiveness of a course website. One is purely qualitative and is an evaluation of the participants' achievements of learning outcomes and how well they perceived they have learned. The other is the quantitative approach and the WEBLEI above is one way of doing this type of research. Various studies use either one or a combination of these (Chandra & Fisher, 2009)but to evaluate the effectiveness in terms of the students' learning and how they are developing thinking skills, a core reason to use robotics, we need to critical analyse their learning development using qualitative means.

Robotics in Technology Education

Technology Education provides students with pathways to gain a broad technological literacy so they can participate in society as informed citizens as well as gaining access to technology careers (Ministry of Education, 2007). Educational technologies are used to help develop students' understanding of new knowledge and skills.

Robotics programs can give students ownership of their learning within an active, enjoyable and non-threatening environment (Chambers, Carbonaro, & Rex, 2007). With the development of robotic kits, robotics has emerged in recent years as a valuable tool in education to teach students various scientific, mathematical, design concepts and critical thinking skills through the designing, building and programming of robots (Chambers et al., 2007) (Moundridou & Kalinoglou, 2008), resulting in a constructionist learning environment. An online robotics course can provide a means for technology teachers, including those with no or little robotics experience, to teach the class. Using a robotics curriculum enables the classroom teacher to produce challenging learning activities to effectively scaffold student knowledge creation. 21st century teaching requires real-world experiences and robotics has been identified as a vehicle to teach students the knowledge and skills required to operate in the 21st century environment.

Web 2.0 Tools

Students can use wikis for project documentation, podcasts for presentation and reporting and blogs for reflection as collaborative knowledge building tools in technology courses (Chandra & Chalmers, 2010). These tools provide a digital environment where students can document their projects including the design, provide ways to do reflection (Chambers et al., 2007) and give constructive feedback to other students. These tools can provide a framework for authentic technological practice (Fox-Turnbull, 2003) to be used in real world projects.

Using social networking tools enhance the teaching and learning process through content sharing and idea collaboration (Lei, Krilavicius, Zhang, Wan, & Man, 2012). Using the Web 2.0 tools outlined above to develop critical thinking skills, which is a vital component to enable the development of new products and systems, can provide better results than the traditional classroom approach (Lunney, Frederickson, Spark, & McDuffie, 2008). Using Web 2.0 tools to teach technology subjects also provide the opportunity to use these digital outputs as valuable resources to the wider community. Figure 1 shows the relationship between Technology Education, Robotics and Web 2.0 tools.

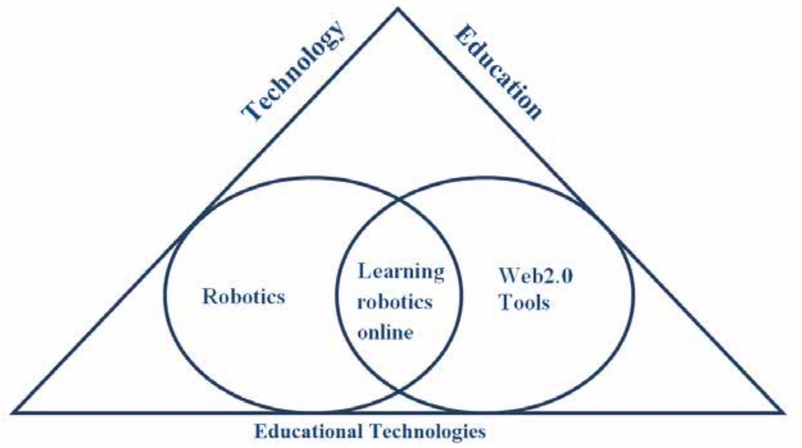

Figure 1: Educational Technologies within Technology Education

Effective Online Teaching

The WWW opens up numerous possibilities to enable students to take control of their own learning, for example the any-time, any-place access it provides (Bellanca & Brandt, 2010). Therefore the pedagogy changes when using an online course site. Although it is possible to upload resources from a face-to-face teacher-directed course, to gain the benefits of an interactive media-rich environment we need to change the way we teach. When creating course websites, four key areas need to be addressed to ensure the usefulness of this teaching method. These are interactivity, modularity, collaboration and learning styles (Lynch, 2004, pp. 30-31). Within these key areas students’ needs can be addressed.

Interactivity

Students need to interact actively with the instructor or course material to ensure they learn effectively. The instructor needs to be available regularly either face-to-face or online to guide students in their learning needs or answer questions. In an online setting the use of interactive learning resources ensure the students take control of their learning and are able to explore course material at their own pace. The use of media-rich pages, online quizzes, simulations and hyperlinks can provide a more motivating and exciting course to explore.

Using online tools for assessment makes it easier for teachers to evaluate and grade students’ performances. Assessment strategies like quizzes can provide valuable formative assessment opportunities (Anderson, 2009). It also identifies areas of concern that teachers can analyse to modify their teaching approach. The WWW provides a flexible environment where students could receive immediate feedback on their progress and retest themselves as many times as they like.

Modularity

It is important to set up the course in modular units where the content explains one concept. This enables the student to master individual units before continuing. It also provides the students with options to explore only certain units based on their prior learning and skills. This environment enables diversity to be addressed. Using Web 2.0 tools also provides a structured environment that students in a robotics program can use to record their experiences, present what they have learned and constructively reflect on their own as well as other students' performances (Chambers et al., 2007).

Collaboration

Collaboration occurs when two or more people work together to do a task. This is a key skill to develop for success in the 21st century. Conversation forms an important part in collaboration. Fox-Turnbull (2010) outlined how conversation is important in technology education and how that help students to "make sense both cognitively and experientially of the world in which they live and work" (p. 26). Conversation is important in online courses as well, as shown in a study by (Palmer & Holt, 2012). In 2005, Deakin University, one of Australia's leading universities, moved a face-to-face course unit fully on-line. Initially Deakin University found no improvement in student satisfaction. They modified the course to include a collaborative, compulsory online activity which improved overall student satisfaction and provided a more effective learning environment.

When creating an online learning site one of the assumptions often made is that students will not have any problems or issues using the online environment. The author created an online robotics site for Year 10 secondary school students. Many students had trouble navigating the online environment and one of the obstacles was online collaboration. This was also found by Carmichael and Farrell (2012) who evaluated the effectiveness of an online learning site to develop students' critical thinking. Online collaboration is a skill that needs to be developed to ensure students can effectively participate in 21st Century society.

Learning Styles

Online course sites can be used to cater for students with different learning styles and needs by using multimedia, simulations and modularity. The modular approach can be used to build up units of work that can address all learning styles and needs. Diaz and Cartnal (1999) outlined five learning styles that needs to be addressed to help students learn optimally. These apply to face-to-face and online courses and are:

- independent students prefer independent study and self-paced tutorials
- competitive students learn to perform better than peers and want recognition for it
- collaborative learners prefer group discussions and group projects
- avoidant learners are typically uninterested and overwhelmed by class activities
- participants learners want to be involved in all activities and work on meeting teacher expectations

METHODOLOGY

A qualitative methodology using a traditional Action Research model was selected. In this study a qualitative research approach will help the researcher to describe, understand and interpret the experiences and reflections of the participants (Bogdan & Biklen, 1998) to determine how much the students have benefitted from the online learning approach. This type of research provides a foundation for educational researchers to develop a deeper and broader understanding of human behaviours in a social environment, like a classroom.

The researcher's approach to learning is that the development of knowledge and skills happen through social constructivism (Fox-Turnbull & Snape, 2011). This epistemological belief supports the worldview that students learn through collaboration with others, experience situations in context and then take an action (Kim, 2001). This approach was embedded into the researcher's beliefs through years of working as a design engineer in industry. To help students creating their own knowledge, thinking and problem solving skills are essential (Lunney et al., 2008). Critical thinking skills is a learned skills and Lunney et al. (2008) outlined a process for using an online environment to develop these skills. Basically students learn through questions and answering these in their own words. Further to this, Lunney et al. (2008) outlines how the students need to create their own questions to further improve understanding. Critically analysing these discussions between instructor and peers and peers to peers help students develop thinking skills. These discussions have a two-fold purpose. One is for student to develop their own learning of the subject matter. The other is for the researcher to analyse how effective these were to the students learning in general.

The qualitative paradigm provides a means to determine how effective the learning of robotics is in an online environment. This evaluation will be done through interviewing the participants, analysing their reflections and online group discussions. This qualitative research approach will be carried out in an action research framework.

Action Research

Action research is well-suited for teachers to work collaboratively in a closed environment, like a classroom, where observation of the students' learning can be done in a controlled setting. Action research is doing what teachers are supposed to do, reflecting and improving their teaching. The difference is that action research is a systematic, planned approach, informed by theory, where observations are documented and reflected on, the plan improved and implemented again. This controlled, iterative process consisting of cycles of improvement, in a real-life scenario, makes action research ideally suited to improve teaching practice (Cohen, 2011). Action research provides a platform to determine if an online learning environment can be an effective and efficient space for students to develop their learning in robotics.

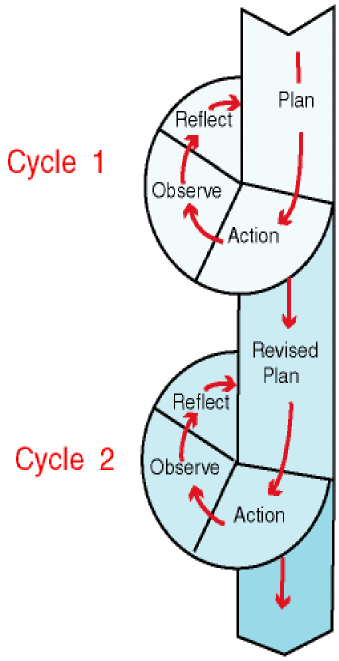

Figure 2: Action Research Cycles (Clark, Nute, & Zellerer, 2001)

To do this the traditional form of action research based on Lewin's "spiral of cycles" will be used (McTaggart, 1991). These cycles of planning, acting, observing and reflection as shown in Figure 2 provides a base for research that can be flexible and responsive. These action research cycles provide a vehicle to develop an online robotics course. Participant reflections and discussions are used to evaluate each cycle and revise plans to improve students' learning.

Methods

As part of this study, the researcher created an online learning environment for robotics on the research school's Moodle site. The robot kits to be used are commercially available and have some extensive basic curriculum documents that can be used to develop the online course.
The following sections address the methods to be followed in carrying out this research. The sampling and selection of the participants will be outlined, how data will be collected and triangulated, how results will be analysed and a discussion on ethical considerations.

Selection of Participants

This research is conducted with a Y13 electronics class in a single-sex, high decile, urban secondary school in New Zealand. All the students in the class receive the teaching resources online and will be invited to participate in the study if they wish to. Participation in the research aspect of the class work is voluntary and informed consent was requested from all participants. From these participants, six students will be chosen for semi-structured interviews to further explore their learning and experiences. The regular classroom teacher is also a participant in the study as her opinions and observations will provide credibility to the data. The researcher is also a participant and her reflective journal will form part of the study. The researcher's main roles are that of researcher and online teacher.

Collection of data

Process: The course site consists of a number of standard sections as well as weekly modules. The standard sections will cover: Hardware and programming information, help information, frequently asked questions, guidelines to use the learning site and extra readings. The weekly modules will include

- physical activities to do with the robots (programming or hardware related)
- quizzes used for formative assessments
- personal reflections
- discussion tasks

During each week the researcher will observe the students' interactions online as well as attend one class session. The researcher will also have on-going discussions with the classroom teacher. This information will be evaluated to critically reflect on the weekly progress and experiences and how effective they were before revising the plan for the following week. Any changes made due to the feedback will be documented as such. This "spiral of cycles" will continue until the completion of the study.
The following paragraphs outline each data collection method used in more detail.

Forum interactions: The students will be expected to interact in online forums as part of each module of the course to develop their understanding of the topic. The course will be structured so that students work on at least one module of work on a weekly basis. The students will also have access to general discussion forums and will be expected to discuss issues they have in these for the teachers or peers to answer.

Students' reflections: Students will be required to reflect on an on-going basis on their e-portfolios. Each section will outline expectation for reflection.

Semi-structured interviews with regular classroom teacher and students: The purpose of the 30-minute, end-of-course face-to-face interviews is to gather data with respect to the participants' experiences in the course and how they perceived it went. Depending on their experiences during the course and their learning reflections on their Wikis or e-portfolios, the students may be asked questions to reflect those experiences.

The advantages of using a semi-structured interview approach is that we can used open-ended questions to determine the interviewee's point of view rather that influencing what they say through structures and meanings imposed by the researcher. These interviews will be conducted at the end of the course.
Informal interviews: During class times there will be informal discussions with the students that will be included in the author reflection notes. These discussions will be included as part of the weekly feedback to evaluate the course and change the course where needed.

Students' work outputs: Students will have weekly tasks to develop their skills using the robots. Students will record their results through video, audio and/or capturing of the programming and other data. These examples form part of the study as that shows students understanding and knowledge development and how well they achieve their learning outcomes.

Triangulation

The data will be triangulated between the students' output, forum interactions and journal entries of all participants and the semi-structured interviews including the author's journal entries. Triangulation is used to validate data and to ensure that biases in the data can be overcome. That provides us with improved confidence in the data (Cohen, 2011, p. 184).

RESULTS ANALYSIS

The researcher will analyse the data gathered from the forums, reflections and interviews to determine a theme and code data accordingly. The author's current thinking is that the data maybe be themed in four areas as outlined by (Chang, 1999):

- **Access:** The convenience, efficiency and autonomy with which students can access the course material
- **Interact:** How easy students could reflect, receive feedback and collaborate
- **Response:** How students felt about the course
- **Result:** How well the online course supported the students in achieving their learning outcomes

Using information from the WEBLEI tool (Chang, 1999) the above themes can be coded as shown in Figure 4.

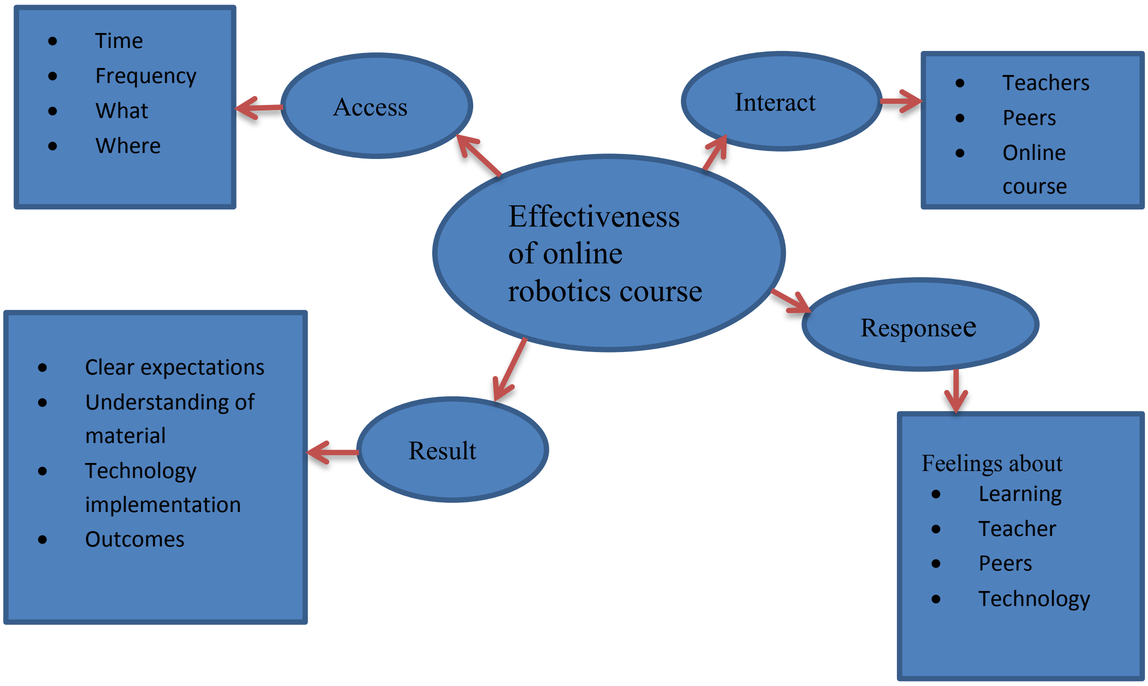

Figure 3: Themes and codes for data analysis

Trustworthiness and credibility

Ensuring that the data is valid and reliable is a key task of the researcher. In qualitative research validity can be addresses through truthfulness and depth and scope of the data, the type of participants, triangulation and the objectiveness of the researcher (Cohen, 2011). This improves the trustworthiness of the data obtained. Reliability in qualitative research shows how well the data reflect what has actually happened in the researched environment. To ensure the reliability or credibility of the data, three elements need to be addressed (Patton, 2001, pp. 552-553) :

- Follow rigorous methods when collecting and analysing data
- Credibility of the researcher which means using her training, background, experience and presentation of self to ensure valid and reliable data
- Philosophical believe in the value of qualitative enquiry

There are three objectives outlined by Yin (2011) for building trustworthiness and credibility. The first objective is to ensure the research is publicly accessible so that other can review and critique the research study. This is called transparency. The second objective is to ensure the research is done methodically. Although there is scope for discovery and unanticipated events in a qualitative study it is important to follow a set of procedures to ensure all aspects of the planned research has been covered to an appropriate standard. The third objective is the adherence to evidence. This means that results from students' reflection, teacher and researcher reflections and interview transcripts need to be analysed and triangulated to ensure validity and reliability of data.

Ethical implications

Lynch (2004) discussed two major areas in online learning that influence our ethical behaviour. The first is how we interact within our online community (virtual communication), and the second is how we use online resources. Lynch (2004) discussed the illegal use of online resources in terms of plagiarism and cheating in assignments.

Further to this are the rights of participants in a research study. The students do not have a choice in using the online environment for learning but they have the right to decide if their participation data can be used as part of an educational research project. Privacy, confidentiality and anonymity are upheld through the use of pseudonyms and keeping the name of the school confidential. Participants were expected to sign a code of conduct that outlined online behaviour.

Assessment in technology subjects (Robotics is an example), face-to-face or online, are mainly project-based. This means students may work in teams and the teacher (assessor) has to ensure that the individual student has actually learned and to what level. In this environment the student's performance must be assessed continuously throughout the time period of the course. This is done through regular activities of student-teacher interactions, student's online discussions and project reflections. Using results from online quizzes can be used cautiously, as it is easy to, unintentionally, use answers from other students (Lynch, 2004, pp. 178-179). Quizzes are, however, a valuable tool to use for formative assessment.

CONCLUSION

The author has outlined a research project to show how an online robotics course for secondary school students can be used to support teachers. Participants at a local school have been identified and the online course site will be developed on the school's Moodle site. The author has extensive background experience, knowledge and skills in both robotics and Web 2.0 tools.

The action research methodology using a qualitative approach is an ideal way to undertake this study as the researcher will be involved as an insider participant developing the course and delivering parts of it. The methods outlined are the selection of the participants, how the data will be gathered and analysed, ethical issues to be considered as well as the trustworthiness and credibility of the study has been addressed.

Reasons why online robotics sites should be used have been discussed in terms the shortage of technologist in New Zealand, the requirements for 21st Century Learning and the benefits of a robotics curriculum. The Ministry of Education has also outlined the importance of using e-learning strategies in education (Wright, 2010). Therefore the successful completion of this research study will benefit future students and schools who would take up this learning environment.

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Knowing Where the Shoe Pinches: Using the Mental Model Mode to Understand How Primary Pupils Can Design Intelligently

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ABSTRACT

This paper uses the English proverb, "Only the wearer knows where the shoe pinches" (Scheffler, 1997, p.73) as a metaphor for the often hard to explain difficulties that individual Primary pupils can face when meeting design challenges. Blisters on toes and heels are hidden beneath the firm leather of the shoe just as the obstacles to designing are embedded in internal, idiosyncratic mental models. Mental model theory provides a theoretical exegesis of the individuality that emerges when pupils seek to respond to authentic problems in Design and Technology.

But, an explanation of the originality of process and product is insufficient if pupils are either stultified by mundane tasks or stalled by their own inability to complete the design process due to cognitive 'blisters'. The Mental Model Mode (Mode) (Edwards-Leis, 2012) explains what happens when pupils are encouraged to take off their cognitive shoes when they pinch and how to deal with the blisters that impede progress. The Mode emerged from a longitudinal research project into primary pupils' mental models of problem solving in robotics (Edwards-Leis, 2010). It comprises six mental model functions and its efficacy to explicate the problem-solving process was validated through tests with pupils.

This paper continues its exploration of pupils overcoming challenges in designing through a critical discussion of how the Mode can contribute to centering Fry's (2009) design intelligence in general education. The Mode delineates a pedagogical approach to Design and Technology that foregrounds metacognition and celebrates the diversity of individuality of thought because it helps to investigate thinking (Freire, 1972). The clarification of a pupil's nature of thinking enables them to walk freely and be risk-takers; creating unique ways to view, critique and redesign the future can only emerge from a greater understanding of how individuals solve problems and design intelligently.

INTRODUCTION

This paper outlines mental model theory and specifically the Mental Model Mode (Edwards-Leis, 2012), a construct that has been tested to explain the problem-solving process used in designing. It then folds Fry's (2009) design intelligence into a pedagogical approach that involves problem solving and reflection – where meta-cognitive activity is used to add to the process of being reflective interrogators of self. This approach to problem solving in design and technology not only demonstrates how we idiosyncratically deal with problems but how we bring latent knowing (Polanyi, 1966) to all that we do. A richer understanding of what is really going on in pupils' heads as they address design problems may provide a more interesting path for them to follow: a path that lets them walk freely into new ways of thinking without developing cognitive blisters that arise from unnecessary repetition and ill-fitted tasks.

MENTAL MODELS

Mental model theory evolved from an interest in how information was processed in problem-solving situations particularly those that involved some interactive artifact such as a computer. Craik (1942) developed the theory to explain the possible differences in interpretation of systems when computer users attempt to interpret the system model created by the designer. Studies since that time (Barker, van Schaik & Hudson, 1998; Edwards-Leis, 2013; Halford, 1993; Henderson & Tallman, 2006; Johnson-Laird, 1983; Norman, 1983) have continued to investigate the processes used by individuals as they negotiate successful solutions to problems or challenges when interacting within a system or domain.

Mental models are of particular interest to educators because of their bimodality (Edwards-Leis, 2010) and there is a 'chicken and egg' type argument about what comes first: an individual will create, retrieve and/or re-work one or several mental models in order to solve a problem the solution of which guides the formation of a remodeled mental model. As a product, they are purposeful cognitive structures that function as storage facilities (O'Malley & Draper, 1992; van der Veer & Peurta-Melguizo, 2002); they are stored in long-term memory and are related or connected to many other models, cognitive structures such as schemata (Johnson-Laird & Byrne, 1991) which are static, and the senses. An individual will create, store and retrieve a mental model idiosyncratically in accordance to the individual's perception of its trueness, its relevance to the situation and its usefulness to achieve a satisfactory outcome.

Mental models also have a process function (Carroll & Olson, 1988; Halford, 1993) where they act as centres for solving problems (Johnson-Laird, 1983; Newton 1996) thereby enabling an individual to perform in novel situations with real world phenomena. The context is important because Halford (1993) argued that mental models used to solve problems reflect the structure of phenomena in the environment within that context. Such phenomena could include situations, events, tasks, problems, procedures or a concept with which an individual is faced. Halford (1993) concluded that if we, as problem-solvers, correctly or incorrectly understood the phenomena then we would have a respective correct or incorrect mental model of it. The reason that incorrect mental models are stored is that they are seen as purposeful; an individual retains mental models that are 'true' for them.

The inaccurate or incorrect nature of mental models that Norman (1983) explored helps explain why we hold fallacious facts, wrong ways, and imprecise information. This "inaccurate/functional nexus seems paradoxical" (Edwards-Leis, 2013, p.24) but Senge (1992) explained that such a multifarious nature allows us to carry the complexity of life's details in our heads. Williamson (1999) suggested that we do not need a have a complete conception of a phenomena or system in order to act. Johnson-Laird (1983) agreed with Norman (1983) that they can be incomplete and be parsimonious but they are, nonetheless, useful. Inaccuracies in mental models can arise from a multitude of circumstances including social and cultural nuances (Vosniado, 2002), beliefs (Norman, 1983) and experiences, personal perceptions and superstitions that may actually help to anchor a mental model.

The bimodality of mental models has implications for teaching: incorrect mental models may be difficult to manipulate and alter due to the strength with which they are embedded in our ways of knowing. However, it is this very strength of caching that serves to make learning more rich and memorable (Edwards-Leis, 2013). To conclude, mental models help us express what we know (Jonassen, 1995) and form the basis of all of our behaviour (Barker, Van Schaik & Hudson, 1998). Senge (1992) suggested that we do not just have mental models – we are our mental models.

THE MENTAL MODEL MODE

The Mental Model Mode (Mode) (Edwards-Leis, 2012) shown in Figure 1 was designed from the six functions of mental models including explaining, diagnosing, predicting, recalling from memory, communicating and controlling. The Mode explains the mental modeling that occurs when individuals are faced with novel problem-solving situations.

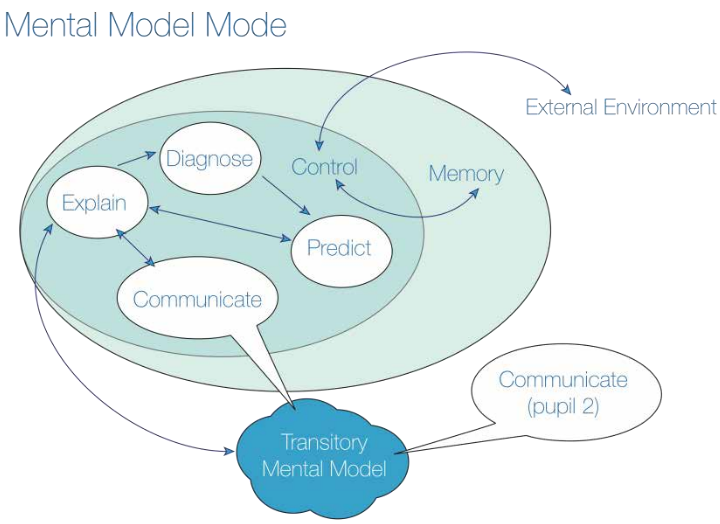

Figure 1: Mental Model Mode

A synopsis of the functions explicates their successful collaboration in seeking solutions. Explaining what is understood enables individuals to find meaningful connections between concepts, knowledge and procedures so that they can select strategies by "facilitating cognitive and physical interactions with the environment, with others, and with artefacts" (Henderson & Tallman, 2006, p.25). Predicting what might happen empowers an individual to forecast how a system or a strategy selected to solve the problem will work (Johnson-Laird, 1983; Norman, 1983). This function differentiates mental models from other cognitive structures, such as schema, that do not account for novel situations encountered. Diagnosing exercises an individual's meta-ability because it enables a testing of the success of the chosen strategy alongside the individual's capability to deliver the required knowledge for its application. This function relies on an understanding that the individual may be working with a mental model that does not allow them to assimilate the new concepts required to complete the task without further guidance or assistance (Royer, Cisero & Carlo, 1993).

The memory function highlights the bimodal nature (Edwards-Leis, 2013) of mental models because of their transience in working memory while they are being run and permanence in long-term memory when stored (Gentner & Stevens, 1983; Henderson & Tallman, 2006). How well they are stored relies on the logic and interrelatedness of an individual's network of understandings (Henderson & Tallman, 2006) fashioned when the mental model is created and stored. Communicating enables individuals to see and understand the mental models of others because they facilitate the communication processes of writing, reading, talking, and listening while thinking through problem-solving situations (Barker et al., 1998). Communication enables an individual's transitory mental models to become evolutionary repositories for the exchange of ideas (Edwards-Leis, 2013). Each partner to the exchange will incorporate selected aspects of the transitory mental model into their evolving mental models. Controlling is the overseer of the other five functions and coordinates, consciously or unconsciously (Henderson & Tallman, 2006) their performance then evaluates the effectiveness of selected strategies.

The validity of the Mode to explain problem-solving processes was validated through a study with 11 year-old pupils in a London school who were given a design problem to solve. Their brief was to design something that would be of use to an individual who was commencing Secondary school and the guidance provided enable them to interrogate the context and assess their efforts including the artifact's user, purpose, and function. They also were required to consider design decisions such as materials, components and production as well as how innovative the product was and whether it met an authentic need. The four participants were filmed while working and were asked to think aloud or talk to each other while working so that their thoughts would be exteriorised. On the same day that the participants were filmed working to solve the problem, the video was played back to each of them individually, using Stimulated Recall Methodology to gain the in-action thoughts. This interview protocol allowed the functions being used to solve the problems to be exteriorised and analysed so as to confirm the use of the Mode to explain problem-solving processes.

What was evident from the study was that encouraging pupils to engage in problem solving in design offers a significant opportunity for them to explain how they interact with the world to solve challenges. The data also indicated that individuals operate in heterogeneous ways during the design process even while working together, simultaneously, to reach a shared goal. A greater understanding of the individualistic approaches for the teacher and the pupil themselves would enable a greater emancipatory potential (Welsh & Dehler, 2001) for learning. This study of how the Mode can be used to externalise the cognitive processes used in problem solving in design through the pursuit of relevant challenges highlights the idiosyncratic or 'un-uniformity' of what really happens when individuals problem solve. How the Mode can be used in classrooms to understand, diagnose, remediate and celebrate individual cognition and meta-ability while they navigate pathways through learning experiences has the potential to give some structure to the "common reflection and action" (Freire, 1972, p.44) necessary for co-intentional and sustainable education.

COGNITIVE BLISTERS

The Mode has the potential to unlock what is happening cognitively in the problem-solving process that promotes designing for learners and their teachers. It contributes significantly to the understanding of metacognition which is more than simply having an awareness of how we learn. Royer et al. (1993, p.226) provided a succinct definition for and some guidance about metacognition when they described it as "one's capability of governing and being aware of one's own learning". It is the governance of the thinking process and the deployment of "strategies to enhance and problem solve situations when there is understanding failure" (Henderson & Tallman, 2006, p.28) that foregrounds meta-ability in pedagogical practice. Learners, with guidance from teachers, can map the functions in the Mode to useful processes such as diagnosing and explaining. Royer et al. (1993) suggested that the development of these meta-skills should begin with a diagnosis of what the learner already knows. Once the learner and the teacher have established this, the learner can retrieve information from long-term memory or control the redemption of procedural or declarative knowledge from their environment in order to utilize the necessary strategies to match the demands of the task. This matching requires the learner to predict the likelihood of the success of those strategies. Monitoring this success (or otherwise) is necessary so that the learner can plan the use of resources (for example time, knowledge, materials) effectively and efficiently. Haycock and Fowler (1996, p.28) found that mental models were a "convenient mechanism with which to consider how we acquire knowledge, achieve understanding, and generalize problem-solving skills to make them available to different situations and develop metacognitive skills". The Mode is, therefore, significant to the learner for the enhancement of metacognition through an understanding of the purpose the functions serve in delivering solutions to novel problems.

The control function, while governing the operative effectiveness of the other functions, also serves as a warning bell when a learner is stalled in the problem-solving process. We can only guess what is really happening in pupils' heads: a learner themselves knows best whether, or not, they have the capacity and capability to complete a task successfully. In order to be successful, an individual is required to control the recognition, selection and retrieval of knowledge from the internal or external environment needed to meet a challenge. But, the idiosyncratic way in which knowledge is stored, sometimes erroneously, through links created by the individual may make these processes problematic. What also may be difficult for the learner is expressing what is known or thought. Polanyi's (1966, p.4) discussion of tacit knowing where "we know more than we can tell" indicated that knowledge can be deeply personalised. Polanyi (1966) explained that a pupil will approach new knowledge with an acceptance of a teacher's authority, or view of knowledge, in order to start creating meaning for themselves. Such an act, understood metacognitively, will ensure that the pupil can continue to control the recognition, selection and retrieval of knowledge according to their perceived needs to complete the task.

Teachers understand that the pupils who are undertaking challenges in design and technology, particularly at primary school level, will 'copy' what they see as being desirable by the teacher. A meek acceptance without awareness of the 'authority' given to the teacher model can be a unexpected consequence of the imperatives of Wiggins and McTighe's (1999) Backward design method where knowledge is transferred and applied by pupils with the use of scaffolds provided by the teacher. Often, such design activities are repeated in a similar way to processes and application of concepts in mathematics that are repeated in order for them to be internalized and remembered.

The mundanity of repetitious tasks which are either ill-designed or designed to keep pupils busy replicating the design of a teacher may also contribute to stalled learning or cognitive blisters where pupils' enthusiasm for learning is rubbed raw by exposure to monotonous missions. Such tasks thwart progress on the learning journey because the "lle" or "life, learning, excitement" has been taken out and the task leaving a pupil to simply undertake "changes" to designs put forward by others. Educating teachers and learners to be aware of how they control their problem solving functionality is essential and part of the meta-ability that they can develop through design and technology education.

DESIGN INTELLIGENT ACTIVITY

Fry (2009) was critical of design theory that has a limited focus on the design act itself and the economic and cultural products of such action. He stated that humans are simply too many and that "there is a pressing need for the way we human beings live, act and engage the world around us, to change" (Fry, 2009, p.12) due to our sheer numbers. The only way forward is to develop design intelligence where sustainment becomes the focus of our development through "design made with sustain-ability" (Fry, 2009, p.12). The Mode can contribute to placing Fry's (2009) design intelligence firmly in education through its focus on control over individual thought and how it allows teachers and pupils to both investigate the thinking process and understand the potential to control those processes.

Fry (2009) admitted that aspects of design intelligence have been around for a long time due, in main, to their inherent link to craft. Resolving design problems through the machine, and now the digital, ages required an increasingly high level of tacit knowledge (Fry, 2009) which Polanyi (1966) would call tacit knowing. Such implicit or latent ways of understanding would account for how any design problem would be validated, approached and solved along with the knowledge of any implications embedded in the solution (Polanyi, 1966). Design intelligence, promoted by Fry (2009) therefore, has the potential to inform all educative practice because it would lead away from content that "inducts learners into unsustainable ways of thinking and acting" (p.12) and instead become a life skill.

The ethical issues of design as a problem-solving process are often touched on lightly particularly in the primary curriculum where design and technology classes involve creating solutions to problems. Most primary educators would promote sustainable practice given the current focus on recycling and reusing. But is this sufficient to engage learners in the critical thinking required for problem solving in the twenty-first century. Fry (2009) described design as being "bonded to a human-initiated act" and that it "takes on a determinate life of its own – designed things go on designing" (p.3). So, contemplating how the things we encourage pupils to create to solve problems continue to act beyond their function (Fry, 2009) would be that part of our tacit knowing that Polanyi (1966) saw as the consequences or implications of such solutions.

Fry (2009) saw design intelligence as involving the ability to "read the qualities of the form and content of the designed environment" as a "mode of literacy acquired by every educated person" (p.12). It would engage pupils in aspects of critical literacy which also looks at the practices of everyday life but through the use of linguistic media to analyze and critique the various norms, systems and practices of those social fields (Luke, 2004). It is, unashamedly, political and originally had the aim of social justice for communities who had been marginalized or disenfranchised (Luke, 2012) such as those supported by Freire (1972) who propounded "common reflection and action" (p.44) as necessary for learning. Freire (1972) like Fry (2009) described the consequences of any action becoming the object of critical reflection and through such interrogation forming authentic praxis. Fry's (2009, p.174) reflective interrogation of knowledge would allow teachers and their pupils "to begin to identify what one has formally and informally learnt and what, in hindsight, can be seen as 'induction into error'". Such errors can be unintentional and perhaps not dissimilar in effect to the ignorance that perpetuated the 'systematic education' that Freire (1972) said subjugated the working classes by social systems that evolved over time. Reflective interrogation is part of a re-educative process that allows the unsustainable to be eliminated from action (Fry, 2009) and such meta-activity can be developed through the Mental Model Mode as a method used by teachers and pupils to develop critical understanding and control of their own thought processes in problem solving.

IN CONCLUSION

The Mode is a proven explanation of thought processes used in problem solving and, as such, can enhance greater pupil metacognition. The control function governs which mental models are run and what knowledge is retrieved enabling individuals to become purposeful reflective interrogators of self (Fry, 2009). The control function also enables the individual to be more aware that they can know more than they can tell (Polanyi, 1966) and that such latent knowing may contribute to how they validate, approach and solve design problems. Teachers can use the Mode with learners to improve their meta-awareness thereby enabling them to gain a conscious realisation of self and of how what influences them (spiritual, social, personal, familial) will be incorporated into their ways of knowing, designing and problem solving. It provides the structure for rich communication with others about how we think. The Mode incorporates the 'fact' of individuality and that any resolution to a problem is going to be imbued in some way by that which is us.

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Equipping all Australians with the Knowledge and Skills Required to Live Sustainably: A Look at the New Draft Australian Curriculum--Technologies

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ABSTRACT:
What is known is that along with the climate, the curriculum is changing (IPCC, 2007 & BAMS, 2012). To enable people to react and adapt to the uncertainties of climate change, Australia –and the rest of the world - have identified "the critical role of education in achieving sustainable development" (UNESCO, 2007, p.5). To realise this, the Australian Government published the *Living Sustainably National Action Plan* to support a coordinated effort through "Reorienting education systems to sustainability" (DEWHA, 2009, p. 23), with the aim of equipping "all Australians with the knowledge and skills required to live sustainably" (DEWHA, 2009, p. 4). This paper will review the food and fibre production context of the *Draft Australian Curriculum: Technologies* document (ACARA, 2013), to specifically look for 'environmental enablers' or desired educational outcomes, that will determine whether students will gain the skills and knowledge to satisfy the *Living Sustainably Nation Action Plan*. To determine how we should prioritise this knowledge, it will be mapped against the basic needs deemed important to human interest by Maslow's (1943) A *Theory of Human Motivation*.

Keywords: Maslow; Sustainability; Australian Curriculum; Food Security

INTRODUCTION

Depending on the lens one is looking through, there are many definitions of sustainability. The New South Wales Department of Environment and Heritage (2013), defines sustainability from a humanistic perspective as, "living within the limits of what the environment can provide"(para.1). Unfortunately, the proliferation of the human race has led to the unsustainable human activities that occur today (Brundtland, 1987).

The *Living Sustainably Nation Action Plan* (DEWHA, 2009) asked the question: What does a Sustainable Community look like? (p. 7) and answered by describing a community that not only deals in measurable outcomes related to the environment, but also the human qualities such as attitudes, values and beliefs that motivate people into action and encompassing a concept of cognitive sustainability.

This concept of motivation is important when considering the will to act sustainably. Strategy 4 of the *Living Sustainably Nation Action Plan*, '*Harnessing the Community Spirit to Act'*, seeks to "tap into this spirit to act" (DEWHA, 2009, p. 26). This paper will attempt to use the most "pre-potent" (Maslow, 1943, p. 373) of motivators, the perceived threat of hunger and thirst, in motivating people towards sustainability.

BACKGROUND

Prior to the development of Australian Curriculum documents, education in Australia was governed by the educational authorities of the eight States and Territories. In a recent response to the need for Australians to be environmentally aware, State and Territory authorities have independently incorporated environmental education outcomes into curriculum documents, resulting in an autonomous, "jigsaw" approach (Gough, 2011 p. 11).

In 2008, State and Territory Education Ministers met in Melbourne developing a set of educational goals for young Australians; these goals, packaged as the Melbourne Declaration (MCEETYA, 2008) reinforced the desire for Australian educational authorities to work together in the development of a national curriculum.

MASLOW'S THEORY OF HUMAN MOTIVATION, 1943 AND SUSTAINABILITY.

Humans as both producer and consumer have a choice. That choice is a lifestyle that is (more) sustainable, or one that cannot be sustained, but what motivates them to choose a more sustainable lifestyle? Grothmann and Patt (2005) discussed the notion of people becoming more motived into action as the perceived risk increases. They state the main determinant of the motivation to adapt, "is the relative risk perception." (p. 202). Are human lifestyles at risk?

Maslow (1943) said that humans are a, "perpetually wanting animal" (p. 91) as evidenced by our ever-burgeoning populations and the unsustainable use of the earth's finite resources. In terms of the most "pre-potent" (Maslow, 1943, p. 370) of desires to motivate us, one could argue that air, water and food, being absolutely necessary for life, would physiologically motivate humans to seek and acquire it, if their life was under threat.

In the context of this article, it is suggested that the possibility of water and food security being a real threat, may be enough of a motivating reason to guide us into a more sustainable consumption trajectory. It was Maslow (1943), in his article, *A Theory of Human Motivation*, who suggested that among all of human desires there is a hierarchy, and humans are little concerned with "higher needs" (p. 375) such as love, or beauty until the more "pre-potent" of needs of food and water have been met (Figure 5).

LIVING SUSTAINABLY: THE AUSTRALIAN GOVERNMENT'S NATIONAL ACTION PLAN FOR EDUCATION FOR SUSTAINABILITY.

Food production, and the water required to produce it, has a political dimension to it. This is especially the case when considering it through the lens of the management of finite and endangered resources (Krabbe, 2013). The *Living Sustainably National Action Plan* (DEWHA, 2009), documented the role that education should play in developing the nation's capabilities through educating young people about sustainability. It recognised that better educational outcomes will result in the provision of information, but also a deeper understanding could be achieved from, "equipping people with the skills, capacity and motivation to plan and manage change towards sustainability" (p. 9).

Of the four strategies outlined in the Living Sustainably document, the second strategy, *Reorienting Education Systems to Sustainability* is specific to Australian educational institutions and school systems. For the purposes of this article, the *Living Sustainably* desired criteria of "equipping people with the skills, capacity and motivation" (p. 4) will be considered in the mapping and prioritising educational outcomes of the *Draft Australian Curriculum: Technologies* document.

PEERING INTO THE FUTURE: THE DRAFT AUSTRALIAN CURRICULUM: TECHNOLOGIES

The *Draft Australian Curriculum: Technologies* document was chosen to be reviewed for three reasons:

1. The document is very new, with a publication date of February 2013, and still in draft format. This provides significant opportunity for a contemporary view on emerging curriculum and the paradigms that they reflect.

2. The *Draft Australian Curriculum: Technologies* document incorporates school subjects that focus on skills development. It is the link between government policy and education, where the development of skills is one desired outcome of the *Living Sustainably National Action Plan*.

3. The document aims to "reflect current national priorities including food security and sustainable food and fibre production" (ACARA, 2013 p. 26), making it appropriate to assess as it demonstrates the link between the curriculum outcomes and the *Living Sustainably National Action Plan.*

The *Draft Australian Curriculum: Technologies* document divides content to be learned into five bands and two subjects: (a) Design and Technologies, and (b) Digital Technologies. Of these two subjects, Design and Technologies contains a framework that seeks to "reflect current national priorities including food security and sustainable food and fibre production" (ACARA, 2013 p. 26). Therefore, the article will be confined to the Design and Technologies subject.

The linkage of the Design and Technologies subject to the *Living Sustainably National Action* is important considering that part of the rationale for the Design and Technologies strand is to, "develop skills that are transferable to family and home" (ACARA, 2013 p. 23). As a mandatory subject, it could be an effective instrument in the education of generations of Australians to essential living skills, and empowering them to play a leadership role in Australian society.

The content within the Design and Technologies subject is split into two distinct strands: (a) Design and Technologies knowledge and understanding, and (b) Design and Technologies processes and production skills (ACARA 2013, p. 25), equipping "all Australians with the knowledge and skills required to live sustainably" (DEWHA, 2009, p. 4).

Of the four interrelated context areas offer within the Design and Technologies subject, the 'content descriptions' of the *Food and Fibre production*, describes "the knowledge, understanding and skills that teachers are expected to teach and students are expected to learn" (ACARA, 2013 p. 5). This context area contains the appropriate content for sustainable living.

METHODOLOGY

This article seeks to evaluate the most motivational, and appropriate subject in terms of Maslow's physiological needs; *Food and Fibre production*. The content descriptions of context area will be documented to determine what the knowledge, skills or understandings are required that will environmentally enable students to live more sustainably. For the purposes of this article, these elaborations will be referred to as 'environmental enablers'.

Each environmental enabler will be commented on in terms of the 'priority of motivation' according to Maslow's Hierarchy of Needs and the desired educational outcomes for all Australians in the *Living Sustainably National Action Plan.*

Priorities in motivation, according to what will drive people into action have been labelled from Priority 1- being the highest priority, to Priority 5- the lowest in priority (Figure 7). These labels will be aligned with the educational outcomes resulting from the teaching and learning activities of the *Food and Fibre production* context area.

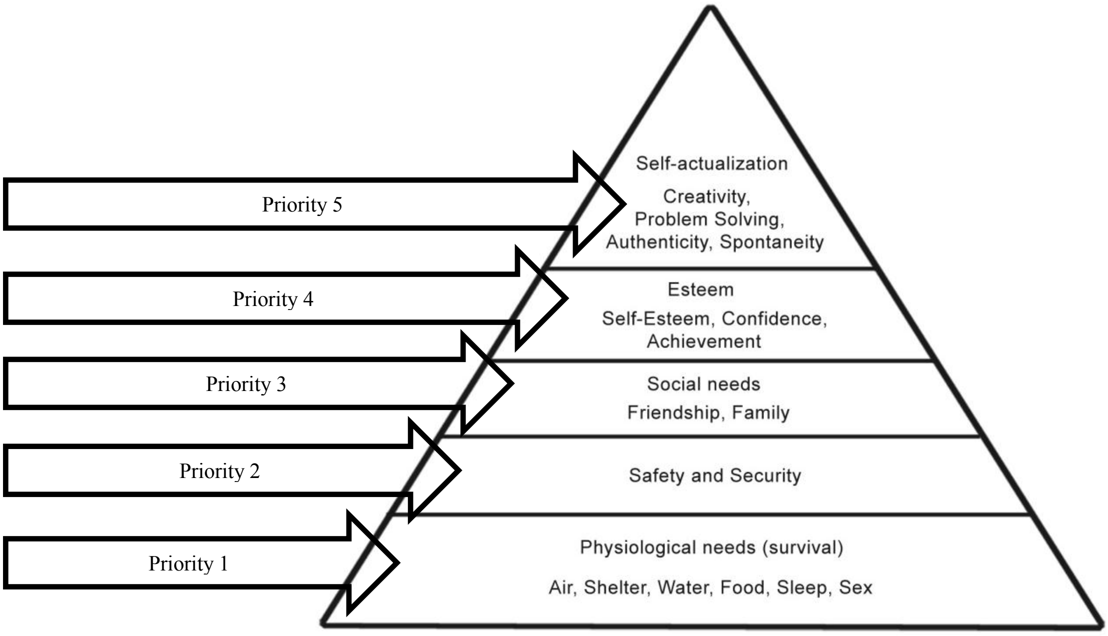

Figure 1: Alignment of Priority level to Maslow's Hierarchy of Needs

ANALYSIS

Content placed in the columns under Content Descriptions and Content Elaborations are quoted from the Design & Technologies subject within the *Draft Australian Curriculum: Technologies* document (ACARA, 2013)

Table 1. Draft Australian Curriculum: Technologies mapped against the prioritised educational and motivational outcomes.

Food and Fibre Production & Food Technologies		**National Action Plan: Living Sustainably & Maslow's Hierarchy of needs.**
Content Descriptions	**Content Elaborations as 'environmental enablers'**	**Equipping people with the skills, capacity and motivation**
2.3 Investigate sustainable systems of care for plants and animals that are grown, raised and processed for food, clothing shelter for an identified purpose.	• investigating systems of care for supporting the needs of plants and animals for growth and enterprise, and how humans manage these processes on farms or in glasshouses.	• Priority 1 needs to know and understand what plants and animals need for growth. • Priority 1 needs in the knowledge of how humans can manage the needs of plants and animals

	• identifying products that can be designed and produced from plants and animals.	• Priority 1 needs in the knowledge of how plant based products can be used for shelter and clothing • Priority 1 needs in the knowledge of how animal products can clothe the body. • Priority 2 needs in knowing how clothes can cover the body protecting it. • Priority 3 needs in knowing how certain clothes can assist people in their assimilation with others. • Priority 4 needs in the knowledge of how brand clothing can affect ones self-esteem.
	• identifying and categorising a wide range of foods into food groups	• Priority 1 needs in the knowledge what types of food should be consumed for a healthy diet.
	• examining how people from different cultures design and create different cuisines based on the plants and animals in their region	• Priority 1 needs in the knowledge of food produced in certain regions. • Priority 3 needs in knowing and appreciating different cultures and the food that they produce.
	• considering the suitability of a range of tools when cultivating gardens, mulching and building garden structures, preparing and cooking specific recipes	• Priority 1 needs in the knowledge of the appropriate use of tools to grow, protect, and prepare food.
4.3 Recognise the contribution food and fibre production and food technologies make to modern and traditional societies	• identifying the areas in Australia and Asia where major food or fibre plants and animals are grown or bred when designing environments for food and	• Priority 1 needs to know and understand what environments certain plants and animals need for growth.

	fibre production.	
	• exploring environments which could improve plant or animal production.	• Priority 1 needs to know and understand what environments may improve plant and animal production.
	• describing ideal conditions for successful plant and animal production including how climate and soils affect production and availability of foods.	• Priority 1 needs in knowing how soil and climate conditions affect food production.
	• recognising the benefits contemporary food technology provides for health and food safety and ensuring that a wide variety of food is available to provide a balanced diet.	• Priority 1 needs in the knowledge of how to utilise technology to ensure a healthy diet is maintained. • Priority 2 needs to ensure food is safe for consumption.
	• investigating contemporary methods of food preservation such as freezing and preserving when designing a food product	• Priority 2 needs to ensure food is safe for consumption.
6.3 Recognise that sustainable resource management is essential in food and fibre production.	• investigating and experimenting with different methods of preparing soil and their effect on soil quality and sustainability or pest and disease solutions.	• Priority 1 needs in the knowledge of how to experiment with different food production and protection methods and the skills required to undertake these experiments.
	• identifying methods of applying, conserving and recycling nutrients in food and fibre production, for example low-input sustainable agriculture (LISA), in a range of environments including Australia and the countries of Asia.	• Priority 1 needs in the knowledge of by-products and waste and understanding of how these products can be used to assist in food production.
	• considering the relationship between plant and animal types and environmental suitability.	• Priority 1 needs in the knowledge and understanding of the symbiotic nature of plants, and animals in environments that are suitable.

	• sequencing the steps in converting an 'on-farm' food or fibre product into a product suitable for retail sale, that is, the 'paddock to plate' supply chain.	• Priority 5 needs in the production of food and fibre for nothing but profit.
	• exploring and comparing the efficiency of different irrigation methods in plant production systems and the impact that developments in ICT have had on improving their effectiveness.	• Priority 4 needs in the knowledge and understanding of more efficient methods of plant production and how ICTs can assist in this efficiency.
8.4 Explain how food and fibre are produced in dynamic and interactive systems	• comparing land and water management methods in traditional Aboriginal systems, countries of Asia and in contemporary Australian food and fibre production.	• Priority 1 needs in the past and present approaches to knowledge and understanding of conditions that effect plant and animal growth.
	• investigating the manipulation of plant and animal growth through natural and artificial means when producing food and fibre products	• Priority 4 needs in the knowledge and understanding of more efficient and alternative methods of plant production.
	• evaluating emerging production methods in terms of productivity, profitability and sustainability and how recent developments in ICT could be used to enhance these systems.	• Priority 4 needs in the knowledge and understanding of more efficient methods of plant production and the role of ICTs in these enhancements • Priority 5 needs in the production of food and fibre to increase profitability.
	• describing physical, chemical and biological characteristics of soil and their effects on plant growth when producing food and fibre products	• Priority 1 needs in the knowledge and understanding of conditions and elements that effect plant and animal growth.
	• investigating different animal grazing strategies, including farmed wildlife such as emu, and their effects on product quality.	• Priority 4 needs in the knowledge and understanding of improving animal product quality through alternate farming

		strategies.
	• recognising the importance of food and fibre production to Australia's food security and economy including exports and imports to and from Asia when critiquing and exploring food and fibre production	• Priority 1 needs in understanding the importance of food and issues surrounding its production in Australia. • Priority 5 needs in the understanding of Asian markets and the economy in exporting production of food and fibre for profit.

CONCLUSION

What this article has asserted is that according to Maslow (1943), "physiological needs are the most pre-potent of all needs" (p. 373). The thought of thirst and hunger from a lack of water and food is highly motivational as, "no other interests exist but food" (Maslow, 1943. p.374). Thus, this article has appropriately focused on the *Food and Fibre production* context area of the Design and Technologies subject.

The 'environmental enablers' for content description 2.3, provide students with knowledge of the types of products generated from food and fibre production. Students learn about foods that should be consumed for good health, and are provided with the opportunity to learn about the conditions that specific plants and animals prefer for growth, and the processes humans follow to manage these conditions.

Content description 4.3 provides students opportunities for deeper knowledge and understanding. Learning activities in this band level enable students to understand what may affect food and fibre production, such as environmental and soil conditions. In terms of health, students understand the conditions that food needs to be kept in to remain fit for human consumption.

Content description 6.3 provides opportunities for hands-on activities where students are able to develop 'skills' as well as a deeper understanding of living systems. The environmental enablers allow students to experiment, seeking efficiencies in food and fibre production, as well as understanding the interconnected nature of food and its requirements for optimal growth.

The final mandatory band incorporating Content description 8.4 seeks to refine student knowledge and understanding by providing opportunities to study through the higher-order thinking activities of comparing, investigating and evaluating. Alternative, past, cultural and emerging methods in food and fibre production are offered to provide a broader perspective on production, looking to the past and ahead to secure a better future.

DISCUSSION

This article aims to map the 'environmental enablers' or elaborations onto the content to be delivered in the Design and Technologies subject of the *Draft Australian Curriculum: Technologies* against the desired educational outcomes for all Australians in the *Living Sustainably National Action Plan* and 'prioritise' human motivation to live sustainably according to Maslow's Hierarchy of Needs.

It is acknowledged that this article has only reviewed the content descriptions specific to the subject content found in the Food and Fibre production from Foundation to Year 8, and Food Technologies up to Year 4 context areas, and that students could still attain environmental enabling knowledge, understanding, skills from other elements, such as teacher expertise (Grundy, 1998).

Following this article there is further opportunity to research the other strands of both the Design and Technologies, and the Digital Technologies subjects to gain a broader appreciation of what knowledge, understanding and skills maybe developed from the whole *Draft Australian Curriculum: Technologies* document. It may be from the completion of the whole 'Technologies' program of study that can support Australian students in their education of sustainable living.

In the development of this article, a question that seeks clarification is: Do the professional development opportunities available to teachers equip them to teach students to live sustainably? The *Living Sustainably National Action Plan* acknowledges that teachers need professional development. Action 2.3.4 states that, "the Australian Government will work with state and territory governments to provide in-service professional development for teachers in education for sustainability, including developing teaching resources" (DEWHA, 2009 p. 24). Given that teachers may be given this opportunity, future analysis in measuring the success of these teacher in-service programs through assessing teacher knowledge, understanding and skills, would be beneficial in determining how Australia is progressing in its journey towards living sustainably.

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The Different Faces of Staging a Technology Lesson and a Science Lesson

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ABSTRACT
In this study, two different lessons taking place within one science and technology classroom are analyzed. Differences emerge in how the same teacher stage the teaching in technology compared to the teaching in physics. The aim of the study was to investigate and describe how the teaching was staged and what was highlighted, when a research perspective according to Bourdieu were used. The results of the study make the teachers strategies visible and show how teaching is related to structures within different school subjects (Bourdieu, 2004; 2008). It reveals specific characteristics of technology compared with physics, which could be important to reflect on and discuss in relation to intentions in curricula.

During the technology lesson the teacher stages a teaching that to a certain extent provokes the students. Relating to the “real world”, the students are forced to reflect and take stands in discussions, which is perceived as difficult. The teacher acts very engaged, charismatic and talks about how we can understand the technology today with an understanding of the historical aspects on technology. The teacher acts with an active body language and very positively tries to involve the students. She is visible in the classroom and wants to communicate her fascination for artifacts’ function and the creative processes behind them. The teacher highlights the understanding of the “big picture” and how important it is to broaden the perspectives. It is needed both with a deep understanding and to let the thoughts run away and it is not necessary with the right answer all the time. The students seem to be unaccustomed to such behavior during science lessons in this specific science classroom.

The teaching that emerge during the physics lesson is interpreted as a traditional laboratory work where students follow instructions and describe in text what is happening and why. The teacher is very quiet and almost “invisible”, walks around and controls the answers. It is stressed that it is important to have control over results, to work disciplined, concentrated and systematically. It is clear that a very traditional physics lesson appears and the students seem pleased about it. The teacher nearly eliminates herself, she walks around and observes. The students own experiences and views seem not to be interesting to highlight. The teacher and the students does not discuss issues together, there is no relations to a broader context giving the students insights in relations to wholes.

Keywords: technology education, doxa, physics teaching, structures

BACKGROUND

In Sweden, curriculum and syllabus highlights that students have to discuss and reflect upon concepts, models and relations both in science and technology. The teaching aims to give students skills and knowledge both for higher education and for a citizenship.

A so-called dialogic teaching based on discussions and the students own thinking and experiences seem to develop knowledge for a democratic involvement both in society, higher education and forthcoming professions (Liljestrand, 2011). The teacher is thereby expected to involve students in a thinking process, let them have a dialog and understand issues (Alexander, 2004; Dolin, 2001; Linn, Davis & Bell, 2004). Dylan William (2007) highlights five strategies for learning and teaching: the purposes with the learning must be obvious for and shared by everyone within the class, discussion and tasks within the classroom must show if and how the learning within the class works, the teachers must give the students feedback that help them forward, the teachers should use the students as recourses for each other and finally, the teachers have to make it possible for the students to own their own learning through self-reflection.

Research shows that different teachers obviously focus on different aspects and embraces different approaches when they teach. In science education one can find different teaching traditions both comprising only strict conceptual understanding and more of conditions that make all students develop a broader scientific knowledge (Aikenhead, 2006). In research, science activities for example laboratory work and other forms of inquiries are highlighted as important but also science in relation to norms and decisions (Zeidler, 2003). Different teaching patterns emerge thus in science education (for example vision 1 and vision 2 in Roberts, 2007; Fensham, 2009; 1988) both in curriculums and in specific teaching (Roberts, 1988; 1994 selective traditions in Östman, 1995). Research shows that even if syllabi emphases both scientific facts and more of socio-scientific issues, the teaching objectives and the assessments seem to mostly focus on concepts, methods and models (Aikenhead et al, 2011; Orpwood, 2007) and often the science teaching includes an inquiry model presented as a strict linear process from hypothesis to results without argumentation, discussions or statements (Davis et al, 2006).

Even within technology education different traditions emerge (Klasander, 2010) that could be seen as descriptions of different patterns in teaching both within teacher approaches and choice of subject contents and themes. Klasander points out the following emphases: the “design- and make”, the “industry”, the “sustainable development”, “handle the everyday”, the “citizen” and the “technology history”. Di Gironimo points out five dimensions that characterise the school technology (”the nature of technology”): As “Artefacts”, “a Creation Process”, “a Human Practice”, “History of Technology” and “The Current Role of Technology in Society”. An individual’s view about technology could thereby be noticed within these dimensions and the teaching could be moving from one to another. The schools' technology teaching has extensively developed practical characteristics both for content and teacher approaches, often with focus on artefacts and an understanding of the artefacts function, their development and purposes (de Vries, 2006; Dusek, 2006). Focus on processes aiming to invent, produce and use are significant (de Vries, 2005; Mitchham, 1994; Kline, 2003). As a complement to this practical approach many researchers highlight how important reflecting and valuing are within the technology education (Pitt, 2006) but it seem to be a lack of such discussions among active teachers. Norström (2013) for example, finds that teachers seem to not have the experience to discuss technological knowledge whatsoever, its nature nor justification.

Both science and technology teaching seem then have specific structures, some highlighted in research as important to be developed and some more of traditions within the subjects. For examples both science and technology seem to have a tradition to be based on inquiry and process understanding. The intention to implement discussions and more of values seem more or less to be absent.

With this as an introduction I will investigate views and strategies within one science and technology classroom during two lessons. I find it in on the one hand interesting to compare a

physics lesson with a technology lesson and see if there are any differences or similarities in terms of approaches, but on the other hand interesting to investigate the teacher´s possibilities in relation to the structures of the subjects.
The research question is: how is the teaching staged within two different lessons?

Thereby this study could be seen as a descriptive study with the aim to find out what emerge when the teacher enters the classroom and start to teach. Such study could be seen as a clarifying of what is possible for a teacher to do within a school practice. A clarifying with this specific perspective could then be used as a ground for further deeper studies with aim to understand what is happening in the classroom.

THEORETICAL FRAME

Bourdieu developed, through his anthropological work, theories about how everyday practices could be understood in relation to social and symbolic orders in society (Bourdieu, 1977). In this study, the classroom and the meeting between the teacher, the students and the subject is seen as an everyday practice, a social practice. I want to find and analyze how this practice emerge, how the strategies used by mostly the teacher but also the students occur within the teaching in the specific subject and specific themes. Strategies are made visible in statements, choices, views, issues, approaches etc. (Bourdieu, 2004) and behind a person's strategies there are relations to social structures in society that makes the specific social practice emerge in a specific way. These social structures both guides and limits how the individual acts, what is suitable or not. Examples relevant for this study are structures within: academic physics science, the technology field and the education-political area. From these structures a system is formed, a system for acting and thinking. That system is embodied in the individual, both in students and in the teacher, incorporated with the person's whole lifetime-experiences. It is a kind of embodied history and gives guiding in the situation here and now, and is seen as "common sense". Within a social practice a specific individual act with its embodied system and therefore we have to understand a person's acting in relation to the structures (Bourdieu, 1977) and how the individual and the dominant structures make the practice emerge (Bourdieu, 1990). In this study I analyze the classroom situation with this perspective. Thereby I will, in limited teaching sequences, analyze with aim to make visible different teaching strategies.

METHOD

In one science classroom, during two lessons (one 60 minutes, the other 100 minutes) one science - technology teacher and twenty students (grade 9, age 15) are video-filmed and observed. The teaching material is a so called NTA-box dealing with Railway issues (NTA, 2013) combining both technology and physics. Lesson 1 (60 min.) is more of a technology lesson, focus on technology history, dealing with a specific issue: How did we travel in the past? And the second lesson is more of a physics lesson, focus on inquiry, and dealing with the task: measuring a force! Both lessons are videotaped and the teacher's discussions with the students are entirely transcribed. The films were seen several times, and then descriptions of what is happening have been compiled and interpreted. Here, in next part, I will discuss what is happening in the classroom.

RESULT AND DISCUSSION

The result comprises descriptions of what occurs in the classroom during the two lessons and how it could be understood in relation to structures within school subjects (and to structures in society) found in previous research. I mean occurs in the sense of how the teacher acts, talk and involve the students but also how the students respond and act.

Within the first lesson, the technology lesson about railways and how we travelled in the past, the teacher acts with great emphasis. She stands in the center of the room and speaks with a rather loud voice. She uses the classroom discussion trying to inspire and provoke. She signals that it is important to think "outside the box" and to discuss spontaneously and that there is no right or wrong. She uses her whole body to stage the characteristics within the "existing" technology history. She wave with arms and walks around in the classroom with different expressions. The teacher reminds the students of the earlier lesson and what they talked about. She reminds them of the museums they have visited, the TV-program they have seen but also literature (historical novels), films, historical TV series they have got in contact with. She uses encouragements such as: “think about..”, “imaging that you are on…”, “why could it be like that?”, “now you get new ideas! Good!”. She highlights different students’ statements: “but E had a reflection, let us hear more…” or “more reasons E, come on..?” The teacher builds on the students own knowledge, their statements and give the students the feeling that they together are searching for knowledge (a dialogic teaching according to Alexander, 2004). She also makes the learning visible and let the students reflect by their own and together with the classmates (good strategies according to Williams, 2007). She signals an embodied feeling of how important knowledge of technology systems and their history are, one of the emphasis found by Klasander (2010). But she also signals a trust and an admiration for technical development and how important it is to understand this development (from success to success) as an explanation for our prosperous today, a view on technology rather naive, according to DiGironimo (2011) but typical within the technology field. The teacher says: “so we must think…”, “it´s important to think backwards for understanding the society nowadays..”. She uses her own body, her discussions and her enthusiasm as strategies to try to arouse interest for a specific view on technology and its history (Klasander, 2010; DiGironimo, 2011). These views and her feelings for them seem to be embodied and thereby strongly signaled within her teaching strategies (Bourdieu, 2004) and her strategies could be understood in relation to a general view on technology and its history, for example with trust and admiration. When the teacher with her embodied enthusiastic engagement mentions how important it is to think “outside the box”, reflect and allow different responses and ideas, the students seem to have some difficulties with answering, they use few words and seem to find the situation unusual within their school practice in general and within nature science in particular. These strategies (effective for learning according to Williams, 2007) seem to be demanding for the students. The teacher has to lead them to speak up and explain what they mean.

Within the second lesson, the physics lesson; the teacher has a reclusive role, speaks quietly and adapts more of a controlling approach. The teacher moves calm in the classroom and wait for questions from the students, she signals with her approach that she almost is not needed. The teacher does not make the students discussions or thoughts visible. She mostly urges students to be well documented, to “draw and write properly”. Orderliness is signaled as a virtue that gives successful strategies within science inquiry (also in Bourdieu, 2004, about laboratory work). The teacher gives brief simple advises and sometimes only points with aim to signal how important it is that the students become independent, become active and investigative by themselves. The teacher says that the instruction within the material (NTA) has a very “good” instruction, “you can read it by yourselves and do not need to ask me”. A good instruction needs no discussions, which also could be seen as a manifestation of a structure of the science field (Bourdieu, 2004). The teacher signals that there is a “right” or a “wrong” answer in this inquiry (also found in Davis et al, 2006). She says: “are you ready?” “Are you waiting for me coming to correct you?”. She also reminds of how important it is not to “be careless”, that they “have to work concentrated and to be patient”. The teacher, in the way she meets different student groups, she shows that she likes the ambitious one, she meets them with a nice smile and encouraging word for example: “ha, ha you will never give up! That’s good!”. Especially the girl-groups work ambitious the whole time, they create their tables, answer the questions in the book, they think and discuss a little bit with each other and then write the answer down and show it for the teacher (cooperating with peers could be good strategies according to Williams, 2007). They use a “right” way of working with this inquiry, the structure is visible for both the teacher and the students, their strategies are embodied and obvious (Bourdieu, 2004) and the students seem to feel comfortable with both the working process: follows instructions and test their hypothesis (Davis et al, 1996) and that their group work could be independent and following a strict routine. The task for the lesson is not related to anything else in the NTA-material or to anything they did earlier but no one, neither the teacher nor the students, ask or explain why they have to do it. This does not seem to be a problem.

Two different lessons arise, two totally different teaching approaches even though it is the same teacher, the same classroom and the same students and also the same teaching material. Different horizons emerge, the teacher choose to stage the lessons totally different. This could be understood as the teacher´s embodied strategy system which emerge within the practice in relation to general structures of, on the one hand, physics science and specific inquiry as it has become traditionally presented within the school practice (for example in Davis et al, 2006) and, on the other hand, dominant structures within technology education and "the nature of technology" where more of reflection, discussions etc. seem to be a natural part (for example in Pitt, 2006) especially when the historical part of technology is highlighted. The teacher´s strategy systems in relation to dominant subject specific structures emerge within the practice and thereby construct the practice. The study gives no information of the teacher and her background but it points out how structures could be visible within the practice embodied in the individuals, both the teacher and the students.

When using this perspective of Bourdieu it gives the possibility to focus on the relationship between conceivable teaching strategies within a practice and dominant social structures in larger fields (for example physics science). Bourdieu use the term "doxa" (Bourdieu, 1977) when describing the social and symbolic orders in society (high valued structures). Within a practice a specific doxa is dominant and in this actual study it is therefore interesting to point out the clear difference between how two lessons are staged by the same teacher although both curriculums and syllabus, and also education research, emphases specific teaching strategies that would be suitable within both teaching in technology and in science inquiry (for example a dialogic teaching in Alexander, 2004; Strategies according to Wiliam, 2007). The teacher seems, very easily, to go from one "doxa" to another when changing from physics inquiry to technology history. As a teacher it could be important to reflect upon what specific structures within specific subjects that will be emerging in the specific teaching and how that is related to other intentions in curricula that not emerge as the dominant "doxa" of the practice. Especially within technology teaching, without structures related to a specific academic field such as physics, it will be important as a teacher to reflect upon the "doxa" of the specific part of the subject.

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Pre-service Teachers' Perceptions of Technology and Technology Education

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ABSTRACT
Technology teachers' perceptions and understanding of the nature of technology heavily influences their perceptions of technology education and consequently shapes their teaching practice. Understanding the nature of technology is also an important component of technology education and in 2007 the New Zealand technology curriculum introduced a new strand called the Nature of Technology. An important part of initial teacher education programmes is therefore to help student teachers develop their concepts and philosophies of technology and technology education. This paper reports findings from a survey of New Zealand student teachers' perceptions of technology and technology education before and after their involvement in a compulsory course in technology education. The findings reported here are some of the initial results from one institution but are part of a larger project aimed at brining together similar data from across the country to inform development of pre-service technology education programmes.

Keywords: Pre-service teacher education, perceptions, technology

INTRODUCTION
This paper reports on the first stages of a national project investigating student teachers' perceptions of technology and technology education. The initial survey reported here explores the views of a cohort of primary teacher education students at the start of their undergraduate degree programme. The rationale for the project is based on recognising firstly that technology teachers' perceptions and understanding of the nature of technology heavily influence their perceptions of technology education and consequently shape their teaching practice, and secondly, the importance of developing initial teacher education (ITE) programmes that can respond to the views of the students involved and contribute to their developing pedagogical content knowledge (PCK).

In order for teachers to teach technology effectively it is necessary for them to have a well-developed understanding of technology (de Vries, 2012; Forret et al, 2011). There is an expectation that pre-service teacher education will develop teachers' understanding to align more coherently with the way technology is represented in the national curriculum and that this will build on the perceptions, understandings, and experiences that students bring into the programme. While teacher education in New Zealand has included technology education in its programmes for nearly twenty years, there has been little research into the perceptions of technology and technology education that student teachers hold coming into the programmes, or when they leave.

BACKGROUND TO THE RESEARCH

For any subject, curriculum changes provide potential for misinterpretation and mixed messages regarding curriculum intent and implementation. This potential is even greater for a relatively new curriculum area such as technology that has evolved from a range of syllabi and teaching approaches (Harwood and Compton, 2007). The current NZ technology curriculum presents a much broader view of technology and technology education than at any time in the past; a view that challenges the existing perceptions of many teachers. It frames learning in technology holistically using technological practice, technological knowledge, and the nature of technology as the main structural elements. In their Ministry of Education research report on student learning in technology, Compton and Compton (2010) identified a number of misconceptions, alternative understandings and partial understandings about technology in primary school students. These need to be addressed and require a sound teacher understanding of technology concepts and of the philosophy of technology.

One way to reduce confusion about the aims, purposes and nature of technology and technology education is to develop a consistent approach to technology ITE. Within New Zealand a well-established technology ITE community has developed a coherent approach to ITE that provides consistency in philosophy while supporting diversity of practice.
The Pre-service Technology Teacher Education Resource (PTTER) framework (Forret et al, 2011) is aimed at supporting a coherence of understanding and purpose amongst teacher educators and student teachers across ITE institutions.

The PTTER framework for technology ITE has four elements:

1. Philosophy of Technology - establishing philosophical foundations of technology as a field of human endeavour;
2. Rationale for Technology Education - examining rationale for including technology education as part of a core education curriculum;
3. Technology education in the New Zealand Curriculum - understanding how the New Zealand curriculum mandates and structures technology education;
4. Teaching Technology - understanding how to plan, teach and assess technology in the New Zealand Curriculum.

While all four elements are important, the first two are seen as foundational in technology ITE and the development of student teachers' PCK.

Much has been written about the nature of PCK since Shulman first introduced the concept in 1987. Magnusson, Krajcik and Borko (1999) sought to clarify the concept by proposing that a teacher's PCK comprises their;

1. Orientation towards teaching (knowledge of and about their subject and beliefs about it, and how to teach it);
2. Knowledge of curriculum (what and when to teach);
3. Knowledge of assessment (why, what and how to assess);
4. Knowledge of students' understanding of the subject; and
5. Knowledge of instructional strategies.

As with the PTTER framework, knowledge and beliefs about the subject are seen as important factors in the development of sound PCK.

In New Zealand, teacher education faces increasing political pressure to focus on literacy and numeracy education. As a result, other learning areas within the curriculum, while valued, are being squeezed into smaller and smaller 'spaces' within teacher education programmes (Ell, 2011; O'Neill, 2012; Thrupp, 2013). Within this context of reducing available time for curriculum ITE, teacher educators are forced to decide what to leave out of their programmes and how best to spend the little time they do have. The PTTER framework represents a foundational core aimed at addressing the variety of perspectives about technology and technology education that students bring with them to ITE programmes (Burns, 1990), and providing the most long-term impact on their developing PCK in technology education.

THE RESEARCH

Following on from the development and use of the PTTER framework within the main ITE institutions in NZ, it was agreed that a survey of students' perceptions of technology and technology education when entering ITE programmes across NZ, and again on exit, would provide valuable insights into the impact of these programmes. The findings reported here are some of the initial results from one institution. The larger project will bring together similar data from across the country to inform the ongoing sustainable development of pre-service technology education programmes.

Participants, data gathering and processing

Participants were primary teacher trainees enrolled in a compulsory, initial technology education paper at the start of their three year undergraduate degree programme. Table 1 shows the age and gender of participants with approximately 90% of respondents being females between 17 and 24 years old.

Table 1: Age and gender of participants

	Before	**After**
Age	92.6% 17-24	88.9% 17-24
Gender	90.6% female	89.9% female

Students were asked to complete a questionnaire at the beginning of the paper before any teaching had taken place and again at the end of the paper. The same questionnaire was used for pre and post implementation except that the post-teaching questionnaire included a additional open questions focused on students' experiences within the paper. The questionnaires included demographic information, Likert scale items and open response questions. Quantitative data were entered into SPSS and a two-tailed t-test applied to determine whether differences between pre and post responses were statistically significant. Qualitative, open statements were coded and examined for response themes. The research adhered to the university's ethical guidelines. Students' responses were voluntary and based on informed consent.

RESULTS

Table 2 shows the quantitative results for three Likert scale questions and displays the number of respondents (N), mean value responses and the 2-tailed, t-test significance (Sig). Significance values of 0.05 are significant at the 95% level and values of 0.01 or below are significant at 99% level or higher.

Table 2: Before and after responses showing number of respondents (N), mean response values and 2-tailed, t-test significance values (Sig).

	Before		**After**		
Question	**N**	**Mean**	**N**	**Mean**	**Sig**
1 How important is Technology to NZ as a country? (1-5) 1 = Not at all important, 5 = Extremely important	96	3.98	99	4.17	0.865
2 What do you think the subject/learning area called technology is mostly about? (1-3) 1 = no focus– marginally about, 2 = some focus, 3 = heavy emphasis					

Learning about electronics and machines	97	2.40	98	2.39	0.830
Learning about new inventions	96	2.27	96	2.47	0.310
Learning how parts of machines and systems work	95	2.24	98	2.42	0.211
Woodwork, metalwork, sewing, cooking	96	2.33	99	2.31	0.056
Learning about technology over time, place and cultures	97	2.39	98	2.57	0.040
Learning what experts in the community do in their job	97	1.91	98	2.22	0.027
Computers	96	2.68	98	2.37	0.010
Problem solving	94	2.34	98	2.85	0.000
Creativity, design & showing others your ideas	97	2.62	99	2.89	0.000
Thinking about the impact of technology	96	2.47	98	2.72	0.000
Planning and making things	95	2.53	99	2.83	0.000
Learning about resources/materials	95	2.38	99	2.75	0.000
Learning about what it means to do technology	97	2.34	98	2.70	0.000
3 Please indicate the extent to which you agree or disagree with the following statements. (1-5) 1 = Strongly disagree, 5 = Strongly agree					
Science and technology are basically one and the same thing.	95	2.25	99	2.26	0.800
Humans often develop new technologies to improve upon previous technologies.	96	4.21	99	4.27	0.726
Most environmental problems can be solved using technology.	95	2.72	99	2.95	0.536
Design is a process that can be used to turn ideas into products.	95	4.23	99	4.49	0.475
Engineering and technology are basically one and the same thing.	95	2.52	98	2.47	0.239
Technology is a small factor in your everyday life.	95	2.00	99	2.05	0.143
The results of the use of technology can be good or bad.	95	3.91	98	4.12	0.010

Perceptions of technology

The first question focused on perceptions of technology High mean values in Question 1 (3.98/4.17) show that a large majority of students considered technology to be very important to NZ as a country. The mean response increased after the paper but not significantly. This question was accompanied by an open response question – *Why do you think this*?

In the before questionnaire, one student who selected 2 on the scale, commented, "*Because it isn't a part of New Zealand's culture*."

Students who selected 3 (moderately important) had a range of reasons, for example:

"*Technology is extremely common in NZ. It can however have positive and negative effects which is why I chose moderately important.*"
"*It is important for the advancement of the country, but I don't think it's the be all and end all. There's nothing wrong with reading a real book, or writing things other than printing. We need to not depend on it*."
"*Because it is a part of the world we live in therefore important. But it is not an important part of all peoples lives like love and humanity is, so therefore only moderately important*."

Students in the before questionnaire who thought technology was very important generally cited the need for NZ to be internationally competitive and the important role technology plays in our everyday lives, e.g.
"*So we can keep up with the rest of the worlds advances in technology and to help grow NZ business wise*."
"*Because it is a part of our daily lives, without technology a lot of people wouldn't be alive*."

In Question 3, students' responses did not change significantly from before to after the paper except in response to 'The results of the use of technology can be good or bad' where there was a significant (0.010) increase in agreement with this statement after the paper.

In the after paper questionnaire, students were also asked the question 'Has your view of technology changed since completing this questionnaire the first time?' and, 'If yes, in what ways have your views of technology changed?' 85 (86.7%) students replied 'Yes' to this question. The majority of responses referred to a broadening of perceptions away from just computers, electronics and modern devices. For example,

"*I thought tech was about computers and electronics, however, now I know tech is much broader, ad it changes everyday.*"
"I used to think technology was just about electronics such as computers and cell phones but now I know it is much more. I now understand that technology involves solving problems, modelling, design and much more."
"That there is so much more involved. It is how things are made and work. It makes you see the world in a different way."

Perceptions of technology education

In Question 2, students were asked what they thought the subject of technology was mainly about. Responses to the statements in this question showed a large number of significant changes from before to after the paper.
Students' views of the extent to which each of the following is involved in technology education increased significantly:

- Problem solving;
- Creativity, design & showing others your ideas;
- Thinking about the impact of technology;
- Planning and making things;
- Learning about resources/materials;
- Learning about what it means to do technology.

Students' views as to the extent to which computers are a focus of technology education decreased significantly (0.010).

In the after paper questionnaire, students were asked the question ‘Has your view of technology education changed since completing this questionnaire the first time?’ and, ‘If yes, in what ways have you views of technology education changed?’

74 (78.7%) students replied Yes to this question. Responses tended to echo their comments regarding how their views of technology had changed, e.g.
“*Its not just about modern computers and phones”,*
“More than just making things”
“I know that it is much more than just cooking, woodwork, sewing etc,, stuff that you do in school, and has a broader context.”

Some had expanded their view of what technology education involved,
“A technology education is about learning and teaching about the ideas and the processes involved in developing ideas and improving products”

Others came to realise that technology education had an important role in primary education*,*
“Didn’t really understand why it was important in primary levels to learn about tech”, “I didn’t think it was a subject so heavily taught at Primary School, but it is and quite a large one”.

DISCUSSION
Our students enter our ITE programmes with a variety of views of technology and technology education. Like those reported in other studies (e.g. Burns, 1990), many students begin their ITE with a relatively narrow view of technology as a mainly modern development associated with high-tech, electronic devices such as computers and cell phones and that technology education will also focus on these things. While aspects of this type of view did not change significantly e.g. at the end of the paper, students still felt that technology education involved Learning about electronics and machines, Learning about new inventions, and Learning how parts of machines and systems work, at the end of the paper, their views on computers as a focus of technology education had reduced significantly.

The most significant changes occurred in the broadening of students’ views of technology education to more strongly consider other aspects - Problem solving; Creativity, design & showing others your ideas; Thinking about the impact of technology; Planning and making things; Learning about resources/materials; Learning about what it means to do technology - as important in technology education.

Although the questionnaire attempted to make clear distinctions between questions about technology and those about technology education, it is clear from students’ responses, particularly their qualitative responses, that their perceptions of technology and technology education were strongly entwined and for the large majority of students, a change in their views of technology was also accompanied by a similar change in their views of technology education. While perhaps not surprising, this result reinforces our view that prioritising the development of a sound understanding of the nature of technology is fundamental to successful ITE.

This paper has reported some of the findings from an initial survey and suggests a positive impact on student views in line with many of the aims and intentions of our technology ITE programme. However while we feel the results are generally positive, further analysis will be needed to more fully examine the data and consider how these findings might inform our practice. We also intend to refine the questionnaire for future use and look forward to combining our findings with those from other NZ ITE institutions to provide a national picture of students’ perceptions of technology and technology education.

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Giving Meaning to the Use of Tools: Some Elements of Discussion about ICT in the French Curriculum of Technology Education

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ABSTRACT
French school gives an important place to ICT-based environments. All subjects are concerned, and, specifically, Technology Education (TE). The aim is to develop the understanding about these technologies (and their social impact) and to give competencies to use these modern tools. Evidently, the link between understanding and abilities depend of the meaning gives to the educational situations proposed to the pupils. If we analyze this, we can define which kind of knowledge pupils need to use computer, to search information and to use it. This analyze need to pose the question of the references to this knowledge and to these skills. According with ergonomic studies as we can find in the recent psychological investigations, the problem is posed in terms of appropriation by the subject of a tool. We know that this process supposed to integrate a procedural process (how to use this tool) and a meaningful process (why I use this tool). We also know the weakness of the learning based on the operation control (because, it concerns only the procedural process). This question is essential if we want to imagine school situations that allow pupils elaboration of operational tools they master, notably about the significant knowledge they need to give meaningful to their practices. The aim of this paper is to introduce this discussion through two relevant situations, analyzed from the viewpoint of the teaching-learning processes:

Keywords: Teaching, learning, representation, tool, instrument, cognitive load, activity, strategy, solving-problem, ICT-based environment

INTRODUCTION
The development in the French schools of an ICT-based environment must facilitate learning for all the pupils. For that, this kind of environments aims to give to pupils a adapted help (Bastien & Bastien-Toniazzo, 2004). The various components of a digital learning environment have to take into account the knowledge constructed through the learning situations proposed in this environment (Balacheff, 2002; Bastien & Bastien-Toniazzo, 2004) with a focused consideration about the functional character of the knowledge, only way for giving it the necessary stability to an easy pedagogical use (Dupin & Johsua, 1989). The particularities of each pupil can be translated by different profiles of learners, integrated in the design of the environment. This is one of the ways to adapt learning to the specificities of learners that must be taken in charge when the man-machine interfaces are designed. (Tricot, 2007). It is not so easy to build this kind of model of the learners' knowledge. There is not a specific model that answers to this question, in spite of the number of studies on the subject. The main difficulty seems come from the real-time diagnostic of the needs of the learner (Leroux, 2002).

This paper aims to show that a cognitive analysis of the activity of pupils allows understanding some indicators of learners' profiles, enough solid to parameterize these environments, with a good efficiency from the viewpoint of learning and answers to the needs of learners. The cognitive analysis is based on how pupils face up the task according to the learning of knowledge referred (Bastien & Bastien-Toniazzo, 2004). This is to give meaningful to the target knowledge through a visual representation of the solution easy to remember, reduce the cognitive load, assist in the planning of each stages towards the solution through sub-goals' definition, provide relevant information about quality of action.

Analysing pupils' activities enlightens an important point of the teaching-learning process. We choose two specific moments in the courses of technology education for pupils aged of 13-14 years-old. They have to design, realise and improve an automated system, using Lego.

THE TEACHING-LEARNING PROCESS

Any learning situations mobilise many cognitive processes at different levels (Anderson, 2000; Mayer, 2005, 2008; Tricot, 2003). Learning, in teaching situations, is often costly cognitively and always difficult for the student who needs to make efforts (Musial & Tricot, 2008). Learning a new knowledge is even easier if the learning is based on prior knowledge, sometimes called precursors, and if the pupil understands the meaning (Cook, Wiebe, & Carter, 2008; Ginestié, 2011; Hérold & Ginestié, 2011; Mayer, 2008).

We identify two main forms of acquisition of knowledge: learning by discovering through action, and learning by instructions. Learning supposes to build the procedural schemes (how to do) and the semiotic schemes (why doing it and why doing it like this). This articulation between procedural and semiotic schemes defines a new knowledge and its functionality (Ginestié, 2008b, 2009a, 2010). The first form of acquisition, learning by discovering through action, is well adapted to learn procedures and to give meaning to the situation. In the teaching-learning process, the learning situation involves the success of the proposed task for that there is any learning. It is necessary to reduce the cognitive load linked to the situation by providing some guidance for the task's achievement (Chanquoy, Tricot, & Sweller, 2007). This guidance aims reducing the cognitive load induced by the situation and releasing sufficient cognitive resources for performing the task and for learning (Musial & Tricot, 2008).

Face to a new situation, the elaboration of a mental representation is the first cognitive process. The interpretation and understanding of the problem represent a major difficulty for the students (Mayer, 2005, 2008). This representation allows the learner to define the purpose of its activity and the use of pictorially supports helps him in the process of solving problems. At this stage, learner has to elaborate sub-goals, as intermediate states that must be achieved in order to reach the purpose.

Providing help to pupils for planning their actions supposes to show them, at every time, operations they have to perform. This reduces the cognitive load associated to the assessment of activities and decision-making inherent to the planning (Hoc, 2005). Simplifying the interface as far as possible (e.g. only one action at a given time) reduces the extrinsic cognitive load and limits the effect of dissociation of attention (Chanquoy, et al., 2007; Mayer, 2001).

EXPERIMENTATION

Methodological aspects

This project concerns technology education at the third year of the lower secondary school. The system they have to develop is a border-guard of a closed space - the territory to protect - by following a continuous black line painted on a white panel. The complete project is organised in different sessions, since the definition of the idea up to the finalisation of the robot. Two criteria qualify the chosen solution: the reliability and the velocity. The robot cannot cross the line. ICT-based tools are widely use at any time of the project. Pedagogical situations are based-on problem-solving and peers interactions through confrontations pupil-pupil and pupil-machine.

The teacher manages the class, the time and the sequencing of sessions. He/she organises general discussions between groups but he/she does not bring any knowledge, formal answer or validation of solution. He/she answers by a reformulation of the question.

This project, based-on 14 lessons of one-and-half hours each, involves 271 pupils - 141 girls and 130 boys in 10 classes from 10 schools - who work by groups of three, composed by gender and by school level (appreciated in different school subjects). This paper does not consider these indicators and presents two specific courses. In the first one, at the beginning of the project, pupils have to look for and collect information on Internet about the GRAFCET (a programming language) and use them to solve some exercises with specific software. The second one, at the end of the project, pupils have built their robot and designed their program; they have to implement the program on the robot, to test it and improve it.

GRAFCET is a graphic representation language very simple in which actions are outputs (when the system does something) and transitions are inputs (when the system gets information for changing from one action to the following one). When an action is activated and the condition of transition realised, the system progresses to the next action. This combination of different actions and transitions organises a sequence and it is possible to execute different sequences at the same time or to execute a specific sequence resulting of a choice (e.g. if the condition “a” is realised, it executes the sequence “A”, but if it is the condition “b”, it executes the sequence “B”). Pupils have to find and apply the rules of elaboration of a program.

The programs elaborated with the GRAFCET by the pupils use a software developed by our laboratory and with a post-doctoral trainee of Tel-Aviv university (Ilia Levin, 2000; Ilya Levin, Kolberg, & Reich, 2004; Talis & Ginestié, 2003). With the last evolutions, pupils can see their solutions through an automaton on the screen that simulates the sequences of actions by applying the transition conditions retained. They can compare the operations of the controller and the sequences' progress of the GRAFCET. In case of errors, the simulator stops and returns an error message. There is also an interface for implementing the program on different micro-controller, including Lego's one. Programming a sequence consist to drop some elements with the mouse and to affect actions or transitions to each of them. The characteristics of each element are a free choice, so, pupils can confuse action and transition or develop incoherent solutions without any soft limitation; they just see the simulation of their choices. Information about users' activities, such as elements chosen or not, tests done, time spent..., are collected in background.

Treatment of information collected on the web

When pupils start this session, they discover GRAFCET for the first time. Rather than a classical organisation, teachers ask to pupils to find the appropriate knowledge on the web. At this level, they know finding information on the web and they know some major concepts about systems as input, output, processor, added value... In this task, they have to link input and transition, output to action and to draft a GRAFCET with the appropriate symbols.

Each pupil performs the exercises individually but they work together by group when they investigate on the GRAFCET and when they collect information. The exercises involve three different levels of use. The first concerns the simple sequential succession of actions and transitions. The second concerns the simultaneous execution of two different sequences. The third concerns the conditional execution of one sequence according to the validation of transitions. At any time, pupils can consult web sites or test their solution through the automaton. Our indicators are, on the one hand, the number of web pages consulted and their degree of relevance and, on the other hand, the distinction between actions and transitions, their succession, and the chronology organisation of sequences. We also look at the number of tries and their logic before they find a good solution.

Robot programming

At this stage, pupils realised their robots and they experimented moving (forward, back, turn...), controlling the actions (activation of motors in different directions) and collecting the inputs (detection of change of colours or obstacles). They did choices and solved many problems; they tried and improved every solution they chose. They realized the wiring of all parts (battery, microcontroller, motors, sensors, inputs, outputs, devices...). The robot they built is operational and they designed the control program.
Now, they have to draft this program with the specific software and they have to implement the program on the microcontroller. We are looking for how they use the software, trying to understand the role of the previous learning on their activities in terms of planning, organising, development and control, and how they use previous knowledge learned and their operational level, with a specific attention, here, for the software use, if it is an help or a barrier, and for the use of the web to find some complementary information.

SOME RESULTS

At the end of the first session, all the pupils realised all the exercises. They consulted and collected information about GRAFCET on the web . The great majority (75%) consulted ten to thirty pages. A few has consulted less of ten pages and 30% of pupils consulted a high number of pages. The great majority found relevant information but among many un-relevant. There is a high level of correlation between the number of pages consulted and the level of relevance. The level of relevance is very low when the number of pages is very low or very high; this level is very high when the number of pages is between ten and thirty, with an optimum around 22 pages. More precisely, the relevance grows up to this optimum and then decreases.

We have a better understanding of the pupils' strategies through the realisation of the exercises with the specific software. All the pupils found the good solution for each and it is interesting to see how they did. About 25%, mainly those who were the most relevant in their web searches, alternated these searches and their progression in the exercises. We can observe the great interaction between these two activities. Some other (about 20%), majority of those who consulted less of ten pages and those who consulted more of thirty pages, spent a long time on the web searches and then they spent all their time trying to solve each exercise. For them, they changed of activity and never go back to the web search. The rest of the pupils developed some alternative strategies; they progressed in the exercises with the help of other pupils, through questions to the teacher or by exploitation of the general discussions. The information they collected by this way seems enough to find solutions.

Three profiles can be identified through activity's organisation. 20% of pupils compose the first. Their strategy is based on the relevance of the use of keywords (GRAFCET, program, input, output...) with the search functions to localise the sites. Their searches become more precise and they spend little time on non-relevant pages. They progress step by step, using the backspace functions but they don't bookmark the interesting pages. The number of pages consulted depends directly of the efficiency of their strategy. Use of web is not a barrier; they know what they look for. Their initial representation becomes clearest: they organise their actions by fixing sub-goals relevant to the general goal. They make frequent go-and-back between the web and the exercises. The ICT-based environment helps them to solve problems.

The pupils (55%) of the second need an extern help to progress. They also use the search functions with keywords, they progress step by step and they interacted between the web and the exercises but they look for confirmation at each step. They prefer teacher's answer but they accept classmate's advice above all if they made it without ambiguity even if it proves inaccurate. For them, the general goal is clear but they are not sure of their strategies. They have a good initial representation; the fact they ask for external validation confirms the lack of confidence in the definition of the sub-goals when they plan and organise the different actions to do. In this case, the ICT-based environment brings a weak help. They need an institutionalisation of their choices in a human-human relationship and do not have confidence in their own relation human-machine.

The third (25%) is quite more heterogeneous. As main common feature, they use the environment without any general strategy. They use the navigator and the software as independent task without any link between the both. They give up easily without taking trouble to build meaningful between the various elements. They permanently look for external help; they are perturbed by the fact that the teacher answers only by a new question. Many videos show their quest of the good answers to their classmates. The unusual class' organisation also perturbs them; they attempt re-establish their familiar relationships: some shout at other through the class, some move... what requires teacher's intervention and his authority to maintain normal life in the class.

In the second session analysed, pupils program their robot. The small groups of three are more stable, they are more familiar with the pedagogical organisations because of the time spent between the both. We do not observe agitation of the first session. The peers' interactions are more efficient and they know the resources of each. They find easily the general goal, what they have to do and how to do. These changes of attitude are really interesting: giving meaning to the aim and clearness to organisations that engage them in a positive attitude. In fact, all the pupils develop their program; they implement it on the microcontroller and proceed to many tests. The discussions are constructive, relevant and efficient. The level of satisfaction is very high each time they develop a good solution. The differences between groups are not on the project's finalisation but also on strategies.

Generally, we observe more confidence in the use of environments and the problem-solving appears easier, e.g., they establish without hesitation the relations input-transition, and output-action. We observe a class effect: different groups in a class share the same ideas - solutions are not strictly identical but based-on the same principles - due to general discussions organised by the teacher and also exchanges between groups. Understanding this process of identification and differentiation is an interesting point. At this moment, pupils took conscience of the challenge: if their solutions are strictly identical, the robot performances will be the same. They use same Lego and devices; the only way to make the difference is the performance of their programs. Analysing their strategies according to their profiles observed before gives us some understanding keys.

The groups (14%) of the first profile develop very quickly a first program, ensuring a first functional base that they test. Then they improve it; for that, they massively use the software simulator before implementing it on the robot. They simulate all ameliorations and we observe many discussions between them. They think in terms of programs as well as structure of the robot (sensors' position, mechanisms as motors, wheels...). They understand that they can maximize performances by reducing response time on the robot position and that depend of the placement of two sensors of light at a short distance. They also maximize performances by programing of simultaneous sequences that control motor movements and velocity. Finally, their concentration to maximise the velocity and the follow-up of the line leads to an efficient solution.

The second regroups 72% of pupils. They are concentrated on the follow-up of the line and not on velocity. The control of the position of the robot is a real problem for them. They try to solve the detection with only one sensor and they need time to understand the benefit of use of two sensors. When they understand this, they minimise the role of the second. For them, the two motors are controlled every time together with three states: go ahead, turn right and left. They never think about parallel sequences with distinct controls; the movement is choppy and path's corrections are amplified. They frequently ask teacher's help and look for the classmates' solutions. At the end, they build a solution, good from the viewpoint of the line's follow-up but not in terms of velocity. To optimise their solution, they proceed by blind strategy of test-error

without traces of a global thinking. They don't use the simulation for improve solutions. The web search is not really used and when they do it, it is not efficient and relevant.
The last group (14%), like the precedent, is centred on the line's follow-up; they try to maintain the sensor on the line. For turning right or left, they stop one motor; they don't think about the possibility to inverse the motors' rotation. They don't use the simulator and the web search. At the end, they haven't a global strategy and they request solutions' elements to their classmates but without any possibility to understand the choices done. Because of this, they cannot optimise the program and the functioning of the robot. They produce an opportunist solution based-on the help of their classmates.

CONCLUSION AND DISCUSSIONS

This study gives us some ideas about the role of the ICT-based environments. The groups of the first profile are in a process of instrumentation (Ginestié, 2011; Rabardel & Béguin, 2005; Vérillon, Leroux, & Manneux, 2005). They progress toward solution by using different environments as tools and, simultaneously, they build procedural and semiotic schemes. The cognitive load weighs more on the strategy's elaboration than on the situation. The decrease of number of groups between the sessions testifies of the complexity of this double process. These results are confirmed by the productions of the groups of the second profile. For them, this elaboration is difficult and the pressure weighs on the situation. The low master of environments gives them some troubles, sufficient for requesting external help. They have some good intuitions about the general meaning but insufficient for defining sub-goals and an efficient strategy. Learning is not easy and requires time, as demonstrate the increase between the sessions of the number of groups in this profile.

At the end, the organisation of courses based-on project, problem-solving and strategies management gives good results. We see that pupils can elaborate relevant solutions and build knowledge without teacher's supports. They find relevant information and they use them in their own strategy. There is some limits but we better understand relationships human-machine and human-human. Specifically, we better understand the new role of the teacher as situations' manager rather than knowledge referent. His role is important in terms of authority and institution referent. This role is sufficient to help pupils, even if he doesn't directly answer. Evidently, this supposes a specific training to change their habits and their representation about learning and about teaching. (Ginestié, 2008a, 2009b).

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Unpacking the Thinking behind Sustainability: A Macrocognitive Perspective

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ABSTRACT
Students in technology classrooms are rarely asked to think about sustainability except in terms of a narrow range of practices. These might include using recycled materials for materials efficiency, using environmentally preferred materials, displaying efficiency in use, allowing for disposal/recycling issues and conducting a life cycle analysis as part of a design process. Yet the contexts in which sustainability might be practiced are not confined to the physical world but also include social, cultural, emotional and cognitive contexts. Addressing multiple contexts simultaneously and sympathetically requires that we understand the thinking behind our decisions and actions.

In contrast to conventional research on cognition that occurs in laboratory contexts, macrocognition is an emerging field of research that considers how people think and act in real-world contexts. Macrocognitive functions include decision-making, sensemaking and situation assessment, planning, adaptation, problem detection and coordination. These basic functions help professionals manage uncertainty, turn leverage points in situations into courses of action, manage attention, promote mental simulations and develop mental models. This paper critically explores how these functions and supporting processes provide a rich set of mental processes by which sustainability can be conceptually described, explained, and leveraged into action. Given appropriate learning experiences, learners can develop sustainability as a conscious and defensible habit of mind as well as a suite of context sensitive actions.

INTRODUCTION
This paper explores emerging fields of research in thinking and the naturalistic enquiry known as macrocognition in particular. Sustainability is used as a framework for this exploration and the primary and supporting processes of macrocognition will be shown to be extremely powerful processes to help develop deep understanding of sustainability issues. These understandings will be shown to be leveraged by the transfer of learning towards the development of habits of mind that reflect flexible and adaptable thinking processes akin to that demonstrated by expert performers in a wide range of domains. It will be argued that these deep thinking processes are a highly desirable goal for technology education students.

Keywords: Macrocognition, habits of mind, understanding, sustainability

THE CONCEPT OF SUSTAINABILITY
As construed in the F-10 curriculum documents presented by ACARA (Australian Curriculum Assessment and Reporting Authority), sustainability is "…futures-oriented, focusing on protecting environments and creating more a more ecologically and socially just world through

informed action." The document goes on to stress the need to consider environmental, social, cultural, and economic systems and their interdependence. This definition extends that proposed by the Brundtland Commission of the United Nations in 1987 (WCED, 1987) by including cultural sustainability as a core element. Both focus on considering development that does not compromise the opportunities of future generations. A common way to represent the nature of sustainability is in the form of intersecting Venn diagrams such as that shown below (Figure 1)

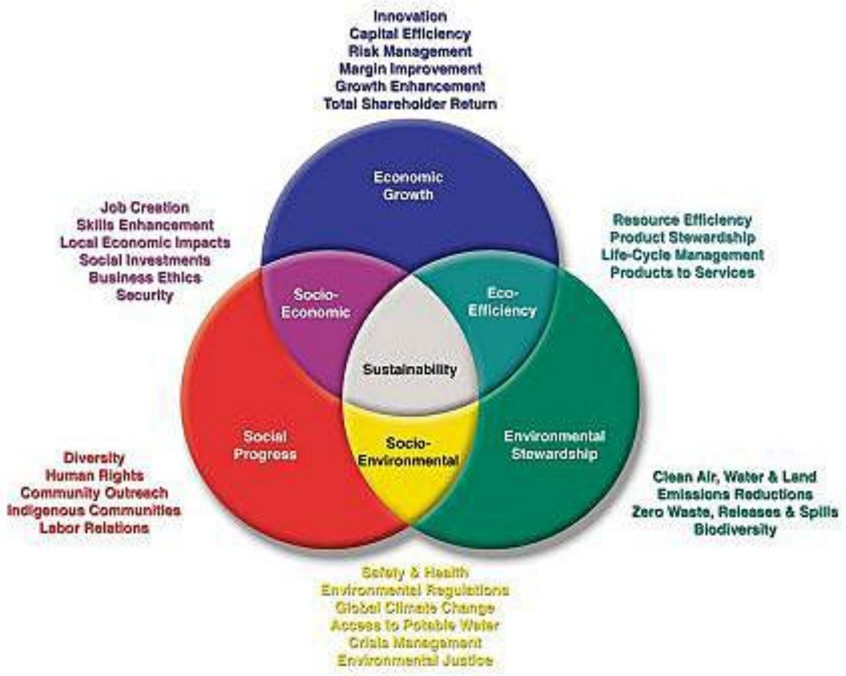

Figure 1: Sustainability (olis.uoregon.edu)

Each of the dimensions contained within the concept of sustainability can be considered on its own or in concert with the other dimensions (though the cultural dimension is absent in this version). The environmental dimension encompasses natural resource usage, environmental management, pollution prevention and control, habitat and land, constructions and settlements, emissions and waste. The social dimension might consider standards of living, educational opportunities, sense of community and equal opportunities for work and leisure. The cultural dimension would be concerned about engagement and identity, performance and creativity, belief and meaning, gender and reproduction, enquiry and learning, health and wellbeing. The economic dimension would be concerned with production and resourcing, exchange and transfer, accounting and regulations, consumption and use, labour and welfare, technology and infrastructure, cost savings and efficiencies, economic growth, research and development, and profit as an outcome for participants in an open market.

The interactions between each of the dimensions yields business ethics, fair trade and worker's rights at the intersection of economic and social dimensions; energy efficiency and incentives for the use of natural resources at the intersection of environmental and economic dimensions; and environmental justice and natural resource stewardship at the intersection of the environmental and social dimensions. At the intersection of all of the dimensions lies the overarching concept of sustainability.

Understanding the complex and interdependent nature of the concept of sustainability takes a long time. Framing and reframing this concept requires sustained thinking on each issue or problem as it might relate to one or more of the dimensions of sustainability in relation to a specific context. This process is further complicated by the changing nature of the each of the dimensions within the concept of sustainability. The changes wrought can be technological, social, political, cultural and temporal in nature. Resources usage changes as non-renewable resources are depleted or other more efficient or financially viable resources replace them. This change leads to technological and social changes. Social changes can force recycling of certain materials e.g., uranium fuel rods, or encourage them through economic subsidies e.g., container deposit legislation, aluminium can recycling, impact other dimensions of the sustainability concept. They change and often distort the economics of materials, production processes and so on. Our current societal interest in renewable energy is an example of the tensions that occur between economic factors (cost of coal versus cost of non-base-load wind or solar energy), and social, environmental, and cultural factors. Short-term economic and social goals often trump long-term environmental goals in these debates.

Making sense of the issue of sustainability in the context of the technology classroom demands that we pay attention to the entire concept of sustainability and not just a small subset lest sustainability be reduced to a standard set of ritualised actions. That small subset can be seen for example, in the focus on recyclable and/or renewable materials, on the decision to undertake a life-cycle analysis of a product when designing it, or the goal of embodying energy/thermal efficiency in a home design by regulating the heat load on the building (see Figure 2). Simplifying a complex concept into a small number of "design factors" necessitates taking a surface and short-term view of sustainability. It often means ignoring the cross-impacts of decisions on the other dimensions of sustainability. This, in turn demands far less integrative thinking from the technology student and can lead to simplistic and unrealistic learning around the concept of sustainability. Yet there are a number of techniques readily at hand that facilitate our understanding of interactions across dimensions of factors. For example, cross-impact analysis (Gordon & Hayward, 1968) has been used for decades in financial forecasting and can be applied equally well to sustainability issues.

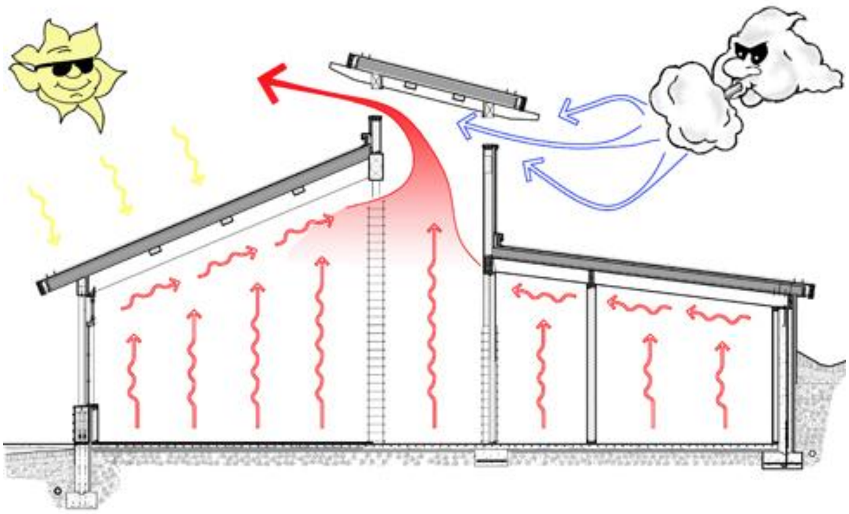

Figure 2: Thermo-siphon design for cottages from bialeckiarchitects.com

In a school context, technology students often demonstrate their learning and understanding of sustainability by doing a life-cycle analysis for their major design project in Design and Technology at the Higher School Certificate. Or they choose to use plantation timbers because they come from sustainable harvesting of forests. Sustainability becomes a simplistic, ritualised process. What is lost in this equation is an understanding of how you can think and learn about sustainability in a broader sense and in so doing, contribute at a more fundamental level to society. Changing focus means using more comprehensive thinking and decision-making approaches that deal at much deeper levels with what each student knows and needs to know about their own knowledge. It also means considering how one can leverage experience and transfer knowledge from one problem to another whilst thinking and acting flexibly and adaptably. This demands the abstraction of core ideas and projection of those abstractions into new contexts and problems.

MACROCOGNITION AS A BROADER LENS WITH WHICH TO UNDERSTAND SUSTAINABILITY

Research on cognition has traditionally been investigated in laboratory settings. The results from laboratory studies have been challenged in more recent times as researchers have sought to understand cognition in authentic contexts and at a level that is closer to lived experience. This level sits above microcognition that is concerned with memory and abstract reasoning processes (and has been extensively catalogued in laboratory studies), and below design processes that are far too broad and which provide little if any guidance to learners (or for teachers) though design perspectives are changing to embrace sustainability issues more holistically (see for example, Manzini, 2010). This naturalistic thinking process research has identified a descriptive macrocognitive model (Schraagen, Klein, & Hoffman, 2008) that posits a range of primary thinking and supporting functions (Figure 3).

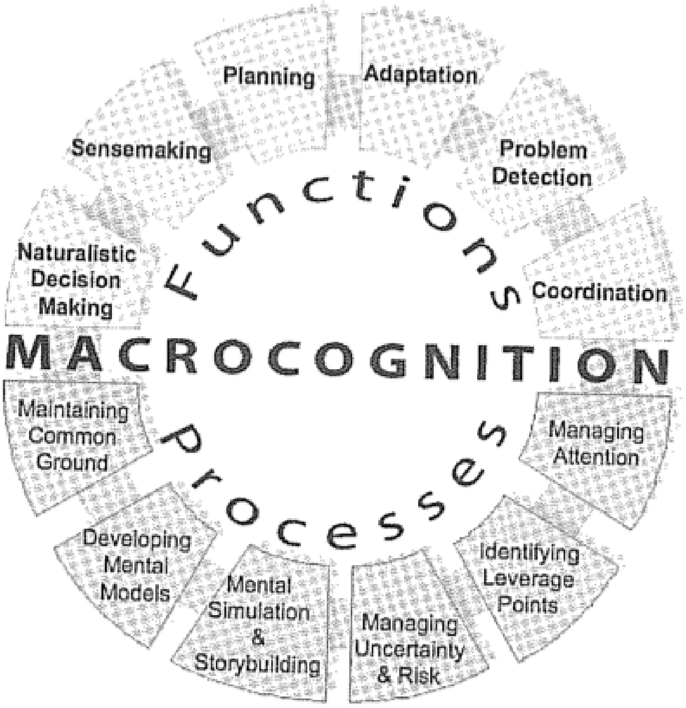

Figure 3: Primary and supporting macrocognitive functions (Schraagen, Klein, & Hoffman, 2008 p.9)

The primary processes afford great importance to perceptual processes as an antecedent to analytical and synthetic processes. What is not immediately apparent in the model is that the primary functions and supporting processes operate in a highly interactive rather than discrete way. Changing perceptions of an environment/situation can lead to emergent problems that then force adaptive replanning and change sensemaking. Mental models become challenged in the light of the new information/data and new stories are made up or emended to better explain the unfolding events. Different leverage points emerge that offer improved opportunities for action and help manage uncertainty and risk. This processes is ongoing and highly context dependent.

Within the Macrocognitive model, naturalistic decision making (NDM) describes how experts size up situations, identify reasonable course of action based on observable cues, and test them out. Figure 4 represents the NDM process. A sense of what is typical and familiar is important in this process because it allows for the development of plausible goals and then the initiation of a typical course of action. Importantly, decision choices are usually the first ones, rather than one born of comparing multiple options. In the case of sustainability, the NDM perspective allows for the learner to judge whether the problems they are encountering are like those they have encountered before and therefore choose appropriate problem solving strategies as a satisficing option, rather than one requiring much deliberation and debate. Where relevant cues recognised from prior experience are not present the learner can then abstract out the underlying features of the problem and initiate more unique and appropriate problem solving processes. This is mindful action.

One of the features of the NDM model is that it draws on long-term memory in the form of prior knowledge/mental models, and short-term memory through patterns observed in a context, through the process of mental simulation of potential ideas (about sustainable actions), and through action scripts that translate reasoning into actions (e.g., choosing to use recycled materials in a design). This is an open dynamic process and is subject to change when more cues become available, new knowledge is added, or early solution attempts do not yield good outcomes. Reflection and metacognitive control of thinking is exerted in order to control, regulate and direct subsequent thinking. These reflections are used to challenge and reason about prevailing mental models.

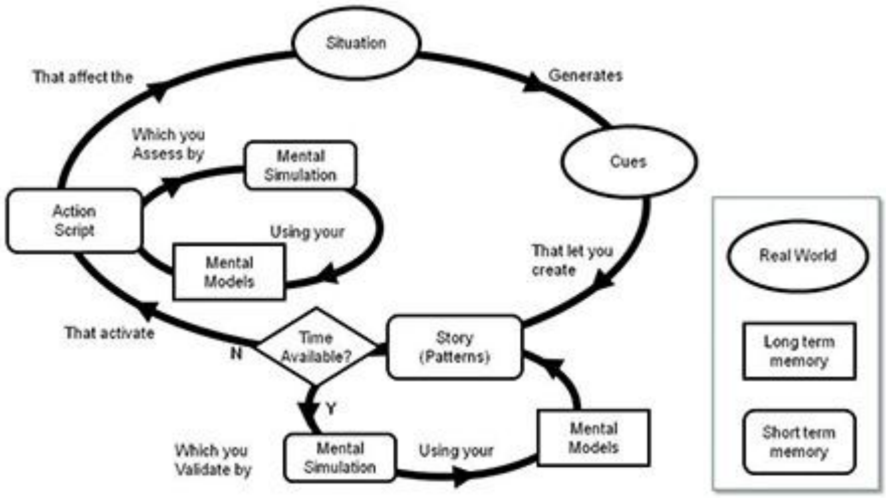

Figure 4: The Naturalistic Decision Making model (www.pnnl.org/coginformatics/media/decision_model_sm.jpg).

Mental models are an important construct in research on thinking (see for example Johnson-Laird, 2010) since they are seen to be central to reasoning. Mental models are an iconic form of internal representation of part of the surrounding world, and include the relationships between the various parts held in long-term memory, and they also include a persons' enduring beliefs and expectations about what they are like. They exert a considerable effect on a learner's behaviours as well as their thoughts and feelings because of their internal structure and content and also because they cause selective attention within specific contexts. Mental models can be developed from observation, imagination and through discourse (Ibid).

Close examination of the NDM process in Figure 4 shows some of the problems that can occur for learners new to the concept of sustainability. Naive learners do not hold complex mental models of sustainability. In fact, Klein and Hoffman (2008) argue that, on the basis of research on laypersons and students, " …mental models can be fuzzy, implicit, mostly wrong, vastly simplified, dynamically deficient, broad, amorphous, and so on" (p.61). Poor mental models make it harder for technology students to recognise cues in their environment/context that they can use to discern patterns that, in turn, match their prior knowledge and understanding of sustainability. This dilemma speaks to the need to cycle through important concepts such as sustainability many times if understanding is to happen. The cycling must pull out underlying, abstract features of the context to facilitate decision making. Furthermore, any course of action based on a fuzzy or incomplete or simplistic model will necessarily be simple as well. Routine approaches often dominate in these circumstances since they have been reinforced in classrooms, in textbooks, or in the wider media. The interactive nature of the dimensions of sustainability cannot be acknowledged, addressed and serviced in this situation. Learning cannot be transferred and habits of mind cannot emerge. Learning then becomes fixated on a few common sustainability practices and the broad concept cannot be remodeled and further developed.

A companion process to NDM is sensemaking. The process of sensemaking is, according to Klein, Moon, and Hoffman (2006, p.71) "a motivated, continuous effort to understand connections (which can be among people, places, and events) in order to anticipate their trajectories and act effectively" rather than the state of knowledge underlying situation awareness. Sensemaking can be seen to be the deliberate effort to understand events and is typically triggered by unexpected changes or surprises that make a decision maker doubt their prior understanding. Sensemaking is the active process of building, refining, questioning and recovering situation awareness (SA - see Endsley, 1995). This process demands careful attention is paid to a particular context and involves the activation or prior knowledge in order to make sense of current events. Limitations in prior knowledge and experience of sustainability will necessarily limit the extent to which a learner can make sense of a specific context and set of problems.

Mental simulations are a component part of the NDM process itself and are also a part of the broader macrocognitive framework. Mental simulations are a conscious effort to enact a sequence of events such as imagining how a sustainability solution will work out in the future. A life-cycle analysis can be considered as an externalised mental simulation. They are necessary in order to work through solution scenarios. Simulations have to make sense. Mental simulations also help in the process of problem detection because they help identify initial factors that might load on sustainability scenarios and solutions. The manner in which simulations are built is through the complementary process of story building.

Stories help us make sense of events and aid understandings. They must be plausible and internally consistent, economical by covering details without becoming too inclusive, and have uniqueness by not being open to alternative interpretations. Stories reflect prevailing mental models and so it is not hard to see how constrained mental models of sustainability limit the stories students can tell. Stories are also causal chains and mostly involve people and their intentions whereas mental simulations tend to address sequences of events for objects as well as people. Stories organize events into a meaningful framework and serve as natural experiments (Klein, 1998). Little experimentation can occur when mental models of sustainability are weak.

Moving towards informed action, transfer and habits of mind

Part of the thesis presented in this short paper involves the idea that the concept of sustainability must be approached holistically through the process of informed thinking. Informed action does not reflect ritualised use of existing methods and materials, but rather a deliberate, mindful attempt to think and act. As such it emphasises the overt nature of thinking and acting, and thus the transfer and adaptation of prior knowledge into new contexts and problems. It also speaks to the need to "see into" situations in context at a far deeper level and make sense of them by building on and elaborating existing knowledge. What emerges by employing and developing macrocognitive skills is initially the transfer of that knowledge and skills, and finally by the development of habits of mind that will continue to guide thinking and acting in the future.

Recent conceptualizations of the phenomenon of transfer see it as preparation for future learning (Bransford & Schwartz, 1999). In this view a broad set of knowledge and skills are used flexibly and adaptively in new situations. The macro-cognitive core and supporting processes must be adapted to new contexts. This must involve mindful abstraction of core concepts and then their transfer across domains. Yet it is commonly accepted that individuals do not transfer knowledge and skills readily from one context to another. The further one context is conceptually from another the weaker the transfer that may occur (Ibid).

For effective utilization of the macro-cognitive processes as measured by their appropriate, contextualized application, the transfer must be of the "high-road" type (Salomon & Perkins, 1989) rather than the low-road type. High-road transfer depends, according to Bransford, Brown and Cocking (2000, pp.235-237), on a number of factors including a sufficient degree of original learning, retrieval or relevant prior knowledge, developing abstractions and principles to apply in future situations, emphasizing meaningfulness and understanding in tasks demanding sustainable knowledge and skills, and learning in multiple contexts.

This would mean, for example, undertaking a range of activities that demanded adaptable consideration of the concept of sustainability in various contexts. This must occur at least three times in its entirety if understanding is to happen according to seminal work on classroom learning by Nuthall (2007, 2000). One of the challenges technology teachers face is that much of the transfer we observe is of the low road type where there are obvious similarities in contexts, processes and materials. In these situations, it is possible to see how a restricted mental model of sustainability would also emerge. Little deep processing is going on and there is little evidence of any abstraction of ideas or classification of the task requirements. Learners become focused on ritualised use of processes just as they have with design activities. These issues are further exacerbated by the lack of opportunities to cycle through important concepts in their entirety at least three times for those concepts to become part of long-term memory (Ibid).

To further enhance transfer it is necessary to abstract key or core concepts from the existing context. This can be helped by requiring technology students to specify links or connections across many design contexts or problems that include one or more sustainability dimensions. Sustainability thinking thus involves activating relevant prior knowledge and then building on it and augmenting it through the abstraction of new knowledge. At the same time existing misconceptions and mental models as well as cultural and social biases are also challenged. This process cannot be routine but must be mindful and quite deliberate. This process develops deeper understandings and requires the development of such dispositions as the ability to be open-minded, to suspend disbelief, to persevere in the face of ambiguity and complexity, and to develop the courage to ask probing questions as part of situation assessment and sensemaking processes. Good judgment and sound decision making emerge. Habits become "second nature". However, the flexible and adaptable use of macrocognitive processes leading to transfer and the development of habits of mind poses an interesting dilemma.

Conditioned habits are by there very nature automatic in order to increase the efficiency of their use (in part by reducing cognitive load (Sweller, 1988)). However, automaticity can undermine the flexible and adaptable use of knowledge embedded in long-term memory. To resolve this dilemma, Costa and Kallick (2008) argue that the learner/performer must be mindful in their use of habits they have acquired and automated. This view is consistent with what we know about experts, particularly those who are adaptable (Bransford & Schwartz, 1999; Feltovich, Spiro, & Coulson, 1997; Hatano & Inagaki, 1986). A technology student's thinking about sustainability must therefore strike a delicate balance between automated thinking on one hand, and mindful, overt thinking on the other for each and every task they attempt. Only then can contextually appropriate actions emerge.

CONCLUSION

Habits of mind can be developed in technology learners to come to grips with the concepts of sustainability in context. The macrocognitive thinking processes underlying cognition in context can be used to learn deeply about sustainability, to abstract key concepts and to mindfully transfer that knowledge to new contexts, thus demonstrating transfer of learning and understanding in the process. More importantly, the knowledge developed will help enrich and build on prevailing mental models and thus facilitate future learnings around sustainability. Powerful habits of mind can be the outcome.

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Bridging Design Research and Theory with Teaching and Learning

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ABSTRACT
Students' ability to design has become a key component of many STEM education publications (AAAS, 1993; ITEA, 2000; NRC, 1996). As pre-engineering enters K-12 education, design has been suggested as a central curricular focus of technology education (Hynes, 2010; Kelley, 2008; Wicklein, 2006). The value of design is already supported as a pedagogical approach through design-based teaching and learning, as it has been applied across multiple disciplines (Crismond & Adams, 2012; Doppelt, Mehalik, Schunn, Silk, & Krysinksi, 2008; Fortus, Dershimer, Krajcik, Marx, & Mamlok-Naaman, 2004; Jacobson & Lehrer, 2000; Wells & Ernst, 2012). Recent research has revealed design experiences increase mathematics and science achievement and spark student interest in STEM fields (Crismond & Adams, 2012; Katehi, Pearson, & Feder, 2009). Furthermore, emerging research on design has examined perceptions towards design (Daly, 2012), student's design cognition during practice (Atman & Bursic, 1998; Atman et al., 2007; Eckersly, 1988; Gero & Kannengiesser, 2004; Purcell & Gero, 1996), and suggestions and theories for addressing teaching and learning of design (Crismond & Adams, 2012; McCormick, 2004). However, as teachers' instructional strategies and preparation are not grounded in cognitive research or evidence based findings (Kelley, 2008), it's posited that there has been minimal research undertaken to examine and bridge these findings into practice (Crismond & Adams, 2012).

The purpose of this paper is to present an examination of recent research on design and learning to reveal promising recommendations and associated implications for technology teachers and teacher preparation. This investigation will present key issues and limitations of prior research and offer alternative research suggestions for investigating this pedagogical approach. Secondarily, from this examination a Design-Based Learning (DBL) framework of categories and a proposed research agenda will be developed that seeks to bridge theory and practice.

Keywords: Design Cognition, Design Research, Design-Based Teaching and Learning

INTRODUCTION & BACKGROUND

Research suggests students' learn best through active learning experiences. This view of learning coincides with the belief that "people construct new knowledge and understandings based on what they already know and believe" (NRC, 2000, p. 10). Thus, when students confront new experiences, they reflect on past experiences, allowing for the creation of new or revision of existing knowledge (Daugherty & Mentzer, 2008). With this in mind, the purview of an instructional activity should be to effectively bridge past and new knowledge. With "compelling evidence that active learning can produce substantial gains in learning when compared with traditional methods of instruction like lecturing" (Mastascua, Snyder, & Hoyt, 2011, p. 69), the design process has been suggested as one viable active learning method that can assist in developing students' schema and bridge prior and new knowledge.

Students' ability to design has already become a key component of a variety of STEM education standards publications (AAAS, 1993; Achieve, Inc, 2013; ITEA, 2000; NRC, 1996). This focus has led to design-based teaching and learning (DB T & L) pedagogical approaches (Wells & Ernst, 2012). DB T & L has already been implemented across all STEM education subjects (Crismond & Adams, 2012; Doppelt, Mehalik, Schunn, Silk, & Krysinksi, 2008; Fortus, Dershimer, Krajcik, Marx, & Mamlok-Naaman, 2004; Jacobson & Lehrer, 2000; Kolodner et al., 2003). More recently, universal pedagogical approaches such as Integrative STEM Education (I-STEM ED) have also been created to intentionally provide students opportunities to apply existing or discover new knowledge while solving ill-defined design challenges.

Within technology education, design has been suggested as a central curricular focus (Hynes, 2010; Kelley, 2008; Wicklein, 2005). Literature on assessment strategies, consensus on teacher needs, and curricula have already been presented to the field. However, although research on design has been widespread across multiple educational disciplines and professions, minimal investigation on students design thinking in technology education has been undertaken (Hynes, 2010; Lammi & Becker, 2013). As Mastascua, Snyder, and Hoyt (2011) posit, "for the teaching-learning process to be effective, it is important to understand what happens in the minds of students trying to learn new material" (p.11). They further suggest, with basic understanding of research on the learning process, instructors can "evaluate teaching strategies and to explain problems when they occur" (p. 11). As technological/engineering design further enters K-12 STEM education, "professionals in the field of technology education should make use of research-based content and instructional methodology in the creation of an overall curriculum framework for understanding and implementing engineering design" (Wicklein, Smith, & Kim, 2009, p. 74).

The purpose of this paper is to review recent design cognition research methods and present a research design that will be undertaken in an upcoming study. In the following section, it is the researcher's aim to not capture and synthesize all existing design research methods, rather, to serve as the author's prerequisite research foundation necessary for conducting future studies.

DESIGN COGNITION RESEARCH

Design is widely considered a very complex and difficult process to describe, making it challenging to provide instructional resources to teach it (Dym, Agogino, Eris, Frey, & Leifer, 2005). Even after over 40 years of design research, investigated through a variety of methods (Aurigemma, Chandrasekharan, Nersessian, & Newstetter, 2013), there is still minimal agreement on how people design or most effective research methods to describe it. Prior participants of design cognition studies have commonly consisted of practicing engineers, design professionals, and engineering students at the tertiary level. Previous studies have included expert-novice comparisons, traditional versus digital sketching environments, working through the entire design process, and perceptions of design. However, minimal focus on K-12 education on students' design cognition has been explored (Lammi, 2011; Lammi & Becker, 2013). This challenges educators, whom have little evidenced-based support on students design thinking, as they implement DB T & L pedagogical approaches in their classroom.

VERBAL PROTOCOL ANALYSIS METHOD

One method used to investigate and analyze design cognition is protocol analysis. Although verbal protocol analysis (VPA) is not the only method of assessing engineering design thinking, it has been a valued approach repeatedly applied (Atman & Bursic, 1998; Tang, Lee, & Gero, 2011). VPA can be performed through two methods, retrospective, where participants verbalize their thoughts as they recall a finished design, or concurrent protocols (Tang, Lee, & Gero, 2011). Concurrent VPA is a "research method in which subjects think aloud as they solve problems or perform a task" (Atman & Bursic, 1998, p. 121). This process concurrently captures students' thought processes through audio-visual equipment, then is transcribed and segmented. Once segmented, a prior coding scheme is applied or one emerges. "This method allows us [researchers] to study the content of what a subject says, organize that content, and analyze it" to "gain an in-depth understanding of the processes students use to solve engineering design problems" (Atman & Bursic, 1998, p. 121). This process can be used for comparative analysis to "determine if specific classroom experiences affect student design processes" (Atman & Bursic, 1998, p. 121).

FUNCTION-BEHAVIOR-STRUCTURE ONTOLOGY

Prior VPA studies have utilized a variety of coding schemes to describe design cognition (Christiaans & Dorst, 1992; Cross, 2001; Ericsson & Simon, 1993; Guindon, 1990). However, "very few coding schemes have been re-used by researchers other than those who established them" (Tang, Lee, & Gero, 2011, p. 3). Furthermore, "most of the coding schemes that have been re-used by different researchers were produced in continuous research papers under the same supervision" (Tang, Lee, & Gero, 2011, p. 3). One such coding scheme that has been developed is the Function-Behavior-Structure (FBS) ontology (Gero, 1990; Gero & Kannengiesser, 2004). This ontology, illustrated in Figure 1, is categorized into six codes, and described in Table 1.

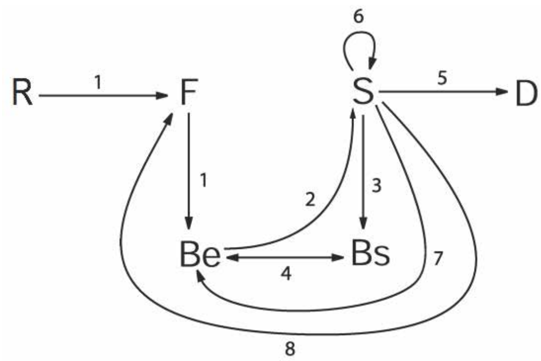

Figure 4. Structure of FBS ontology. Personal communication with John Gero

Table 1
FBS Coding Scheme

Code	Description
R	Requirement
F	Function
Bs	Behavior from structure
Be	Expected Behavior
S	Structure
D	Description

Note. Adapted from "Generalizing Design Cognition Research" by J. Gero, 2010, *DTRS8: Interpreting Design Thinking,* DAB documents, Sydney, pp. 187-198.

Following coding and arbitration, students' thought processes can then be linked to a specific step in the design process. Table 2 presents the eight steps designers have suggested to work through. At this stage, students' thought processes can be subjected to statistical analysis using various methods. Some examples include time spent on each segment, reasoning between FBS categories, paired t-test comparisons between groups, or correlational studies. Graphical representations are also commonly used and include box plots, time graphs, activity charts, or bar graphs to illustrate students' thought processes.

Table 2
Stages of Design Thinking

Stage	Transformation
Formulation (1)	R>F,F>Be
Synthesis (2)	Be>S
Analysis (3)	S>Bs
Documentation (5)	S>D
Evaluation (4)	Be<>Bs
Reformulation I (6)	S>S
Reformulation II (7)	S>Be
Reformulation III (8)	S>F

Note. Adapted from "Generalizing Design Cognition Research" by J. Gero, 2010, *DTRS8: Interpreting Design Thinking,* DAB documents, Sydney, pp. 187-198.

The FBS ontology, although repeatedly applied and validated, has seen concerns from within the field of design research. Dorst & Vermaas (2005) posit that "definitions lack precision when analysed in detail and allow for some latitude in their interpretation" (p.18). Thus, as a research method the FBS ontological framework might subject itself to bias and reliability concerns as coding can vary across researcher. However, Dorst & Vermaas also suggest that this method informally connects design practice and can lead to further development of a holistic theory on design.

Through verbal protocol analysis, the FBS ontology provides researchers and educators descriptive data leading to insight into students' design cognition. Previous findings have suggested "information acquisition is important in design, novice designers tend to seek less information than experts and tend to decompose the problem more than experts, and poor problem scoping and lack of hypothesis testing contribute to poor performance" (Atman & Bursic, 1998, p.122). However, the FBS ontology has yet to be linked with specific teacher instructional strategies. It is hypothesized that through a professional development session, paired with a previously proposed instructional tool, teachers can further develop students design thinking to leading to the higher order thinking and the design of better products. This instrument is the Informed Design Matrix. This matrix can provide valuable and seminal understanding of how students' think through design-based learning experiences.

INFORMED DESIGN MATRIX

Traditionally, the engineering design process has been taught as a linear approach (Hynes, 2010; McCormick, 2004). A common example seen is "teachers simply relaying the steps of the process to their students, instead of providing detailed explanations of the purpose and rationale of the steps" (Hynes, 2010, p. 348). Since "many students' first encounters with design activities will happen under the watchful eyes of teachers with few to no design experiences under their belts and little training in using these activities" (Crismond & Adams, 2012, p. 739), it is important for teachers to have effective instructional tools to assist them in developing students' design thinking. The Informed Design Teaching and Learning Matrix developed by Crismond and Adams (2012) provides specific examples of what beginning versus informed designers do, learning goals of students, and specific teaching strategies. See Crismond and Adams (2012) for the full Informed Design Teaching and Learning Matrix.

Directly referencing the FBS ontology, Crismond and Adams (2012) suggest "linking what a solution needs to achieve (function) with how it is used (behavior) and the form it takes (structure) is an important attribute of design capability and measure of effective designing" (p. 751). Research has already suggested expert engineers spend more time discussing function compared to novice designers' focus on structure components (Turns, 1998). Through use of the Informed Design Teaching and Learning Matrix, teachers can identify and assess students' ability in problem framing (function) and provide strategies for improvement. Since one specific design cognition issue for students has been premature decisions related directly to structure (Crismond and Adams, 2012), this is a vital initial step that teachers can assist students. There have been minimal studies, if any, that have investigated and compared students' design cognition following specialized teacher interventions.

RESEARCH DESIGN AND METHODOLOGY

An experimental design using the FBS ontology will be used in a future study to investigate students' design cognition following the use of the Informed Design Teaching and Learning

Matrix. Through the use of extant data from a previous control group and from an existing NSF funded project by Gero, Williams, Wells, Paretti, and Lammi (2013), a comparative analysis will be performed to examine differences between groups. The follow sections describe the research questions, participants, and phases to be implemented and proposed data collection and analysis.

RESEARCH QUESTIONS

RQ_1: What cognitive differences are there in students' design thinking following the use of an Informed Design Teaching and Learning Matrix instructional approach?

RQ_2: To what extent does a teacher feel comfortable implementing a specific instructional tool for assessing students design thinking?

RQ_3: What are students' experiences while working through a design challenge following a guided instructional approach?

PARTICIPANTS

The anticipated sample in this study will be an extension of past research and through convenience sampling select students on availability for study (Gero, Williams, Wells, Paretti, & Lammi, 2013). Although convenience samples may lead to bias and reduce generalizability, the primary purpose of this research is allow for transferability, and to have a greater understanding of relationships that may exist (McMillan, 2012). The previous control group of 18 high school junior engineering students, ages 15 -17, in nine design teams, will be compared to nine design teams of a similar high school. The same teacher from a previous study will be participating in the study working through similar curricula. The primary difference will be the use of the Informed Design Teaching and Learning Matrix by the experimental group.

DATA COLLECTION AND ANALYSIS

This study will take place in the following phases:

[1]. Pre-Planning PD Workshop – The researcher will collaborate with the teacher whom participated in the previous study prior to the start of the new semester to explain the Informed Design Teaching and Learning Matrix. Both the teacher and researcher will discuss a specific instructional activity that the teacher plans to use. Over the course of 3 days, each consisting of 2 hours, the researcher will demonstrate how the teacher can afford time, resources, and strategies to assist students' in their design thinking, based on the Informed Design Teaching and Learning Matrix.

[2]. The researcher will observe the instructional activity during the school term. Observational data will be collected on how the teacher implements the matrix and how students respond to it. This will further guide future use and meet suggested needs stated by Crismond and Adams (2012).

[3]. Following the instructional unit, the students will be presented with a similar design challenge from the previous study by Gero, Williams, Wells, Paretti, and Lammi (2013) on designing a window for an elderly home. Using VPA the students' design thoughts will be recorded, transcribed, coded, and analyzed using the FBS ontology.

[4]. A comparative analysis of the experimental and control group will be performed to compare differences in design cognition distribution of their utterances during the design challenge. Students' mean scores of occurrences in each design issue will be analyzed and t-tests will be used to examine differences in mean scores between both groups.

CONCLUSION

Analysis and findings from this and other studies will enable STEM educators to approach design from an evidence-based perspective. Although the purpose is not for every teacher to use the FBS ontology as a summative assessment tool, the findings will be useful for preparing and assisting design-based teaching and learning practices. Also, through the use of the Informed Design Teaching and Learning Matrix, feedback from the participating teacher and observational data can further develop this tool to better equip teachers, particularly STEM and technology and engineering education teachers, as they assist students in developing their design cognition.

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Teachers’ Views Regarding Assessment in Technology Education

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ABSTRACT

Numerous studies have demonstrated that there is a lack of certified technology teachers in Swedish schools.

In this study we explore possible differences between teachers with and without subject-specific education in technology didactics. The research question highlights to what extent teachers with subject-specific training (1) are using steering documents and (2) assessing students differently compared to teachers without academic subject-specific training. The collected data consists of a survey within a large teacher-training project ‘Tekniklyftet’, a technology initiative in which 28 schools in the Stockholm area have signed up for an ambitious technology education development program in their school.

The results show that teachers with subject-specific training perceive themselves as more secure in their professional (technology) teacher role and express greater confidence in how to assess pupils in the subject of technology and also in how to use steering documents compared to non-subject specific trained teachers.

Keywords: assessment, teacher training, technology education

INTRODUCTION

Technology has been a mandatory subject in the Swedish school system for more than three decades. Despite this fact, there is still no consensus regarding the content and practice of the subject (Norström, 2011; Skogh, 2006), resulting in insecure teaching (Association of Swedish Engineering Industries ASEI, 2005; Nordlander, 2011) and varying knowledge among students.

There are several reasons for this troublesome situation in the context of teaching technology subjects in the Swedish school system. For example, the syllabuses for technology classes have been vague and imprecise (Norström, 2011), which has resulted in difficulties in achieving a common national base of technology education for teachers to rely upon. In 2011, however, a new curriculum was introduced that featured new syllabuses for all subjects in the Swedish school system. The new syllabus for technology is stricter and contains knowledge demands for year six and nine as well as core content in three time spans (years 1–3, 4–6 and 7–9), which will hopefully lead to higher achievement among all pupils.

There are no strict regulations regarding how much time should be spent on technology education. Although other subjects generally have their own timetable (except social sciences), there has been and still is a joint national timetable for technology and science education (800 hrs minimum). Although some regulations about time-sharing have been suggested (Skolverket, 2010), no restrictions regarding the exact amount of time for technology teaching have been determined.

There has been a dramatic decrease in the amount of certified teachers in compulsory school in Sweden. Many teachers lack formal teacher education (Andersson, Johansson, & Waldenström, 2011). The situation is particularly problematic in technology where the shortage of subject-specific trained teachers is greater than in other subjects (Skolverket, 2013). Thus, there is an evident lack of trained teachers in technology in the country. Even though this has been known for many years, two recently published reports (ASEI, 2013; Skolverket, 2013) show that it is difficult to accomplish a change and so far the situation in Sweden becomes worse as time pass.

The abovementioned challenges have resulted in many students receiving little or no technology education; in some known cases, technology is only taught one hour a week in year eight or nine when the grading starts (ASEI, 2005; Hartell, 2011; Teknikdelegationen, 2010). As teaching in technology varies among teachers and schools, neither teaching nor assessment is always aligned with the current steering documents (ASEI, 2005; Bjurulf, 2008; Klasander, 2010).

Many initiatives have been undertaken in Sweden in order to solve the troublesome situation for technology education. One of the largest investments is called '*Tekniklyftet' (*The boost for technology), a project which is run by the House of Science in Stockholm and funded by the European Social Fund (ESF). The project started in 2011 and the main purpose is to educate teachers in technology and boost the status of the subject in schools in the region. The aim of this effort includes the ambition to increase the interest in technology among pupils. The project works as a pilot programme involving 20 secondary schools (school year 7–9) during this first run in a three-year period.

The project has approached this challenge by involving people, institutions, industry and organisations representing different levels in society that are all profoundly affected by the quality of technology education. Activities that boost the schools and train the teachers have been and will continue to be developed during the project period. Strategic collaboration (in a broad sense) was built into the project from the very beginning in order to secure its efficiency and continuation.

Researchers and evaluators will evaluate the project during the three-year period. The research questions that will be examined during this evaluation focus on, if and how it is possible to increase the quality of technology education during the project period. As previous studies has shown that trained teachers are important for the quality of teaching (Andersson et al., 2011), we wanted to perform an initial study of the project in which we highlight possible differences between subject-specific trained (technology) teachers, (*technology teachers with academic credits in technology* TTAC) and non-subject-specific trained teachers in technology (*teachers with no academic credits (in technology*) TTNC) with respect to their ability in teaching and assessment in the subject area of technology.

In the very beginning of 'Tekniklyftet', a questionnaire was distributed to all teachers and administrative personnel in the 28 participating schools.

ASSESSMENT IS A LINK BETWEEN TEACHING AND LEARNING

Assessment is a crucial factor in students' learning. In general, the aims and purposes of assessment vary within different educational contexts. For example, one purpose of assessment is to make sure that pupils follow the intended path towards the curriculum goals (Wiliam, 2011). Another purpose of assessment is grading the pupils in order to evaluate and report results to the authorities (Gipps, 2004; Newton, 2007; Pettersson, 2009). However, if the purpose of the assessment does not include the students' future progress, one might be justified in questioning its utility (Bennett, 2011; Black & Wiliam, 2009; Gipps, 2004; Newton, 2007; Nyström, 2004).

It is common for assessment to be performed continuously in the classroom. Whether intentionally or not, teachers assess their students all the time by asking questions or looking for 'glimpses in the eyes of the pupils' (Hartell, 2012). Continuous assessment is used in order to be able to plan the next step of teaching where the goal is to develop the pupils' understanding as much and as efficiently as possible (Wiliam, 2009, 2011). In such a formative approach, assessment can be seen as the link between teaching and learning.

THE IMPORTANCE OF TEACHER QUALITY IS A COMMON SUBJECT FOR DEBATE

The importance of teacher quality is often debated in Swedish society. While many people claim it is important to have certified teachers, there are still few studies that prove that having more formally educated teachers will result in higher pupil achievement. Some studies show that teachers who teach technology and lack subject-specific training feel insecure when teaching this subject (Nordlander, 2011; Teknikdelegationen, 2010). Andersson et al. (2011) showed that having certified teachers will result in higher achievement among pupils in the Swedish compulsory school system; in their study, pupils with highly educated parents profited the most. On the other hand, Williams (2009) has questioned the efficacy of long teacher education programmes, and others (Hattie, 2009) have argued that teacher training does not matter very much with respect to pupils' achievements. Instead, such researchers claim that experience is what matters most, and experience, as Wiliam (2011a) argues, does not come by itself.

RESEARCH QUESTION

Our study is a contribution to the overall investigation regarding how subject-specific teacher education affects teachers' ability to teach according to stated regulations.

Gipps (2004), Bjurulf (2008) and Moreland, Jones and Barlex (2008) argue that a teacher's own view about technology is reflected in their teaching practice and has implications for assessment. We believe that teachers who perceive that they know how to use the steering documents and how to assess the subject possess a better ability to do so.

Therefore, our specific question is as follows: *Is there a difference among subject-specific trained teachers and non-subject-specific trained teachers regarding their perception of their own ability to teach and assess technology?*

METHOD

In order to deepen understanding of the situation regarding the subject of technology in participating schools a questionnaire was distributed among the participants as they were arriving to the kick off seminars for Tekniklyftet (August, 2011). All teachers and all management in the participating schools were asked to answer the questionnaires. There were 682 attendances registered. The informants returned the questionnaires before entering the introductory lectures. In total, 651 individuals (school staff e.g. teachers, principals etc.) all employed at 28 participating schools answered the questionnaires to different degrees.

The questionnaire consisted of 45 questions about attitudes towards the subject of technology, about teaching and assessment and about available resources and equipment. The guidelines provided by Statistics Sweden were followed for designing both the layout and the questions (http://www.scb.se; Cohen et al, 2007; Djurfeldt, 2003). In this study, 6 out of 45 questions regarding teaching and assessment of technology were quantitatively analysed. The result can be viewed as statistically pledged variations between the teachers with subject-specific training and those with no subject-specific training.

Participants

Different groups of informants where presented with the questionnaire (teachers, principals, subject teachers, etc.). In this study, only answers from those who stated that they teach technology were analysed. The informants belong to the following groups:

I. School staff working as technology teachers with academic credits (TTAC) (n = 60)
II. School staff working as technology teachers without academic credits (TTNC) (n = 28)

In order to investigate if participating schools are somehow representative of the Swedish education system as a whole, the participating schools were compared to schools throughout the country (table 1). Official records (SIRIS and SALSA) compiled by the state agency Statistics Sweden (SCB) and presented by the National Agency for Education (NAE) were used, as these records are often used in various settings when describing the results of Swedish schools.

As a group, the participating schools could be seen as representative with regards to available school background variables, with the exception of the average grades in technology and the higher amount of second-generation immigrants (Hartell & Svärdh, 2012).

Table 1: Official school data regarding the schools in 'Tekniklyftet' compared to the schools in the country.

Average values for 2009-2011			
	Country	Boost for technology	Stockholm
Imigrant background			
Born abroad	8%	11%	8%
Born in Sweden	6%	22%	10%
Boys	51%	52%	52%
Parents' education	2,15	2,15	2,19
Merit values	206	210	209
Teachers with exam per 100 pupils	7%	6%	
Average grade in Technology			
Pass	42%	39%	
Pass with distinction	38%	33%	
Pass with special distinction	14%	17%	
Failed	6%	10%	

Table 1 also shows that the reported grades are similar in 'Tekniklyftet' (Boost for technology) and for the country. A closer look reveals, c.f. table 2, a large variation in grading (almost 70%) and the fact that many schools in Tekniklyftet do not use the whole grading scale.

Table 2: Variation between schools' grading in technology.

Variation of grading in technology		
	Max	Min
Pass	74.7%	4.8
Pass with distinction	58.2%	11.4
Pass with special distinction	47.7%	0%
Failed	37.1%	0%

RESULTS

The data consists of a questionnaire (45 questions, five-grade Likert scale). The results are presented at a group level as descriptive statistics in order to provide an ocular overview. Mann-Whitney U-tests are used to look at significance (Cohen, Manion, & Morrison, 2008).

In this paper, we have chosen to present results from the six questions most significantly related to assessment in technology.

Question 1:

The national syllabus for technology is of great importance for how I teach.

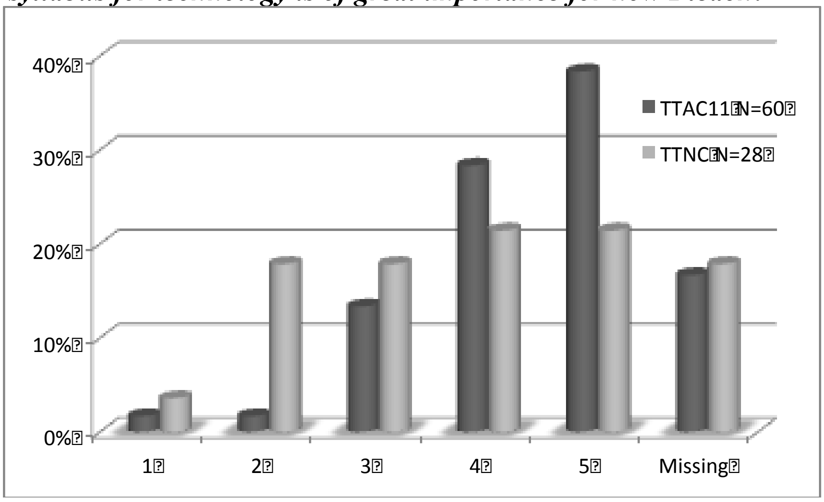

Diagram 1: TTAC Mean 4.20, Std. Deviation 0.926, TTNC Mean 3.48, Std. Deviation 1.238 Mann-Whitney P = 0.015

According to the questionnaire results, the teachers in the TTAC (technology teachers with academic credits, dark grey) group emphasise the importance of the steering documents more than the teachers in the TTNC group (technology teachers with no academic credits, light grey). The differences are significant at a level of 5%.

Question 2:

My school's local syllabus for technology is of great importance to how I teach.

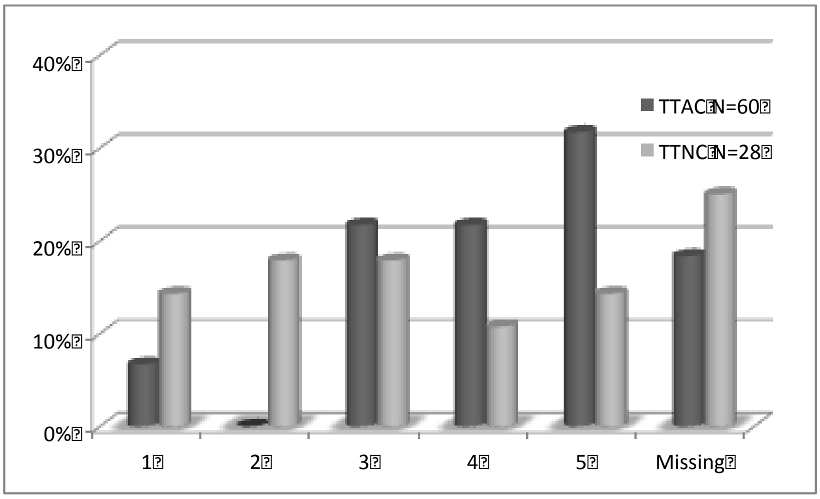

Diagram 2: TTAC Mean 3.88, Std. Deviation 1.184, TTNC Mean 2.90, Std. Deviation 1.411 Mann-Whitney P = 0.006

The TTAC group with academic credits has a stronger tendency to use the school's local plan for technology than the TTNC teachers. The differences are significant at a level of 5%.

Question 3*:*
I can describe the student's level of knowledge in the written assessments in a structured way.

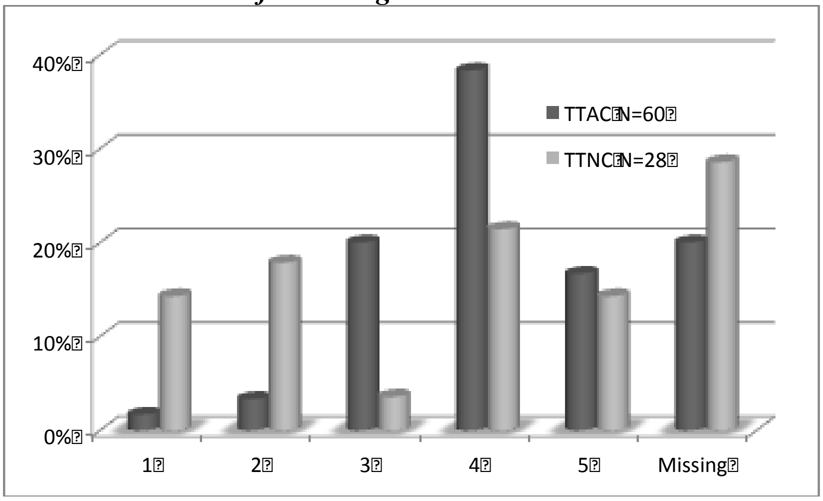

Diagram 3: TTAC Mean 3.81, Std. Deviation 0.891, TTNC Mean 3.05, Std. Deviation 1.504 Mann-Whitney P = 0.070

Part of the teacher's job is to assess the students by describing each pupil's current position and where they should go next. This information is gathered in the Individual Development Plan (IDP) document, which is stipulated in a written form together with the student and their guardian during the teacher-guardian meeting every semester (Hartell, 2013).

The TTAC group expresses greater confidence (significant at a level of 10%) than the TTNC group when it comes to describing their students' knowledge in technology in the IDP documents.

Question 4:
This school year, I can clearly describe to the students the skills needed for various grades in technology.

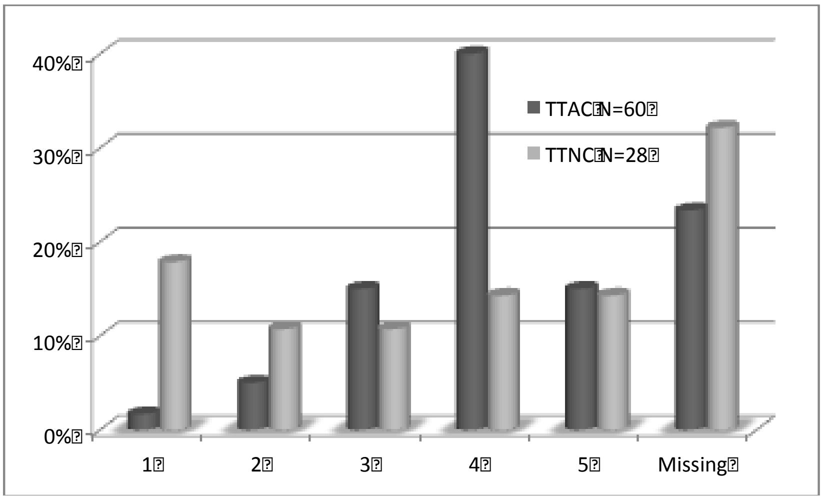

Diagram 4: TTAC Mean 3.80, Std. Deviation 0.910, TTNC Mean 2.95, Std. Deviation 1.545 Mann-Whitney P = 0.040

The TTAC group expresses greater confidence than the TTNC group when it comes to describing the skills needed for various grades in technology.

Question 5:
I was able to award informed grades in technology according to the Lpo-94 curriculum.

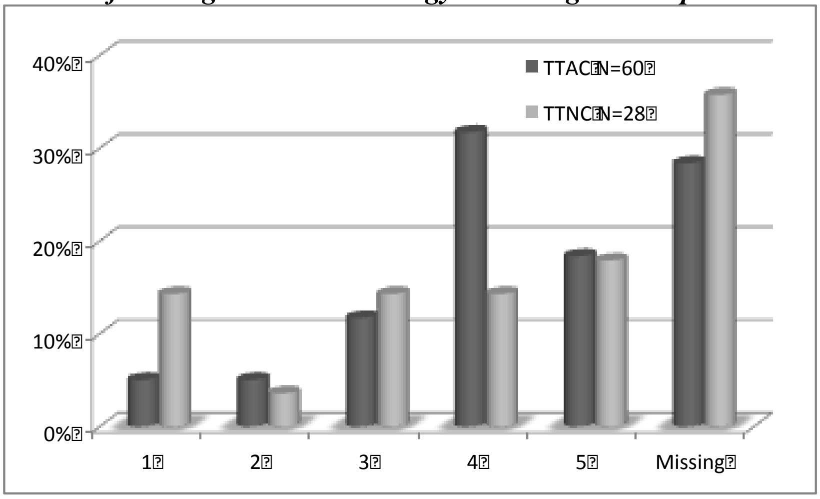

Diagram 5: TTAC Mean 3.74, Std. Deviation 1.136, TTNC Mean 3.28, Std. Deviation 1.526 Mann-Whitney P = 0.315

The differences here are *not* significant, but the trend is that the teachers in the TTAC group have more self-confidence when it comes to assessing the former syllabus in technology.

Question 6:
During the past school year, I felt confident when I informed the students about the skills and knowledge qualities that should be assessed in technology.

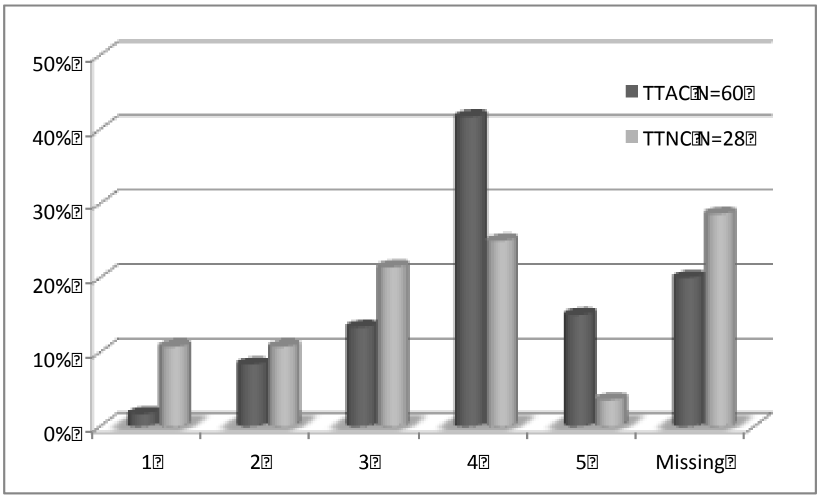

Diagram 6: TTAC Mean 3.75, Std. Deviation 0.957, TTNC Mean 3.00, Std. Deviation 1.170 Mann-Whitney P = 0.010

The teachers in the TTAC group felt more secure in providing information on grading criteria in 2011 than the teachers in the TTNC group. The differences are significant at a level of 5%.

DISCUSSION
In this study we examined possible differences in teachers' perceptions of their ability to use steering documents and their ability to assess students in the subject area of technology. The

study shows a difference in attitudes and self-confidence between our two examined groups of teachers (TTAC and TTNC). According to the questionnaire results, the teachers with subject-specific education (TTAC) appeared to use steering documents as a base for their teaching to a greater extent than the non-subject-specific educated teachers. The study also demonstrated that TTAC teachers are more secure regarding what should be included in technology education and what needs to be assessed in order to award the students the correct grades.

It is interesting to consider these results since one could argue that teachers who are not educated would need to adhere more strictly to the available steering documents than teachers who are educated. This study shows that this is not the case, at least not in terms of how the teachers responded when asked about their views regarding their own teaching. Instead, it seems like teachers that are educated are also more likely to utilise the available directions, which in turn indicates that formal education results in wider teacher capacity.

This uncertainty among non-educated teachers in using the steering documents probably leads to an uneven quality of education for the pupils as previously reported. If this is the case, more uncertified teachers means more teachers that do not use the syllabus as their base for teaching technology and more teachers that are unsure how to assess their pupils, which in turn leads to uneven and unfair assessment.

In the background analysis of this study we showed the variations in average grades in all participating schools (table 1). We also found huge variations within the distribution of grades (table 2). Some schools reported almost no pupils that did not achieve the goals, while some schools reported the opposite. It was common for many schools not to use the whole grading scale. It would be interesting to analyse these differences in a future study.

In the future we want to study whether the beliefs expressed by the teachers in the studied questionnaire also align with the reality in the schools. We are currently in the midst of several on-going studies in which we are analysing, comparing and investigating what is taught and assessed by examining the collected tests and the IDPs in order to deepen the understanding about teachers' ability to assess the technology subject. Complementary interviews will be undertaken to obtain a deeper understanding of the teachers' views on and knowledge about how to teach and assess technology and, furthermore, how (and if) the 'Tekniklyftet' project has affected them.

Another question that arises in this context is how to resolve the difference between the subject-specific trained teachers and the teachers without such training. One aim of the 'Tekniklyftet' project is to find out if training the teachers during this project will accomplish a change. The teachers who teach technology and participate in the project will be educated by taking academic courses and by attending seminars where local work plans for the subject are developed. In future studies it will be interesting to examine how teachers not just express themselves but actually behave in the classroom and compare this reality with the results achieved in this study.

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Technology Education for Systems Thinking and Sustainability: What Swedish Pre-Service Technology Teacher Students Know about Technological Systems

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ABSTRACT

Research in the history and sociology of technology in the last decades has shown that technological systems have partly different characteristics and dynamics compared to single objects and artefacts. It is therefore pivotal that technology education incorporates a systems perspective. The Swedish technology curriculum for compulsory school (ages 7-16) has integrated systems content for nearly 20 years. Although studies indicate that pupils can understand systems structure to some extent the more complex aspects are still difficult to grasp. This may be a result of high demands in the curriculum but also the fact that technology teaching is lacking in this regard, because studies show that Swedish compulsory school technology teachers do not have a very developed understanding of technological systems. Although there have been no Swedish studies of systems in relation to teacher education, there is good reason to believe that teachers' understanding of systems at least partly has to do with their training, while it may also have to do with other factors such as prior other education. In this paper we report on a pre-study made to investigate how pre-service technology teacher students understand technological systems, their dynamics and evolution. The following research questions are posed: How do pre-service technology teacher students understand technological systems, their dynamics and evolution? What is difficult for them to understand? How can technology teacher education about systems be improved? We collect empirical material by conducting in-depth surveys with five Swedish pre-service technology teacher students and analyse the material by using a hermeneutic method. Theoretically we rely on research on technological systems within the philosophy, sociology and history of technology as well as technology education.

Keywords: technological systems, technology teacher education, systems theory, sustainability

INTRODUCTION

Technology has become increasingly systemic in the last 150 years as artefacts interconnected in technological systems have become vital to a multitude of human activities. Technological systems are therefore part of our everyday lives; we use them, affect them and are affected by them. They are interwoven with our society to such an extent that we often take them for granted and they almost become invisible to us, especially since much of the infrastructure is either in the ground beneath us or in more invisible form such as air waves. Research in the history and sociology of technology in the last decades has also shown that technological systems have partly different characteristics and dynamics compared to single objects and artefacts (Hughes, 1983, 1987; Ingelstam, 2002). A technological system constitutes a whole that is more than the sum of all its individual parts; it consists of components and connections between them, but serves a function not immediately reducible to each component. It is consequently clear that in order for students to understand technology in all its variety they also have to be introduced to technological systems and their characteristics. Therefore technology education should also incorporate a systems perspective. Several countries have already adopted an explicit systems component based on current research in their technology curricula, the United States and New Zealand being the most prominent examples (*Standards for Technological Literacy: Content for the Study of Technology*, 2000; "Technology in the New Zealand Curriculum," 2007).

The Swedish technology curriculum for compulsory school (ages 7-16) has integrated a systems component for nearly 20 years. Although studies indicate that pupils can understand systems structure to some extent the more complex aspects are still difficult to grasp (Svensson, 2011; Örtnäs, 2007). This may be a result of high demands in the curriculum but also the fact that technology teaching is lacking in this regard, because other studies suggest that Swedish compulsory school technology teachers do not have a very developed understanding of technological systems themselves (e.g. Klasander, 2010). Although there have been no Swedish studies of systems in relation to teacher education, there is good reason to believe that teachers' understanding of systems at least partly has to do with their training, while it may also have to do with other factors such as prior other education. It is therefore crucial to bring technology teacher students into our understanding of technology in the school, since teachers acquire much of their subject knowledge in their pre-service training (McGlashan & Wells, 2012).

In this paper we report on a pre-study made to sharpen the analytic tools necessary to investigate on a grander scale how pre-service technology teacher students understand technological systems, their dynamics and evolution. The following research questions are posed: How do pre-service technology teacher students understand technological systems, their dynamics and evolution? What is difficult for them to understand? How can technology teacher education about systems be improved?

TECHNOLOGICAL SYSTEMS IN THE SWEDISH SCHOOL CURRICULUM

Focussing on a broad technological literacy, the curricular rubric *Components and systems* in the 1994 Swedish national curriculum for the first time provided required subject content concerning systems. The current national curriculum of 2011 does not have such an explicit focus on technological systems. Instead they are now a part of the rubric *Technology, humans, society and environment*. Still it is the first time in a Swedish curriculum that a core content in technology has been worked out, and technological systems are prescribed content for the ages 10-16 years old (*Läroplan för grundskolan, förskoleklassen och fritidshemmet 2011*, 2011; "Swedish Technology Curriculum, Lpo 94," 2000).

PREVIOUS RESEARCH

Recent international research in technology education has shown an interest in and even developed systemic issues and perspectives (Compton & France, 2007; Frank, 2006; Jones, 2003; Williams, 2000; Zuga, 1994, 2004). Arguments have been made that ”[t]he understanding of systems is essential in developing knowledge in technology” (Jones, 2003, p. 90). There have also been actual classroom studies on technological systems, such as Koski & de Vries who designed an intervention study where primary pupils and teachers did a pre-test, the teachers lessons and then the pupils a post-test, all related to how they perceived various aspects of technological systems and how the teaching could be improved. The concept of input, for example, was clearer to the pupils than output. Setting boundaries to systems was also a challenging task. The teacher, however, included some systems thinking and was thereby able to introduce alternatives to approach the problems discussed in class. Although systems thinking was rather limited, the pupils were at least able to reach beyond basic descriptions (Koski & de Vries, 2013).

In recent years there have been a number of Swedish studies on technological systems in relation to technology education. For example Örtnäs studied how secondary school students perceived technological systems in their everyday life. Her conclusion is that with a little scaffolding they can understand how the cell phone system, the deposit can system and the washing machine work, at least the structure of the systems and how they relate to sub-systems and humans. However, the older pupils show a greater knowledge of single components than the younger ones (Örtnäs, 2007). Svensson, who studied 10 and 15 year-old pupils' experience of technological systems, concludes that they understand the structure quite well but not to the same extent how components interact and how humans fit in the systems (Svensson, 2011). Klasander concludes that systems thinking among teachers is often poor and is hampered either by a focus on scientific, reductionist aspects of systems or a focus on single artefacts (Klasander, 2010). Svensson & Klasander studied how two groups of technology teachers plan teaching about technological systems in lower secondary school. The study shows that the teachers require a better understanding of which systems may be relevant. More knowledge about the similarities and differences between various technological systems could be helpful to be able to select systems. A better understanding of the system's components and different layers could also contribute to a more developed understanding (Svensson & Klasander, 2012).

Even though the previous research on technological systems in technology education is rather limited, one can draw a few conclusions of relevance for this study. First of all, pupils seem to gain a deeper understanding of systems as they grow older, especially regarding the included components. Secondly, pupils also seem to better understand systems when they are scaffolded, either by an interviewer or by teaching interventions. Thirdly, teachers seem to be confused as to what systems to teach and would require more knowledge of various differences and similarities between technological systems.

METHODOLOGY, RESEARCH ETHICS, AND THEORY

The empirical material was collected by conducting in-depth surveys with five Swedish pre-service technology teacher students, four men and one woman. The selection was made from a proximity point of view. These were five of the six pre-service technology teacher students for secondary education enlisted at a university in southern Sweden in the spring of 2013 (the sixth person did not want to take part). They all chose technology as one of their subjects and had read one semester when the survey was taken, although they had had no courses about systems. They were all informed about the purpose of the study and that they could terminate their participation whenever they liked. Furthermore, all information about their identities will be kept confidential and the collected material will be used for research purposes only (not, for instance, for assessment or grading). One of the authors was teaching the students at the time when the data was collected. However, this is a pre-study designed to sharpen the tools of analysis; the major study will be carried out at several universities, prior to them beginning their technology courses.

The survey is divided into two parts. Each part and its questions were constructed to gauge the teacher students' understanding of more generic knowledge of technological systems, that is, a survey question often deals with one particular system but what we are after is more general knowledge that is applicable even to other systems. Part I asks the students to shortly relate their view of technology, technological systems and technological change. Part II deals with technological systems more directly; how they work and evolve, the relationship between the components and the whole, the systems borders, relationship with human beings, society, the environment etc. There are seven questions in part II:

1. The Stockholm congestion tax. Open question about the congestion tax, its possible advantages, and how it affects the system of traffic in the whole city.

2. The cell phone. The students are given some of the functions in the cell phone and they are asked to explain if and how these functions are system dependent.

3. The elevator. The students are provided with some information, but are also asked to fill in some, about what the elevator needs in terms of human-given and automatic input in order for it to work. They are also asked to name a system that works in a similar manner.

4. The road transport system. The informants are asked to pick out and explain connections between five given components, for the system either to lead to a reduced number of accidents or lessen its negative environmental effects. They are also asked about what they themselves can do to achieve less accidents and environmental side effects caused by the system.

5. The electric hand dryer. The students were asked about how the dryer can start when they hold their hands underneath it and why there is a delay before it switches off.

6. The electric grid system. The students are provided with historical maps of the evolution of electricity networks in comparison with telephone networks. They are asked what similarities and differences there are. They are also asked to draw and name other components in the electricity system today and what would happen if one of these malfunctioned, how it would affect the whole system.

7. Urban water and sewer systems. This question provides some information about the historical establishment and evolution of these systems in relation to what was before. The students are then asked to name three different needs that led to the introduction of these systems, how they work today, positive and negative effects, etc.

Part II was quite time-consuming and all students did not fill in all parts of the survey, which may also be because they found the content difficult.

A hermeneutic method is employed when analysing the material, that is, single texts are related to the whole body of texts and the current context in a reciprocal, re-interpretive way (Ödman, 2007). A broad synthesis of systems theories were compiled into a set of *systems significants* (e.g. Bertalanffy, 1973; Bijker, Hughes, & Pinch, 1987; Capra, 1996; Churchman, 1979; Ellul, 1980; Hughes, 1987; Ingelstam, 1996). These significants are used in two ways by a method adapted from Säfström (Säfström, 1994, 1999). Firstly for the purpose of telling when something related to technological systems is expressed in the students' answers (reading-in). Secondly for the analysis and interpretation of how systems-related content is expressed, in what ways it could be expressed instead or if something is excluded (reading-out).

Eleven clustered groups of concepts make up the partly overlapping and mutually dependent *system significants* as follows:

- The technical core of a system
- Hierarchies, sub-systems, components
- Connections and wholeness
- System boundary and surrounding
- Isolated, closed or open systems
- Control, feedback, flow of information

- Systems' functions and behaviour, processes, models
- Scale and complexity
- Dynamics, development, change
- Socio-technological perspectives
- Systems for innovation, conditions for production.

The paper is informed by sociocultural theory in that it is the students' conceptual understanding of technological systems in a social and cultural context that we study by using a survey with certain built-in scaffolds to aid this understanding (Schoultz, Säljö, & Wyndhamn, 2001).

RESULTS

We have structured the results according to general patterns of systems knowledge that our analysis shows that the students have either acquired or not. The following themes dominate:

Structure, function and flow

The results were very mixed here, that is, how well the students performed depended on what kind of system the question was about. The elevator, which is a kind of control system, gave the best results. The students generally perceived structure, function and flow very well when it came to the elevator and fairly well also concerning the road system/congestion tax. These are systems they are already familiar with at the same time as they are physically relatively well defined - at least the elevator. There has been a public debate about the congestion tax in Stockholm and Göteborg the past few years, which may be one reason certain aspects of this system has been picked up by the students. Most students mention, for instance, the main environmental object of the congestion tax – that it evens out traffic both in time and space – but fails to note increased tax revenues which was one of Stockholm City's financial aims. They also fail to mention larger systems effects such as the fact that the tax may not reduce pollution but only relocate it unless people use public transportation more (Tarr, 1996).
The systems that they did not understand the structure, function and flow so well in were the electric power system, water supply and sewer systems, the mobile phone system and the electric hand dryer. The mobile system, in particular, was difficult. The students understood that the cell phone as an artefact is connected to many other components, but not exactly which components nor how the connections work. As regards the electric power system the students were asked to name components in the system today, but few managed to name more than various power sources. The electric hand dryer is surprising since it is a small system, but the automatic switch-off function was hard to grasp both in terms of what sensor is at work and how it is a part of the regulation of the system.

Interaction and dependence between components, in relation to the whole system

When asked to define a technological system all but one of the students emphasize the interconnectedness of components in a system, using phrases such as "components that work together" or "a number of technological artefacts that in one way or another communicate". However, the dependence between components is not so well understood by the students when asked how more complex systems like the mobile system work (see above). When asked to name five components in the road transport system that must be improved/changed in order to achieve fewer accidents or less negative effects on nature, the students usually pick out relevant components but are less successful in explaining the relations between the components and humans or the environment. The students are also asked about "technological advances" that like the dynamite contributed to the expansion of water and sewer systems. The three who answer this question mention not only artefacts such as digging machines but also construction material such as concrete and ways of joining together pipes such as welding. This goes a little beyond a narrow focus on artefacts, but is still quite limited since they do not show how it affected the whole system.

The system's relation to and influence on its surroundings

We cannot say so much about this as the tasks/questions usually focused on one particular, delimited system. Some questions concern environmental issues and the relationship between the system and the environment. We have mentioned the limited understanding of the effects of the congestion tax on the city environment as a whole and only one student states clearly that the extension of sewer systems initially led to contaminated water sources.

The historical evolution and change of technological systems

It is very clear from how the students answer the question about water and sewer systems that technological change is very difficult when it concerns a particular historical development that the students are not familiar with. However, when given some support – a scaffold, so to speak – this is much easier, which is evident when the students are supplied with historical maps of the evolution of electricity grids and telephone networks. The students are then able to conclude, for instance, that telephone systems developed faster than electricity and that both systems were slow to reach northern Sweden. They do not discuss these two systems in terms of their *intra-urban* or *inter-urban* character, that is, to what extent they are confined to cities or go beyond city boundaries, the latter of which both of them did during their evolution (Kaijser, 2004).

CONCLUDING DISCUSSION

First of all, Svensson shows that the artefacts in a system can be a good entrance to knowing the whole system (Svensson, 2011), and we can see some such understanding in that the students can name some components and relate them to each other. However, the overall impression is that artefacts also tend to obscure systems effects, system boundaries and relations between the components and the whole system. It is as if it is too complex to focus artefacts and system at the same time. In the case of the cell phone the students can pinpoint a lot of system dependent functions – surfing, calling, positioning, calendar sync etc. – but generally cannot sort out how they function and what system(s) they depend on, so-called *secondary systems* (Hughes, 1987; Summerton, 1998). This is not surprising because Kroes *et al* talk of a "Russian doll effect" when analysing a technological system, where each component can also be viewed as a sub-system depending on your perspective (Kroes, Franssen, van de Poel, & Ottens, 2006). This kind of analysis thus requires a great deal of knowledge of technological systems and systems thinking.
Secondly, humans are considered important to the systems but mostly as users on various levels in the system. The students do not see humans as actors on a more systemic level, for example, what Hughes calls system builders: system owners, innovators, politicians, etc. (Hughes, 1987). As a rule one can say that this is more difficult for them the more complex the system is, which goes for the understanding of components in relation to systems as well. In the more complex systems with a great deal of "hidden" infrastructure and a lot of societal components, functions and actors remain elusive to students. These systems could in line with Hughes (1987) and Kroes *et al* (2006) be called *socio-technical systems*, which are the most difficult to understand.

In relation to the system significants we can say that the technological core, sub-systems and components of a system are most often easy to understand for the students, but if they fail to grasp the function of a single component such as in the case of the hand drier this gets more difficult. One may well argue that this also has to do with failure to grasp the flow of information. Hierarchies, connections and wholeness are more demanding, especially in more complex systems such as the mobile system and the internet, the latter of which is sometimes referred to as "the cloud" without any clear specification of what that is. However, function and behaviour in well-defined systems works well. System boundaries and surrounding are accordingly hard to understand, except for well-defined systems such as the elevator, which also shows that they are quite familiar with simple control and feedback loops. Increasing scale and complexity generally leads to a lesser understanding of the system, especially concerning lesser-known systems where you add an evolutionary perspective.

In conclusion, teacher students did not show a very developed understanding of either the electricity system, the internet or water and sewer systems, which are required content in the compulsory school (*Läroplan för grundskolan, förskoleklassen och fritidshemmet 2011*, 2011). Consequently we propose that technology teacher education includes a clearer systems component, in Sweden as well as in other countries. Furthermore, we suggest that in order for future technology teachers to be able to scaffold their pupils in school they also need to be scaffolded so as to be able to compare relevant systems and gain a deeper generic understanding. As for the continuation of this study we need to revise and reduce the set of survey questions, and develop the analytical framework to be able to categorize various levels of understanding systems. This may be provided by e.g. Churchman (1979) or Kroes *et al* (2006), who identify different levels of systems complexity, from traditional engineering systems to socio-technical systems – or the made world as a whole.

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Engaging Pre-Service Teachers in the Modernization of the Secondary School Design & Technology Curriculum

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ABSTRACT
This paper builds on a previous work by the authors concerning a new framework for an undergraduate design and technology teacher training programme at a university in England (Hardy & Barlex, 2012). This paper reports on a module within this undergraduate design and technology (D&T) teacher training course that aims to support the modernisation of the D&T curriculum in schools and includes opportunities for initial teacher education (ITE) students to debate and develop their own knowledge of scientific and technological changes (Ofsted, 2011; Williams, 2009). The module attempts to respond to some of the challenges for D&T and teacher education identified by Barlex (2011) and Dow (2006).
The paper will be in four parts.

First it will provide a brief summary of the reasons for modernizing the design & technology curriculum.
Second it will describe a module in the ITE course taken by pre-service teachers at a university in the East Midlands of England devised specifically to develop knowledge, understanding, skills and values required to respond to the modernization agenda.

Third it will present and analyse examples of student assignments in response to the module. The analysis will attempt to identify the extent to which the students are a) acquiring relevant knowledge, understanding, skills and values and b) showing intentions to introduce elements of modernization into their practice. Fourth it will present a conclusion detailing ways forward.

Keywords: teacher education, secondary school design & technology curriculum, modernisation

WHY MODERNIZE THE DESIGN & TECHNOLOGY CURRICULUM

Barlex (in press) has suggested the use of procedural principles to develop and implement a technology curriculum: Here two of these principles: developing a perspective on technology and enabling technological capability, will be used to justify the modernization of the design & technology curriculum in England. New technologies and technological practices are continually influencing our lives as they permeate society. If young people are to gain insight into this as required by developing a perspective on technology it is essential that they consider such technologies and practices as they emerge. Hence the curriculum must respond by continually updating this aspect of itself. In developing and demonstrating technological capability pupils will be required to devise and produce technological outcomes in a variety of forms. If the tasks through which pupils develop such outcomes are to be authentic then the way such products are designed, made and function should as far as possible reflect technological practice in the world outside school. This is not as outlandish as it might seem. Professional level digital design tools are freely available on line and digital manufacturing is increasingly becoming affordable for schools (Barlex and Stevens, 2012) and recently, July 8 2013, the government in England commented that "Three-dimensional printers will become standard in our schools – a technology that is transforming manufacturing and the economy. (Guardian, 2013). The way products work can now incorporate embedded intelligence with relative ease. If pupil capability is to embrace these possibilities then the technology curriculum must respond through modernization. Again the curriculum must respond by continually updating this aspect of it.

AN ITE MODULE IN RESPONSE TO MODERNIZATION

This module is part of the course's curriculum framework which has four elements:

1.Mainly designing

2.Mainly making

3.Designing and making

4.Design and technology in education and society

This is shown diagrammatically in Figure 1

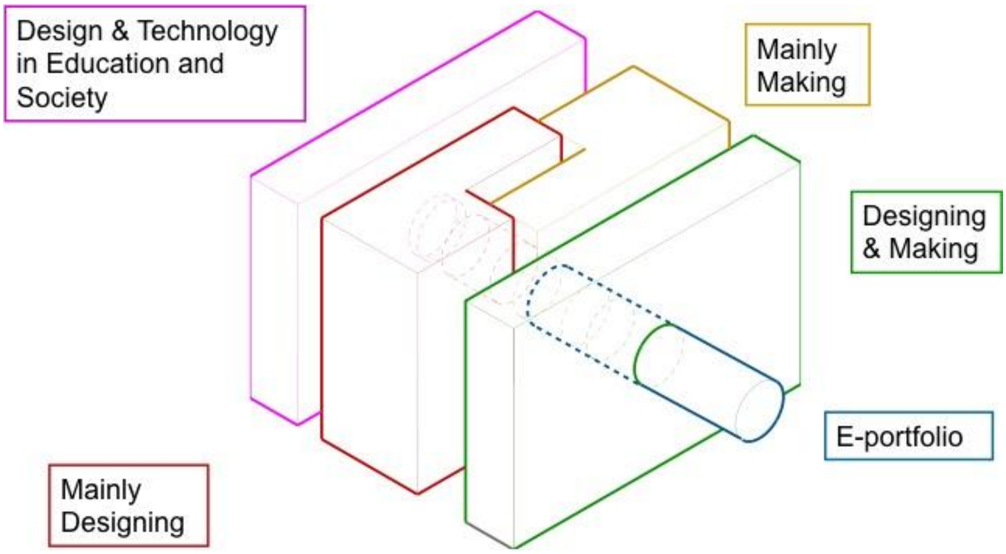


Figure 5: Graphical representation of the course's framework

This graphic shows the four elements which make up the modules as horizontally aligned rather than vertically stacked representing the belief that no one part if more significant than the other. The element of Design and Technology in Education and Society is where students debate and develop their own philosophy of the school subject D&T, their understanding of technology and is impact. The overarching aim of the module discussed in this paper is to provide students with space to develop their knowledge and understanding of topics that relate to the modernization agenda with a particular emphasis on developing a perspective on technology (see Hardy and Barlex (2012) for more detail of the curriculum framework).

The impetus to develop this module came from frustration with the course team's relative ignorance about topics relating the interaction of technology and society and the impact of technological activity on both the made and natural worlds. This was compounded by our observation of school practice in which such issues were dealt with mainly through a bolt on approach to sustainability (Pavlova and Pitt 2009) involving little more that a ritualized treated of the 6Rs (rethink, refuse, reduce, reuse, repair and recycle) usually limited to recycling and reusing (Practical Action 2013). There was little if any reflection on issues that required critique particularly with regard to aspects that could be considered in the broad terms of justice and stewardship. Hence the module was developed so that students would meet the following requirements:

1.Become knowledgeable about significant and contemporary developments in technologies and design;
2.Understand how ethical, cultural, economic and environmental factors influence the design of products, systems and environments and can affect technological change;
3.Engage in appropriate activities that highlight the need for debate, tolerance of beliefs and respect for values in dealing with controversial and/or social issues and
4.Consider the process of technological change and the technological issues in society within the context of Design and Technology education
The students were set the assignment shown in Figure 2 which was underpinned by the course leader's wish to predispose them to modernisation and provide them with a modernisation 'experience':

You are to research one topic from the following prescribed list:

- Cradle to Cradle
- Active Consumer
- Designing for the other 90% project
- Food security
- Product development
- Impact of Technology
- Eco textiles
- Globalisation
- Disruptive technology
- Power of the supermarkets
- Energy resources
- Manufacturing systems

You will use your research to lead a 90 minute seminar. Your research (an extended piece of writing), additional findings resulting from the seminar and a critique of your seminar will be submitted as part of an e-portfolio presentation. The extended writing should include:

1. Discussion on your seminar topic;
2. Consideration of how the topic could be taught in schools, developing pupils' creativity, thinking and problem solving skills;
3. Reflection, with evidence, on the value of your seminar topic to design and technology education.

Figure 6: The student assignment

Students were supported in this assignment by means of the availability of an assignment dedicated wiki the use of which had been modelled by the course leader, an initial set of 'fish bowl' tutorials and seminar presentations the style of which had been previously been modelled by the course leader. Evidence from these activities will be used to scrutinise for indications that the students met the requirements outlined above. In addition student comments on the university course feedback form will be inspected.

PRESENTATION OF EVIDENCE

The following comments posted on the wiki, made during the seminars by the tutor, taken from the seminar presentations and made in the university survey can be seen as an indication of the students acquiring relevant knowledge, understanding, skills and values. Each piece of evidence is numbered for ease of reference in the discussion section.

Comments on wiki

One week prior to leading their seminar students posted pre-seminar activities on the wiki for their peers to complete; these activities demonstrate their acquisition of knowledge about their topic.

1. Relates to the topic of 'Designing for the other 90% project'

'Above is a video I would like all of you to watch. After watching it I would like you to write down next to your name below that describes your first thoughts towards the video...'

Using the project themes of exchange, reveal, adapt, include, prosper and access the student then asked peers to explain 'how you think they affect designing?'

2. Relating to the topic of eco-textiles:

'For my seminar read Eco-clothing, Consumer Identity and Ideology, by K. Niinimaki pages 151-153. This will help you to get a better understanding of the information I will be sharing with you during my Eco-Textiles seminar. After reading these pages I would like you to write a few sentences about the way you choose and buy clothes. What makes you want to buy an item of clothing? What are your attitudes to buying clothes?'

Students who gave their seminars earlier in the year had less sophisticated activities:

3. Active Consumers topic:

'Watch adverts either on television or on YouTube of any products you could buy in a shop or online. As an alternative you could go into shops and observe products. I would like you to note down any key points the packaging focuses on, for example, does it promote the taste of the product? Does is promote the brand that sells the product? Does it inform you of the nutritional values?'

Comments made on the wiki by students before attending the seminar;

For the topic 'Designing for the other 90%' students answered the question 'how do you think they effect designing with comments such as:

4. Designers have to be willing to be able to adapt and change parts of designs to meet customers different needs and wants
5. Different cultures will have their own views on technology

For the Food Security topic students were asked to respond to YouTube videos and news articles. Their reaction to the implications of this new topic is easy to see:

6. 'Ew Bugs!!!!! Interesting how much more protein they contain. Wasn't aware that they were as widely eaten already.'
7. '[Easting insects is] a good idea, not very nice to think about. To be honest I'd prefer to eat the bugs instead of a stem cell grown piece of meat.'

Comments made by the tutor after the seminar

8. Power of the supermarkets: 'Excellent balance about the argument for & against supermarkets'
9. Energy resources: 'Excellent technical understanding'
10. Active consumers: 'Clever take on active consumers, how we are being manipulated/duped by labels which make us think we are being ethical consumer'

Items taken from seminar presentations

11. Cradle to Cradle: Participants were asked to think about 'What do we need from our environment? What do we want from our environment?'

Examples of learning objectives or outcomes shared at the start of a seminar:

12. Active consumers learning outcomes: To describe factors that influence active consumers decisions to purchase products.
13. Eco-textiles learning objectives: be able to consider the impact of sustainable textiles in design and technology.
14. Disruptive technology: Outline how disruptive technologies will affect teachers and the classroom

Comments in the university survey

15. 'Everything we learn about makes us question what we already know'
16. 'Gaining experience in new topics which were new to us'

The following comments made by the tutor after the seminars, taken from the seminar presentations and made in the university survey can be seen as an indication of the students showing intentions to introduce elements of modernization into their practice.

Comments made by the tutor after the seminars

17. 'Good reference to National Curriculum in justifying how it can be taught in school'
18. 'Some good ideas about how to utilise the topic in D&T although I wonder about your reliance on biology for this assignment.'
19. 'Good understanding of how to engage pupils in D&T, e.g. starting points and inspiring their creativity'

Items taken from seminar presentations

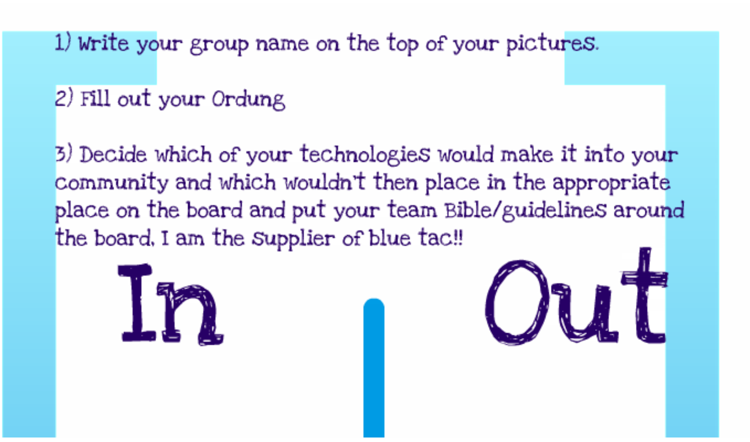
Many of the seminars included quick design activities or decision making activities which were relevant to D&T:

20. Cradle to Cradle seminar asked for reflections on 'Do you think the amount of waste has changed in recent history? Based on your reading, discussions and the video from the session, so (sic) you this this will increase or decrease? What is a good example of cradle2cradle?'
21. Energy resources: Students were grouped and asked to give reasons why a particular method should be the main alternative.

Some activities were more conventional, setting a design brief:

22. Eco-textiles activity

23. Impact of Technology Activity



24. Power of the Supermarket:
'The video clip shows just one way that Tesco has managed to increase its sales in South Korea. Your task in groups are to come with some ideas that could increase sales for any of the supermarket chains without having a detrimental effect on the people who produce the goods.'

Comments in the university survey

25. 'Given ideas of how I could run sessions in the future'
26. 'I enjoy this lesson and will help me later in classes when we are teaching'

DISCUSSION

In this discussion we will compare the evidence with each of the four learning requirements to ascertain the extent to which these learning requirements have been met.

In the case of learning requirement 1, become knowledgeable about significant and contemporary developments in technologies and design, four pieces of evidence provide support that this learning requirement has been met as indicated by evidence items numbered 6, 9, 14 and 16.

For learning requirement 2, understand how ethical, cultural, economic and environmental factors influence the design of products, systems and environments and can affect technological change, the following ten pieces of evidence support that this learning requirement was met as indicated by evidence items numbered 1-4, 7, 8, 11-13 and 15.

Thirteen examples support that the learning requirement 3, engage in appropriate activities that highlight the need for debate, tolerance of beliefs and respect for values in dealing with controversial and/or social issues, was met as indicated by evidence items numbered: 5, 6, 8, 10-13, 15, 20 and 22-25.

The final learning requirement, consider the process of technological change and the technological issues in society within the context of Design and Technology education, five pieces of evidence support that this learning requirement was met: as indicated by evidence items numbered 17-21.

Although all of the learning requirements have been addressed by some of the topics no single topic addressed each of the learning requirements from the evidence selected for analysis. Only two topics addressed three requirements; these were food security and cradle to cradle. And several topics did not support any of the requirements based on the evidence used here: these were product development, manufacturing systems and globalisation. This may have been due to students' preconceptions and prior knowledge of these topics. In the written report the student who researched globalisation in D&T focussed on how D&T could support this topic in geography.

It is disappointing to note the limited evidence supporting the first learning requirement which closely aligns with the overarching module aim. The topics given to the students and the availability of modern and relevant resources may have been limiting factors.

All of the students suggested in their extended writing, not part of the data used here, how their topic could be taught or used in a D&T lesson; however their examples lacked originality and tended to be used either at the beginning of a design project to set a scene or at the end to extend the context. This may be due to their limited teaching experience prior to this module.

CONCLUSION

This paper has highlighted issues which need to be addressed in the next cycle of teaching this module:

- The topics in Figure 2 were from a list provided by schools that work with the university and tended to meet their needs rather than the modernisation agenda discussed earlier. Therefore the topic list needs revising to support new and emerging topics as a central aspect of the modernisation agenda.

- During the taught part of the module there should be greater focus on how fundamental to D&T's development the modernisation agenda is and their role within it.

- Provide more meaningful opportunities to work in schools prior to and during this module.

This module is a key component of the course's aim to support the modernisation of the D&T curriculum in schools and to include opportunities for initial teacher education students to debate and develop their own knowledge of scientific and technological changes (Ofsted, 2011; Williams, 2009). The evidence presented here shows that this occurs only to some extent during the module. An immediate next step will be supporting the students who have taken the module in using the knowledge, skills and values learnt in their teaching practice. A key method will be to inform school tutors about this module and its content. From here course and school tutors can work together with students creating teaching activities for the students to test out in lessons. This will be a topic for a further paper.

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Starting the Journey: Discovering the Point of D&T

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ABSTRACT
Starting with the question 'Why teach Design and Technology in secondary schools?', this paper describes the first stages of a journey to discover a values framework for D&T in English secondary schools.

Events and reflections, some of which are described, have informed the initial stages of my PhD studies which is to develop a framework defining the value of D&T in secondary school education in England. This paper is a presentation of some initial findings for the framework.

This is only the start of my PhD journey in which there are three stages:

1. An exploratory study of interviews and personal rationales to develop a framework of the value of D&T,
2. Using the framework to make judgements about the profiles different stakeholders have of the subject
3. Using the framework, evaluate the practice in schools

The values reported here have been identified from two stakeholder groups: trainee D&T teachers from my own university and D&T academics. At this stage in the study I am not comparing the values held by different stakeholders only in discovering their values which will inform the values framework.

At the start of their D&T teacher training my students write a personal rationale on why design and technology should be part of the secondary curriculum. A coding method from grounded theory was used to investigate and analyse the rationales (Aurebach ad Silverstein, 2003). The second data set for the framework came from interview transcripts with four D&T academics and was analysed using he same coding methods. Combining these led to the formation of the first version of the framework that consists of twenty-two value statements. It is expected the framework and method presented in this paper will stimulate debate and contribute to both the author and wider community's thinking about the value of D&T.

Keywords: Values, values framework, series, design and technology education

INTRODUCTION

'Why teach Design and Technology in secondary schools?' is a question I ask new cohorts of trainee D&T teachers during an introductory session. During this I share my own values of D&T, which when I started my career as a teacher educator I found difficult to articulate concisely or with clarity. After one of these sessions I stood back and reflected: 'Are these my values or am I just repeating what I have read and heard? Do I believe what I am saying is the value of D&T?' This made me reflect on what exactly were my values and could I define them more clearly?

After the session students are asked to think about the contribution D&T makes to pupils' education, and afterwards write a brief piece entitled 'A Rationale for Teaching D&T'. Within this writing students emphasized different values of D&T: some focused more on the benefit of learning skills for employment ('create many opportunities such as future employment prospects'), others talked about the value of developing their creativity skills ('opportunity for pupils to think creatively'), other looked at more philosophical values ('greater understanding of the workings of the world').

This led me to question whether there were any common values within their different responses? Based on subsequent reading about values (Braithwaite & Law, 1985; Rokeach, 1973; Schwartz, 1994; Thurstone, 1959) I believe, maybe naively to some, there must be some common ground: a value series/framework of D&T. Steve Keirl last year discussed the challenge and the potential impossibility of finding common ground (2012); this paper begins to respond to his challenge.

Rokeach proposes that a value 'becomes, consciously or unconsciously, a standard or criterion for guiding action, for developing and maintaining attitudes toward relevant objects and situations' (1968, p.160). Accepting this explanation means the values a person holds of D&T will inform their behaviour towards the subject. For different stakeholders this could be how they engage with, teach, think about or act towards D&T. Looking back to the students' rationales I began to see how this would affect their approach and teaching in a school.

An example of how different values can impact on D&T occurred during this time of personal reflection, highlighting to me why it was important to clarify the value of D&T. The new Secretary of Stage for Education had launched a 'Call for Evidence' about the National Curriculum in England, an aspect of which could have implications for D&T: 'Should all school subjects be compulsory' (Department for Education, 2011), that is: were some more important than others? The result of this consultation led firstly to the value of D&T as a key component of a child's education being questioned (Great Britain, 2011) and secondly a new D&T curriculum proposed which emphasized the domestic and life skills aspect of D&T (Department of Education, 2013). As expected there were vocal responses from the D&T community (Barlex et al., 2012; Design and Technology Association, 2011) and others (E4E, 2013; Hardy, 2013; Prince, 2013; Royal Horticulture Society, 2013).

During this I wondered if the fragile position of D&T in the curriculum was really a surprise? D&T is comparatively new in England; first coming into being as a compulsory subject in 1992 following the 1988 Education Reform Act (Toft, 2007) after an evolution of over one hundred years (Eggleston, 1976; Penfold, 1988). Previously it consisted of separate subjects such as craft, home economics, sewing and technical drawing which is how many who are involved in influencing and shaping the subject today experienced it. A further consequence and change in focus for D&T, which could be as a result of or effect stakeholder's values, has been that since its inception as a single subject in to the National Curriculum for England and Wales it has gone through four National Curriculum reviews in 1993, 1999, 2005 and 2012 (House of Commons, 2009), resulting every time in changes to either title, content or both. As a result of its history and subsequent changes, it is my belief that stakeholders in D&T have different definitions of its identity and value, which may manifest as a lack of understanding between the different stakeholder groups.

I identified four main stakeholder groups as part of my preliminary thinking about these groups:

1. Shapers, e.g., Secretary of State for Education, head teachers, non-ITE university lecturers.

2. Users and consumers, e.g., Pupils, employers and businesses.
3. Influencers, e.g., Parents, non-D&T teachers.
4. Holders, e.g., D&T academics, teachers, teacher educators and trainee teachers

These events and reflections have informed the initial stages of my PhD studies which is to develop a framework defining the value of the D&T in secondary school education in England. This paper is a presentation of some initial findings for the framework. At this stage in the study I am not comparing the values held by different stakeholders only in discovering their values which will inform the values framework. The comparison of values held by stakeholders will form the second part of my study.

FINDING THE (OR A) VALUES SERIES OF D&T

The aim of this stage of the research is to construct a values framework using textual data generated by individual stakeholders in which values of D&T are discovered. A purposive sample representing the above different stakeholder groups is being used. The analysis method is based on a coding technique from Auerbach and Silverstein (2003) which they describe as taking small steps up a staircase moving from a 'lower to a higher level of understanding …(of) your research concern' (p. 35).

The values reported here have been identified from two stakeholder groups: trainee D&T teachers from my own university and D&T academics. These groups have been labelled 'students' and 'experts'. Both groups are within the field of D&T, which I recognise is a limitation and will be discussed later in the paper. Thirteen students gave consent for use of their rationales mentioned at the start of this paper. Four experts told me their values of D&T during face to face interviews.

Described below are the two phases and two steps in each phase based on Auerbach and Silverstein's coding method. Some anonymised examples from the data are included for clarity.

Phase 1: making the text manageable

Step 1. Identifying the research concern: What I want to learn and why

What: I want to identify the values the two groups hold about D&T.
Why: to create a values framework.

Step 2. Selecting the relevant text

This involved scrutinising each line of the text and copying relevant text to a new document. Each copied word or phrase I judged to be an example of a value (note: Auerbach and Silverstein call these 'ideas'). For example from the sentence 'D&T is everywhere; it is such a diverse subject which can create many opportunities such as future employment prospects' the text 'future employment prospects' was selected as relevant.

Phase 2: Hearing what was said

Step 3. Repeating values: 'record repeating ideas by grouping together related passages of relevant text' (p.44).

The values from step two were grouped together and called 'Repeating Values'. Repeating value number six from the students' data is included below as an example. Each bullet point is an individual value identified in step two. The repeating value is named using an excerpt from the original text. This minimised overlaying the interpretation of other's values with my own.

Repeating value 6 – encouraging the pupils to challenge, explore and question their surroundings

- practical and theoretical exploration of relevant physical objects and structures, encouraging the pupils to challenge, explore and question their surroundings
- as we are surrounded by it; everything we wear and eat are products of D&T
- everyone is aware that the first part of being a discriminating user of a product is deciding if the product is needed at all
- look at their surroundings with 'new' eyes
- challenge expectation
- evaluate products from the past and inspiring them to design products for the future whilst exploring the aspects of current consumerism
- learn from past designers, inventors and manufacturers

Step 4. Themes: 'Organise themes by grouping repeating ideas into coherent categories'. (p. 43)

In this step the repeating values from both groups were brought together to create a master list of values.

After these four steps the master list of values were tested through returning to the original text to check and refine the values. This was to minimize the loss of meaning through removing further away from the original data.

FINDINGS

This section will only report on steps three and four as these led to the final series of values.

Step 3. Repeating Values

From the students' text: grouping the relevant text (phase one) produced twenty- five different values and seven 'orphans' (text which is not repeated) (Auerbach & Silverstein, 2003).

From the experts text: seventeen different values were identified with only two orphans.

Step 4. Themes (Creating a Master List of Values)

Initially there were twenty-two discrete value categories organized from combining the repeating values from students and experts.

- Fifteen values had repeating values from both stakeholder groups. All of which had only one repeating value from the expert group; seven had more than one repeating value from the student group.
- Two had repeating values only from the student group.
- Five had repeating values only from the expert group.

Through this process I was able to place all of the repeating ideas and orphans and one of the student repeating ideas (i.e., number two: aware of the impact of technology on society now and in the future) was included in more than one value category. After this process each category had a summative sentence written using the writing frame either 'I believe D&T is of value because….' Or 'I value D&T because…'.

During this iterative process repeating ideas were moved as the original data revealed that the repeating idea misrepresented the original intention. For example one category value initially had four repeating ideas with a summative sentence: I believe D&T is of value because it combines learning through using both hands and brains. The four original ideas were:

1. learning through using brains and hands
2. fuses design technology, practical skills and theory
3. engages pupils in different ways of learning
4. application and development of specific knowledge and skills

But looking back to the original text led to points two and three moving to a different category and point four being rephrased as ‘combine both intellectual and practical skills’.

Each final summative sentence was reduced to a value statement and twenty-two value statements were the final outcome of this lengthy process creating the following values series:

1. Meaningful activity of solving real problems with real solutions
2. Learning happens through using brains and hands together
3. Empowers society to act to improve the world
4. Personal ownership of decisions and actions
5. Learning of vocational skills and techniques that open doors to a range of careers
6. Using raw materials to make a product
7. Designing for future needs and opportunities
8. Develops the skill of creativity
9. Freedom to take risks and experiment
10. Considers the ethics of technological development
11. Alternative to academic subjects
12. Identifying problems to be solved
13. Activity of designing
14. Helps the understanding of human beings' position and existence in the world
15. Become aware of the economic impact of technological development
16. Develops the skills of autonomy and collaboration
17. It is fun and enjoyable
18. Provides a practical purpose for other school subjects
19. Examination and questioning of the made world
20. Learn from evaluating personal success and failure
21. Contributes to the nation's industrial and economic competitiveness
22. Learn practical life skills

These axioms are in any hierarchical order but as they were discovered from the data, although I acknowledge some may appear lower down as a result of my personal judgment as to their importance.

CONCLUSION

Auerbach and Silverstein (2003) describe this coding method as hypothesis generation research linked to grounded theory. I am not using grounded theory methodology, only the potential this method gives me to use words from the participants rather than imposing my own words on the interpretation of the individual’s values. It allows me to remain in ‘contact with the empirical base’ (Alvesson & Skoldberg, 2009, p. 57). Therefore the methodology is reflexive as the different levels of interpretation interplay with each other and are acknowledged in the development of the framework. Within my research there are four levels of interpretation (see table 1). Each of these levels will, I believe, have an implication in how the final framework presented above has been developed. At this stage of my PhD journey I am still exploring my understanding of these levels but I want to explain my current thinking at this stage and how these levels could be impacting on my interpretation of the text.

Table 1: Levels of interpretation (Alvesson and Skoldberg, 2009, p.273)

Aspect/level	*Focus*
Interaction with empirical materials	Accounts in interviews. Observations of situations and other empirical materials
Interpretation	Underlying meanings
Critical interpretation	Ideology, power, social reproduction
Reflection on text production and language use	Own text, claims to authority, selectivity of the voices represented in the text.

The first level is interpreting the empirical material being mindful of how the data were created. The student rationales were not created only for use in this research, whereas the interview transcripts were. Also the student rationales were influenced by my earlier mentioned talk.

The second level is my interpretation as the researcher. I am not objective as I hold my own values of D&T, which could 'limit the possibilities of making certain interpretations' (Alversson & Skoldberg, p. 273) even though I struggle to articulate my values. During the coding and values generation process I did have an affective response to some phrases used by participants to define their values of D&T. For those I had a negative response to I was conscious not to exclude them. For example I found refining value number eleven difficult as I did not want to acknowledge that for some pupils D&T provides a 'change from intense academic subjects' (words from one student). Being mindful of this after step four each individual's values from step two were cross-referenced with the final values to ensure all were included.

The third level is the critical interpretations which includes ideology, power and social reproduction. The labels I had given the two groups, students and experts reveal my relationship, and therefore the power, I ascribe to them within my interpretations. It was interesting to reflect that I used the experts repeating ideas to lead the formation of the categories at step four; is this evidence of the power I ascribe to this group of people? Earlier I placed this group as part of the Holders group but maybe I subconsciously placed them into the Shapers as part of my own interpretation of the power they have over the curriculum? Also the location where the data were created (time and physical space) could influence the values described within the text. The students wrote a rationale about D&T knowing I would read it and some of the interviews took place during a conference. All data collection took place during the curriculum upheaval mentioned earlier.

The final level is my reflection on the 'text production and language use'. The voices in this paper are all from within D&T and represent only the Holder group. Therefore the framework can only claim to represent the values held by this limited group and possibly only the representatives from these groups. For it to be more representative the values of other voices from outside the immediate D&T community need to be heard.

The study's next stage is interviewing members from the other stakeholder groups to discover their values (steps one to three of the coding process); these values will then be combined with the repeating ideas from all of the stakeholders to form the final framework (step four). This final framework will be used for stage two of the research, which is to make judgements about the profiles different stakeholders have of the subject.

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Student Decision Making in Technology: Its Impact on Student Technological Practice

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ABSTRACT

A key aspect of technology education in New Zealand and internationally, is the provision for students to undertake technological practice. It is expected that this provision not only enables students to develop technological outcomes of worth, but that they also acquire an understanding of technological development in general. The New Zealand curriculum (Ministry of Education, 2007) was revised in an attempt to ensure the technological practice aspect of student learning in technology is better informed by their developing understandings of technological knowledge. This revision also placed an emphasis on students' development of critical thinking. The informed and critical nature of this learning can be ascertained by focusing on decisions that students make. In this paper we discuss an action research undertaken to explore how and why students make the decisions they do when undertaking technological practice. Based on data collected from New Zealand classrooms during 2008-2009, we illustrate the role of functional and practical reasoning in decision-making and discuss how this influences the focus and nature of the technological practice students undertake.

Keywords: technological practice, technological knowledge, functional reasoning, practical reasoning, decision making, fit for purpose' in their broadest sense, Indicators of Progression

INTRODUCTION

Technology education in New Zealand is taught as a compulsory part of school curriculum for all students in years 1-10, and as an optional subject in senior secondary school at years 11-13. First introduced as *Technology in the New Zealand Curriculum* (Ministry of Education, 1995), it was reframed in 2007 to align with a revised New Zealand Curriculum [*NZC*] (Ministry of Education, 2007). Technology in the *NZC* (Ministry of Education, 2007) introduced three new strands and eight components which together support the aim of technology education. That is, to provide an opportunity for students to develop a deep, broad and critical technological literacy (Compton and France, 2007a; Compton and France, 2007b) so that they may "participate in society as informed citizens and give them (better) access to technology-related careers" (Ministry of Education, 2007, p.32).

Understandings about how student learning progresses in the components of the Technological Practice strand (brief development, planning for practice, and outcome development and evaluation) were researched inside New Zealand classrooms prior to the release of the 2007 technology curriculum (Compton and Harwood 2003; 2004; 2005). Research to develop similar understandings for the components of Technological Knowledge and the Nature of Technology strands however did not occur until after the release of the revised curriculum. This research called *Technological Knowledge and the Nature of Technology: Implications for classroom practice* [TKNoT: Imps] was conducted in 2008 and 2009.

It is believed that when the curriculum strands and their components for technology in the *NZC* (Ministry of Education, 2007) are combined within a teaching programme they support students to develop a sound philosophical insight of technology, robust understandings about technological knowledge and an ability to undertake technological practice to form outcomes which they can justify as 'fit for purpose' in their broadest sense (Compton & France, 2007a; Compton & France, 2007b). While this belief is well founded on national and international literature (Compton, 2009; Compton & France, 2007a; Compton & France, 2007b), no research has been conducted to date in New Zealand classrooms to explore the relationship between the 2007 curriculum strand components, and whether combinations of these lead to students being better prepared to develop technological outcomes that are 'fit for purpose'.

Similarly no research has been undertaken to determine if, when student understandings are enhanced in an individual curriculum strand component, it also increases their understanding/competency in another. This paper reports on a study that was undertaken when an emphasis was placed on enhancing student knowledge of technological modelling, a component of the Technology Knowledge strand, to determine if this enhanced their achievement in the components of Technological Practice and lead to them better justifying their developed outcomes as 'fit for purpose'. The study followed 27 students across three schools as they moved from years 11-13. Student data which was analysed included student responses to a technological modelling questionnaire, portfolio evidence of their undertaking technological practice and student interview. An Action Research methodology enabled this study to both monitor student achievement and identify opportunities to enhance next learning within and across three research cycles. Between cycles teachers introduced a range of structured teaching activities focused on enhancing student understandings of concepts underpinning technological modelling.

In this paper we begin with a brief overview of the technology curriculum strand - Technological Practice and its components; the Technology Knowledge strand component - technological modelling, and introduce the component's respective Indicators of Progression. We discuss the category labels that were used to explore student decision making when undertaking technological practice, and determine the 'nature of student reasoning' and 'nature of the practice' they sought to undertake. Findings from the research are presented and we conclude with an overview of how the research findings can inform the design of teaching programmes for technology in the *NZC* (Ministry of Education, 2007).

TECHNOLOGICAL PRACTICE AND MODELLING IN THE NEW ZEALAND CURRICULUM

Technological Practice

The Technological Practice strand in technology in the *NZC* (Ministry of Education, 2007), is focused on students undertaking their own 'technological practice' to realise solutions to problems that require competing criteria to be addressed. This strand also encourages students to inform this practice by reflecting on the technological practice of others (Compton & Harwood, 2010). The components of this strand, brief development, planning for practice, and outcome development and evaluation, describe 'subsets' of technological practice, which have been shown to be relevant to all technological contexts and areas, irrespective of the level of practice (Compton & Harwood, 2004). These components are intrinsically linked in the act of undertaking technological practice, akin to Hughes' (1986 - cited in Layton, 1993) 'seamless web' of interactive components. However, they each have an identifiable differentiating 'outcome'. For example: the outcome of brief development is a 'developed brief', the outcome of planning for practice is a 'plan for undertaking technological practice' and the outcome of development and evaluation is a 'developed outcome that is evaluated'. How these outcomes are realised, however, is not defined by a series of 'pre-determined steps', or a defined process such as: identify-design-make-evaluate (Williams, 2000). Rather, teachers and students are encouraged to select, adapt and modify their practice to suit the context of the need or opportunity under investigation that offers the prospect of a technological outcome to be realised.

Technological modelling

A 'model' is used to represent reality. In technology, modelling is used to represent the physical and/or functional qualities of an outcome that is yet to be fully realised. The use of technological modelling therefore enables technologists to 'test' an "outcome's potential and probable impact in the world, as it moves from a conceptual idea through to being fully realised and implemented in situ" (Compton 2010 p.49). For this reason, technological modelling is considered a key concept underpinning technological development across all domains of technology (Compton & France, 2006). Technological models can be grouped into two categories: those that are used to test a 'design idea' called functional models, and those which are used to test and refine a 'technological outcome' called prototypes (Compton & France, 2006).

The indicators from the Indicators of Progression for the Technological Practice strand (Compton & Harwood, 2010) and technological modelling (Compton and Compton, 2010) were used in the research to determine the curriculum level understandings students demonstrated for the components: brief development, planning for practice, and outcome development and evaluation, and technological modelling. Two sub category labels where introduced at each curriculum level to distinguish between students that demonstrated some of the competencies expressed by the indicators for a Level and those who demonstrated all of the indicators at that level.

Student's justification of 'fitness for purpose' of their developed technological outcomes; the technological practice they undertook to develop these, and the reasoning behind their decision making were explored.

DECISION MAKING AND REASONING IN TECHNOLOGY

Decision making is often referred to as a mental process that deliberates on multiple options (or alternatives) to select one that best meets the goals of the decision-maker (Hardy-Vallée, 2007; Milkman, Chugh & Bazerman, 2008). The outcome of decision making manifests itself as a conscious action or "opinion of choice" (Bohanec, 2009, p.24), that may in turn lead to a change in a decision maker's disposition towards a certain topic (Ferrand, 2007). While the deliberation on alternatives may be "explicit and complex or implicit and rapid, without consideration of alternatives no decision making can be said to have taken place" (Galotti, 2002, p.2). Considering alternatives within an informed decision making process is therefore important for determining which alternative or decision to follow. While decision-making is the process of determining what to do or selecting an alternative (Beyth-Marom, Fischhoff, Jacobs-Quadrel, & Furby, 1991), it is *reasoning* that enables assessment of the probable success of considered alternatives (Fischhoff, Crowell, & Kipke, 1999).

'Reasoning' is a process that allows humans to change (or not change) their views and conclude a proposition that is reflective of their present-day understandings (Harman, 2009). As such reasoning allows beliefs and desires to be integrated into intentions or actions, (Carruthers, 2003) supporting decisions to be made. In technology in the *NZC* (Ministry of Education, 2007) two forms of reasoning, functional and practical reasoning, have been highlighted to underpin decision making when students undertake technological practice, and critique the practices and outcomes of others. Students are supported to develop conceptual understandings about the importance of these two forms of reasoning by the curriculum component, technological modelling (Compton, 2010; Compton and Compton, 2010).

Use of functional reasoning within technology, enables the technical feasibility of design ideas and outcomes to be explored (Compton, 2010; Compton & France, 2006). As a consequence both the practice of 'how to make things happen' and an understanding of 'how it is happening' can be captured in a physical description. Practical reasoning within technology is focused on addressing social considerations such as moral, cultural and ethical viewpoints surrounding a design idea, and the testing of an outcome to be explored (Compton, 2010; Compton & Compton, 2010; Compton & France, 2006). This form of reasoning uses normative understandings to regulate action (Railton, 1999). When technologists use normative practical reasoning, in the act of developing outcomes that are 'fit for purpose', it provides them with a framework from which to consider opinions, and the potential impact on immediate and wider community stakeholders to the outcome under development.

According to Fisher (2008) and Ullman (1992) the determination and realisation of the functional needs of a design solution needs to not only address the technical aspects of the solution, but also ensure its social acceptance. A 'physical description' of both the design problem and its solution therefore should not only consider the technical feasibility of a yet to be realised design solution, but also recognise and address socio-technical considerations that underpin the development of a solution. To support informed decision making towards a design solution (technological outcome) and ensure that both the technical feasibility and social appropriateness of a developing design solution are considered, both functional and practical reasoning should therefore be apparent when students undertake technological practice.

Category Labels for Reasoning and Decision Makings

To enable the nature of student reasoning to be identified and the nature of their technological practice to be determined, the following category labels were determined by the researcher as a result of exploring the literature and interrogating the research data:

Nature of Reasoning

- practical reasoning
- functional reasoning
- integrated reasoning

Nature of the Practice Sought

- completed outcome
- best outcome
- best technological practice.

These labels are explained in Table 1.

Table 1: Category of Reasoning and drivers underpinning Decision Making

Category	***Description***	***Category Label***
Nature of Reasoning		
Practical Reasoning	*Reasoning* ***centred*** *on selecting a* ***socially accepted*** *technological outcome; consideration of moral, cultural and/or ethical concerns apparent* (Compton, 2010; Compton & France, 2006b).	P
Functional Reasoning	*Reasoning* ***centred*** *on determining the* ***'technical feasibility'*** *of a technological outcome* (Chakrabarti & Bligh, 2001;	F

	Compton, 2010).	
Outcome focused Integrated Reasoning	*Reasoning that provides justification that* ***a developed technological outcome*** *is socially acceptable and technical feasible* (Harwood, 2013).	IRo
Practice focused Integrated Reasoning	*Reasoning that provides justification that* ***both*** *the* ***practice undertaken to develop a technological outcome*** *and the* ***outcome itself*** *are socially acceptable and technical feasible* (Harwood, 2013).	IRp
Nature of the Practice Sought		
Completed outcome	Decision making focused on **completing** an alternative, i.e. a technological outcome which is **good enough** (i.e. it works) (Harwood, 2013).	CO
Best outcome	Decision making focused on finding (and implementing) the **'best'** alternative, i.e. a technological outcome that is **'fit for purpose'** (Harwood, 2013).	BO
Best technological practice	Decision making focused on ensuring that **both** the **technological practice** undertaken and **selected alternative** is the **'best' available**. Resulting technological outcome is considered to be **'fit for purpose' in its broadest sense** (Harwood, 2013).	BT

To enable differences within categories to be distinguished for *practical* and *functional reasoning*, two sub category descriptions were identified in the study – *superficial (s)* and *robust (r)*. Student evidence classified as *superficial* mentioned reasoning in passing but did not use it as a 'driver' for future decision making. Evidence classified as *robust* consistently reasoned out alternatives to determine their contribution in future decision making (Harwood, 2013).

The categories of completed outcome, best outcome and best technological practice required no further categorisation as they, by their very nature, depict a hierarchy of decision making from one category to the next. Students either presented data that predominantly focused decision making on a completed outcome or their decision making focused on realising a best outcome. The student(s) whose decision making focused on realising a best outcome were identified to display more advanced decision making than those whose aim was a completed outcome.
These category labels where used to interrogate data that arose from the action research cycles.

RESEARCH METHOD

An action research design was adopted for this study due to its responsiveness to the context in natural settings, and focus on critical reflection with intent to improve understandings and practice within social settings (Elliot, 1981; Poskitt, 1994). Quantitative and qualitative data were gathered, consisting of a questionnaire, portfolio evidence and interviews. These data were gathered over three research cycles from 27 student participants who were in years 12 and 13 in 2008 and 2009 respectively. Adopting an action research design allowed the researcher to observe both "cause and effect" (Cohen, Manion & Morrison, 2002, p.181) of strategies used to enhance student concepts of technological modelling. It also allowed the researcher to identify if enhanced student knowledge impacted on their ability to justify their developed technological outcomes as 'fit for purpose'. An action research approach enabled emerging themes to be interrogated and refined with subsequent data collection and analysis over the three cycles of action research (Guba, 1979).

RESEARCH FINDINGS AND DISCUSSION

The research demonstrated a strong correlation exists between student understanding of the concepts underpinning technological modelling and their curriculum level achievement in the components of Technological Practice. That is, when student understanding of technological modelling increased, through explicit teaching focused on developing their knowledge of concepts underpinning technological modelling, their competency in undertaking brief development, planning for practice, and outcome development and evaluation also increased.

Those students who displayed the lowest curriculum level understandings of concepts underpinning technological modelling also demonstrated the lowest achievement in the Technological Practice components. By comparison, those who demonstrated the highest conceptual understanding of technological modelling also displayed the highest curriculum level achievements in the Technological Practice components.

The research also showed that the majority of students, following teacher interventions that increased their curriculum level understandings of concepts underpinning technological modelling, changed the focus of their decision making. This change shifted from a focus on developing a completed outcome, to decision making focused on a best outcome. In addition, some students, following an increase in their curriculum level understandings of concepts underpinning technological modelling, focused their decision making on undertaking best technological practice.

Students who held high curriculum level understandings of technological modelling (curriculum level 6 or above) were more likely to employ robust practical and/or functional reasoning when developing technological outcomes. Such students could discuss how practical and functional reasoning "work together to enhance decision making during technological modelling", and discuss "how evidence and reasoning is used during functional modelling to identify risk and make informed and justifiable design decisions" (Compton & Compton 2010, p.93). These students' possessed understandings that equipped them to justify outcomes developed through undertaking technological practice as 'fit for purpose in their broadest sense' (Compton & France, 2007a; Compton & France, 2007b).

In contrast, students who held low curriculum level understandings (below curriculum level 5) of technological modelling were most likely to employ superficial practical and/or functional reasoning when undertaking technological practice. While students who possess curriculum level 5 understandings of technological modelling can "identify examples of functional and practical reasoning within decision making" and "explain how evidence gained from functional modelling was used to justify design decisions" (Compton and Compton 2010 p.92), this research identified that they lacked awareness of how practical and functional reasoning work together to enhance decision making, to support informed and justifiable design decisions.

Analysis of student data using the category labels 'nature of student reasoning' and 'nature of the practice' revealed that there were strong links between student use of practical and functional reasoning and how they integrated these when undertaking technological practice. That is, students who undertook robust practical and functional reasoning also tended to integrate these to justify the social acceptance and technical feasibility of the practice they undertook when developing technological outcomes, as well as the outcomes themselves. These students were categorised for 'nature of the practice' as undertaking practice focused integrated reasoning. However, students who demonstrated robust practical reasoning with superficial functional reasoning, or vice versa, who integrated both reasoning types, with a focus on ensuring that the technological outcomes they developed were socially acceptable and technically feasible, were identified to demonstrate outcome focused integrated reasoning.

A strong relationship between the 'nature of reasoning' students employed and the 'nature of the practice' they undertook was also identified. Students categorised as employing practice focused integrated reasoning were identified as more likely to focus their decision making on undertaking best technological practice. These students were seen to develop technological outcomes that were ‘fit for purpose’ in their broadest sense (Compton & France, 2007a; Compton & France, 2007b). Students who employed outcome focused integrated reasoning, however focused their decision making on developing a best technological outcome with little consideration given to the nature of the technological practice they undertook to create it.

CONCLUSION

This section addresses the research findings implications on the design of technology classroom curriculum and concludes the paper.

A number of the structured activities used by the research teachers required students to critique the technological practices of technologists to identify their use of technological modelling-in-practice and the conceptual understanding they may have held. This pedagogical approach employed by the research teachers was identified to enhance student understandings of concepts underpinning technological modelling. The positive connection between the use of these activities, within and across technology units, and the resulting increase in student understandings of concepts underpinning technological modelling, and achievement in the components of Technological Practice, suggests there is merit in other teachers employing similar activities.

The category labels for the ‘nature of (student) reasoning’ and the ‘nature of the (students) practice’, identified by this research, present themselves as tools for determining the types of reasoning students employ and the focus of their decision making when undertaking technological practice. If these labels are used as a formative assessment tool by teachers, to focus interventions with students, they present an opportunity for teachers to identify and address barriers to students developing technological outcomes that they can justify as ‘fit for purpose’. Furthermore, the category labels offer support for teachers to plan ‘next’ student learning experiences, which include: addressing identified student misconceptions; enhancing how students apply practical and functional reasoning; and focusing their decision making when undertaking technological practice so that they are supported to develop a technological literacy that is ‘broad, deep and critical’ in nature (Compton, and France 2007a; Compton, and France 2007b).

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Appropriate Technology as the Basis for a Technology Education Curriculum

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ABSTRACT
This paper reports on a small-scale Delphi study conducted to identify essential content for a secondary school technology education curriculum focused on appropriate technology. Appropriate technology (AT) is defined, a summary of the AT movement's history and philosophy is provided, and new developments within the field are discussed. The findings of a Delphi study to identity AT core concepts/foundational principles, technical topics, and functional skills and abilities are presented. A case is made that using AT as the basis for a high school technology education course will provide meaningful opportunities for student engagement and may attract more students, including female students.

Keywords: appropriate technology, sustainable development, curriculum development, technology education)

OVERVIEW
The position outlined in this manuscript proposes appropriate technology (AT) as a thematic focus for technology education. This will accomplish many of the same curricular goals as existing courses in technology education while at the same time aligning effectively with the *Standards for Technological Literacy* (ITEA, 2001, 2007), the technology and engineering components of the *Next Generation Science Standards* (NGSS Lead States, 2013), and the *Framework for K-12 Science Education* (National Research Council, 2012). A case is made that an AT-oriented curriculum can be used to promote student involvement in STEM fields and provide rich opportunities for engagement around topics of societal importance. Also reported here are the findings of a small-scale study undertaken to identify essential content for a high-school level course focused on appropriate technology (AT). Although not a new concept, AT has played a minimal role in technology education curriculum models, despite some relatively recent publications promoting this perspective (Wicklein, 2001, 2005). There exist both philosophical and educational rationales for taking a new look at AT.

For example, Miller, Sarewitz, and Light (2008) report on a two-day workshop on Science, Technology, and Sustainability held at the National Science Foundation. Participants agreed that insufficient attention has been paid to how "a better understanding of the human and social dimensions of science and technology could also contribute to improving both the understanding of sustainability challenges and efforts to solve them" (p. 2). They note: "The complex challenges of sustainability facing 21st century societies are thus bound up…not just in technological systems and their impacts on the environment and society but more importantly [how] technological systems are integrated into the ways individuals and groups live, their designs and ambitions, and their goals" (p. 5). It is this very recognition of the contextual importance of technologies that is at the heart of AT.

Although limited, there is evidence that involvement in AT activities can lead to student gains. Pearce (2007) experimented with use of AT-oriented activities in his university-level physics courses. He found that students showed increased motivation to learn physics, voluntarily spent more time outside of class meetings working on their AT projects, had more favorable comments on end-of-course evaluations, and posted modest gains in pre/post exam grades.

Schmidt (2011) cites studies examining underrepresentation of girls and women in STEM fields that show sex differences are the most important factor in preferences for college majors and occupations. In spite of having similar scores on tests of general mental abilities, including in science and mathematics, girls consistently score lower on tests of technical aptitude than do boys. Schmidt posits that this may have more to do with differences in *exposure* to technical subjects, which in turn contributes to technical aptitude. Because individuals are likely to invest intellectual resources toward subjects that interest them (thus increasing their exposure and subsequent aptitude), the challenge is then to find keys to enhance girls' interest in technical subjects. Studies like those conducted by Modi, Schoenberg, and Salmond (2012) and by Weber (2012) and Weber and Custer (2005) can offer guidance in this regard, and suggest that an AT-focused curriculum may hold some potential.

A SHORT HISTORY OF APPROPRIATE TECHNOLOGY

The AT movement is generally acknowledged to have had its basis in the work of the late E.F. Schumacher, whose work coalesced in writing of the influential book *Small is Beautiful* in 1973. Schumacher channeled a philosophical ethos that advocated for the needs of all humanity and that addressed the growing ecological awareness that natural resources are finite. Although seen by many as a sort of counter-cultural approach to economic development, the AT movement did not shun science and technology; rather, it advocated for technological development that embraced a more comprehensive set of development criteria. In broad terms, this approach meant examining the relationship between technology, quality of life, and the health of the environment, as manifested in both developing and developed nations.

At least two features of the AT movement have meant its influence in the U.S. in the past forty years has been modest. First, AT has an overt focus on the needs of developing countries. Second, AT can have a distinctly "low tech" flavor, since it promotes development of technological systems that meet localized needs and are locally controlled. In this way, it seems to contradict the driving force of high-tech development associated with work in developed nations: namely, economic growth through innovation (Morrison, 1983). Nonetheless, key components of AT have persisted and have continued to grow in recent decades under other names (these include eco-engineering, sustainable development, and so on). The AT movement "is not a fixed entity; it is dynamic, evolving. There are shared beliefs and concerns that bind the organizational and individual advocates of AT, but each is free to emphasize different aspects and to innovate in ideology, structure, and strategy" (Morrison, 1983, p. 221).

Pathways toward how AT might manifest within technology education were suggested by the various authors in the Council on Technology Teacher Education Yearbook *Appropriate Technology for Sustainable Living* (Wicklein, 2001). For example, Hoepfl (2001) examined the role of design as being at the heart of decision-making regarding technological development and as the process through which human needs and values are translated into physical form. Two examples she provided to illustrate this concept were urban ecology, which focuses on design of urban spaces that are human-scale and that promote greater community health; and industrial ecology, which emphasizes reduction of waste and pollution in manufacturing processes, including through the life cycle of a product by incorporating design for disassembly. These are sophisticated concepts with a place in modern-day technology and engineering classrooms, yet that adhere to the principles of AT.

DEFINING FEATURES OF AT

Hazeltine and Bull (1999) note "a central concept of Appropriate Technology is that the technology must match both the user and the need in complexity and scale" (p. 3). By definition, then, "appropriateness" is place- and user-dependent. Still, there are foundational principles that are generally agreed to apply to ATs. They are:

- Affordable and durable
- Energy efficient, using renewable power resources where possible
- Environmentally sound, minimizing waste, pollution, and disturbance to the biosphere
- Created with consideration of local community needs in a way that includes mechanisms for participatory development
- Controlled and repairable by members of the local community, thus promoting self-reliance and employment
- Conducive to the good health of humans and habitat (see, for example: Hazeltine & Bull, 1999; Hoepfl, 2001; Pearce, 2012b; Schumacher, 1973; Wicklein, 2001, 2005).

Applied to a high school educational setting, these principles provide an expanded roadmap of criteria that can be applied by students investigating "real-world" needs and designing systems to address those needs. For example, Baird (2008) describes the many areas of consideration when trying to achieve building energy efficiency, such as site planning, material choices, and energy systems, but notes we have given insufficient attention to the tenets of design for sustainability. In his view, sustainable design "doesn't violate or compromise conventional design goals and objectives, but refines them to produce innovative solutions that can be justified economically as well as ecologically" (Baird, 2008, p. 15). AT content and activities can provide an avenue for moving beyond the "smash and crash" (McCarthy, 2009; McCarthy & Slater, 2011) mentality that has characterized conventional technology education activities and into a realm that many high school students can more fully embrace. Most importantly, the concepts and technologies explored are relatively *simple enough* that they are intellectually accessible to students, while at the same time offering numerous opportunities for rich inquiry, analysis, design, development, and testing.

NEW DEVELOPMENTS IN AT

Among the exciting new ideas surrounding AT is the idea of "open source appropriate technology" (OSAT), promoted by Pearce (2012a, 2012b) and Pearce et al. (2012). OSAT harnesses the same kind of approach as that used by open-source software developers, in which information is shared freely, critiqued and added to by users, and in this way leveraged to create better and more robust solutions. In a process they call "Enabling Innovation (EI)," this open source approach to technological development would also include detailed sharing of the ways in which technologies evolved, information about the cultural and environmental contexts in which the appropriate technologies work best, and a system to rate the effectiveness of the technology, much like one sees with online retailers such as eBay (Pearce et al., 2012). In this vein, the wiki-format Appropedia web site (www.appropedia.org) contains thousands of pages offering a host of AT topics, research reports, a blog, and a gallery of student-led AT service learning projects. According to Pearce et al. (2012), "Appropedia has already become the AT venue of choice for organizations such as Engineers Without Borders-Australia and Demotech and is set to expand rapidly" (p. 44).

OSAT is offered as a way of combating what is seen as lack of access to information that is critical for sustainable development. These technologies can be solutions for small rural communities or more complex devices that rely on sophisticated equipment—but all sharing the defining characteristics of AT as outlined above (Pearce, 2012b). According to Kaplinsky (2011), the challenge is to align technological progress and innovation with ecologically sound and equitable development and distribution, "with very limited trade-offs between these two objectives" (p. 194). Engaging students in this type of challenge plants the seeds for future leaders in sustainability who are better prepared to work in a globally connected economy within an increasingly resource-constrained world.

IDENTIFYING ESSENTIAL CONTENT FOR A HIGH SCHOOL AT CURRICULUM

Advancing from the position that AT represents a meaningful and content-rich focus for technology education curriculum at the high school level, I conducted a small-scale Delphi study in Fall 2012. The goal was to identify essential content for the study of AT at the secondary level. Ten participants were selected based on their professional engagement with AT as demonstrated by their instructional responsibilities, their involvement with STEM education, and their record of publications that address the principles of AT. The Delphi methodology was chosen due to its recognized utility as a means of achieving consensus for a variety of purposes, including for identifying the essential elements of a curriculum (Delbecq, Van de Ven, & Gustafson, 1975; Hsu & Sandford, 2007).

The Delphi survey was administered online, using the Qualtrics® survey platform. In each round, the instrument was divided into four sections. Section 1 focused on identifying an operational definition of "appropriate technology" for the high school context. Section 2 asked participants to rate the importance of a set of *foundational principles and concepts* for AT, Section 3 asked them to rate a set of AT *technical topics*, and Section 4 asked participants to rate a set of AT *functional skills and abilities*. Within each section, participants were invited to write in additional comments and to identify any additional concepts/topics/skills not already listed that they deemed important. Participants were instructed that, although advocates of AT examine the social, cultural, and economic implications of technological choices, the emphasis within this study would be on the *technological* elements, or those topics, concepts, and skills that relate to the design, development, and application of appropriate technologies. Topics drawn for the Round 1 survey were culled from a variety of sources, including Hazeltine and Bull (1999), Wicklein (2001), Wikipedia (http://en.wikipedia.org/wiki/Appropriate_technology), and the National Center for Appropriate Technology (http://www.ncat.org), among others.

OPERATIONALLY DEFINING AT FOR THE SECONDARY SCHOOL CONTEXT

Round 1 offered the following definition of AT, taken from the CTTE 50th Yearbook titled *Appropriate Technology for Sustainable Living*: "Appropriate Technology seeks to aid and support the human ability to understand, operate, and sustain technological systems to the benefit of humans while having the least negative societal and environmental impact on communities and the planet" (Wicklein & Kachmar, 2001, p. 5). Although Round 1 respondents felt this definition was adequate, some suggested that a more detailed definition would provide better guidance for teachers. Therefore, in Round 2 a revised definition was suggested:

Appropriate technology reflects an approach to technological development that considers the social, environmental, political, and economic aspects of a proposed technological solution to a community need or problem. Appropriate technologies are generally characterized by being affordable and durable; energy efficient, using renewable power resources where possible; [small scale]; environmentally sound, minimizing waste, pollution, and disturbance to the biosphere; created with consideration of local community needs in a way that includes mechanisms for participatory development; controlled and repairable by members of the local community, thus promoting self-reliance and employment; and conducive to the good health of humans and habitat.

Sixty percent of participants indicated a preference for the longer, revised version, with one addition: inclusion of "small scale" as a defining characteristic of an appropriate technology. This change is reflected in the definition provided above, in brackets.

APPROPRIATE TECHNOLOGY CONCEPTS/FOUNDATIONAL PRINCIPLES

In Section 2 of the survey, participants were asked to rate a series of AT concepts/principles based on the degree of importance for inclusion for high-school level learners, where 1 = not important or not important *for this level* of learner; 2 = slightly important; 3 = important; 4 = very important; and 5 = essential concept. The original list of 23 concept/principles was refined through successive iterations of the survey to a final list of 14 concepts, which includes all those that achieved a rating of 3.5 or higher during the final round of the Delphi survey (Table 1).

Table 1: AT Concepts/Principles Rated as Important or Essential (mean score of 3.5 or Higher)

Concept	Mean	Variance	Standard Deviation
Sustainability	4.64	1.45	1.21
Design for the environment	4.10	.54	.74
Sustainable development	3.91	2.29	.95
Localism (local resources, local labor, local control)	3.90	.99	.99
Ecological footprint	3.78	1.19	1.09
Systems thinking	3.70	.90	.95
Conservation	3.70	.90	.95
Cradle-to-cradle resource use	3.70	1.34	1.16
Rates of growth	3.70	.90	.95
Rates of consumption	3.70	.90	.95
Decentralization	3.60	1.38	1.17
Quality of life indicators	3.50	.94	.97
Integrated design	3.50	1.61	1.27
Social justice/Just sustainability	3.50	1.83	1.35

APPROPRIATE TECHNOLOGY TECHNICAL TOPICS

In Section 3 of the survey, participants were asked to rate a series of AT technical content topics based on the degree of importance for inclusion for high-school level learners, using the same five-point rating scale. The original list of 20 technical topics was refined through successive iterations of the survey to a final list of 16 topics, which includes all those that achieved a rating of 3.5 or higher during the final round of the Delphi survey (Table 2). One participant noted that the renewable energy technology topics don't need to be broken out separately but could instead be looked at as a group, while another suggested "there is no need to cover all issues, one or two could be learnt in depth." A third participant concluded that "these are topics that well-informed citizens will have to grapple with."

Table 2: AT Technical Topics Rated as Important or Essential (mean score of 3.5 or Higher)

Question	Mean	Variance	Standard Deviation
Water supply and treatment technologies	4.30	.68	.82
Energy efficiency in buildings	4.10	.54	.74
Sustainable agriculture	4.00	.67	.82
Food production	4.00	.67	.82
Sanitation/wastewater	4.00	.67	.82
Waste management	3.90	1.21	1.10
Sustainable building design and construction	3.90	.54	.74
Power generation and use	3.90	.99	.99
Alternative transportation	3.70	.90	.95
Wind power	3.60	.93	.97
Solar photovoltaic power	3.60	.49	.70
Passive solar buildings	3.60	.71	.84
Pollution prevention	3.60	1.16	1.07
Electricity storage and transmission	3.60	.93	.97
Solar thermal power	3.50	.72	.85
Health care	3.50	1.17	1.08

APPROPRIATE TECHNOLOGY FUNCTIONAL SKILLS AND ABILITIES

In Section 4 of the survey, participants were asked to rate a series of AT functional skills and abilities based on the degree of importance for inclusion for high-school level learners, using the same five-point rating scale. The original list of 12 functional skills was refined through successive iterations of the survey to a final list of 10 skills, which includes all those that achieved a rating of 3.5 or higher during the final round of the Delphi survey (Table 3).

Table 3: AT Functional Skills and Abilities Rated as Important or Essential (mean score of 3.5 or Higher)

Question	Mean	Variance	Standard Deviation
Working with basic units of energy (e.g., kilowatt, Btu, mpg, etc.)	4.10	.77	.88
Data analysis	4.00	.89	.94
Collaboration	4.00	1.11	1.05
Cost-benefit analysis	3.90	.99	.99
Finding and using information resources	3.90	.77	.88
Reading technical information	3.90	.77	.88
Life cycle analysis	3.80	.84	.92
Using the design process	3.80	1.07	1.03
Identifying alternative resources	3.70	.68	.82
Designing under constraint	3.50	.94	.97

CLOSING REMARKS

Although small in scale, this study provides a preliminary listing of essential topics that should be included in a high-school level technology education curriculum focused on appropriate technology. Even in the absence of a single course focused on these concepts, topics, and skills, existing courses can be modified to incorporate AT-oriented units. The rationale for doing so is increasingly compelling given the societal goals of STEM literacy and environmental sustainability.

There is evidence to suggest that AT-oriented activities could prove to be more engaging for students, particularly for female students. Like Milgram (2011) and Weber and Custer (2005), McCarthy and Slater (2011) found that female students responded favorably when given choices in tackling design briefs in their technology classrooms, including being able to “reframe” the focus on elements that addressed human needs and the ways that their work could be used to help others. Cunningham (2007) suggested that another important intervention to increase girls’ interest in technology is to focus on what can be called a “capabilities approach.” That is, emphasis could be placed not on “what skills or jobs girls and women can pursue, but how technological learning contributes to freedom,” autonomy, and self-development (p. 15).

By focusing on topics and capabilities associated with AT, technology educators could tap into a groundswell of interest that places sustainable development at the center of future innovation and economic activity. “The demand for sustainability has created two parallel workforce phenomena—the development of new careers in the green industry, such as solar panel installers and wind turbine technicians; and the ‘greening’ of all other jobs” (Association for Career and Technical Education [ACTE], 2008, p. 2). According to the Political Economy Research Institute, within the United States the leading green economy investment areas include building retrofitting, mass transit, energy efficient automobiles, wind and hydro power, and cellulosic biofuels, with career options ranging from engineers to chemists to equipment operators (Pollin & Wicks-Lim, 2008). Meaningful and accessible AT-oriented educational experiences can serve as a conduit toward engaging students in future-focused STEM educational pathways.

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Science and Technology Communication Literacy for All: What is it and how is it Cultivated?

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ABSTRACT

In Japan, technology education for all is provided only in the subject areas of industrial arts and homemaking at the lower secondary level and information science at the upper secondary level. In addition, teachers tend to focus on skill education rather than cultivation of problem-solving ability. To improve this situation, we propose a new approach to technology education in the subject area of science because more than half of all students feel that the science education that they receive is not useful in daily life (National Institute for Educational Policy Research 2007). Recently, many studies on science and technology communication (STC) have been conducted. However, we anticipate that these studies focused on cultivating the STC ability of scientists and administrators in order to persuade the validity about undertakings' benefit of their studies and policies. Based on these considerations, we propose a citizen-centered model for STC; citizens should cultivate their own abilities to make decisions and build consensus cooperatively regarding the use of technology and the formulation of policies for science and technology. This approach is related to the informatics education that is conducted in two compulsory subject areas for technology education. For this purpose, we developed an instructional game that applied a design framework for instructional game materials for informatics education and conducted a classroom study in order to evaluate and improve this game.

INTRODUCTION

Technology education for all in Japan

In Japan, technology education for all is provided for only about 90 and 70 hours in lower and upper secondary schools respectively. On the other hand, science for all is provided for 385 hours and more than 140 hours in in lower and upper secondary schools respectively. Therefore, we propose a new approach to technology education in the subject area of science. To this end, we focus on a recent trend according to which many studies on science and technology communication (STC) have been conducted to associate technology education with science education (Kaji et al. 2009, Ishimura 2011). In Japan, scientists and administrators use STC to provide the public with the latest information about science and technology. Initially, STC activities in Japan were conducted on the basis of a "deficit model." More recently, they are being conducted as consensus conferences and science cafes, featuring "participation" and "interactivity" based on a "context model" (Wynne 1991).

However, we believe that both these models presume that scientists and administrators who conduct STC are knowledgeable and trustworthy and that laypeople are ignorant or incapable of understanding science and technology. The objective of science education at school is to understand phenomena correctly on the basis of scientific knowledge. However, technological problems almost never have one correct answer. As the Standards for Technological Literacy (ITEA 2007) require that students develop an understanding of technology and society, technology education should cultivate citizens' abilities to make decisions on the use of technology in our society.

Abilities required for STC for all

Based on the above considerations, we propose a citizen-centered "democratic" model for STC; citizens should cultivate abilities to make decisions by themselves or build consensus cooperatively regarding the use of technology and the formulation of policies for science and technology. In this case, scientists and the government are only some of the information providers. Citizens need to cultivate their abilities to understand information from both supporting and opposing groups, to evaluate it critically, and to build consensus by utilizing information technology.

The approach we are proposing is related to informatics education conducted in two compulsory subject areas for technology education. According to the National Course of Studies for Upper Secondary Schools, one of the compulsory subject areas, Information Studies, requires that schools conduct activities to encourage students to consider using ICT in order to make proposals and build consensus. STC has been conducted as informal learning with learners who were not children but adults. However, informatics education is conducted in school. Therefore, we suggest conducting STC for developing students' understanding of scientific and technological issues as formal education in cooperation with science education.

PURPOSE

In this study, we propose a design framework of gaming material to cultivate students' ability to communicate about (or discuss) technology and use scientific views and ways of thinking for problem solving. This framework is the extension of Hirabayashi and Matsuda (2011)'s framework for informatics education. We also developed gaming materials and evaluated them in an experimental lesson.

DESIGN FRAMEWORK FOR GAMING MATERIALS FOR STC EDUCATION

Apply the Hirabayashi & Matsuda's framework of informatics education to STC education

We propose the framework for using scientific and technological views, ways of thinking, and knowledge to problem solving in daily life. In order to collect the necessary information, learners need to ask researchers and administrators for information, examine the reliability of information, and build consensus among citizens. These processes are very similar to the Hirabayashi & Matsuda framework for problem solving in Information Studies. This framework consists of five processes: goal setting, technical understanding, rational judgment, derivation of optimized solution, and review. In addition, it involves learners using informatics-based and systematic views and ways of thinking (Matsuda 2003) in these processes and requires logs of learners' judgments and outcomes in these processes for giving feedback during the review process.

In order to apply this framework to STC education, we consider whether the five processes are sufficient for STC activities. According to Bruer (1993), domain-specific knowledge, metacognitive skills, and general strategies are all important elements of problem solving. We believe that problem solving with the above framework should correspond to general problems. This means that it is better to use the same framework across the curriculum rather than providing a different framework for each discipline. However, as a framework for STC, it is not sufficient only to derive an optimized solution but to make consensus. Therefore, we add the process of consensus building after the process of derivation of optimized solution. Because this new process requires collaborative problem solving activities, this framework (Figure1) is appropriate for informatics education and problem solving in other disciplines.

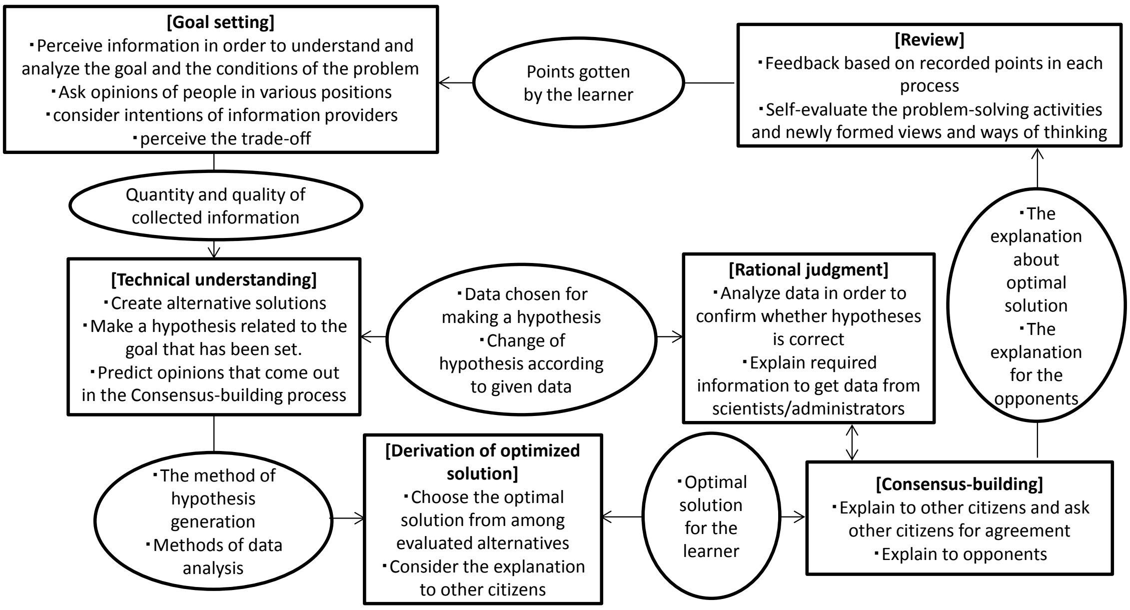

Figure 1: Framework to cultivate science and technology communication and decision-making abilities

Next, we consider activities required for each process, as well as scientific and technological views and ways of thinking that should be applied in those activities. Moreover, in order to evaluate the adequacy of learners' activities, we decided to use two types of evaluation. First, we evaluated whether learners had gone through the five processes adequately. We call this evaluation "process point" in the framework. Second, we evaluated whether learners behaved adequately in each process. We call this "behavior point."

Development of instructional materials for STC education

In this study, we developed new instructional materials for high school students about the energy policy that gained prominent attention after the Fukushima nuclear power plant accident. In our game, each student plays the chief director of a condominium association. The students need to decide whether they should install solar panels on the building. They are required to search for information about photovoltaic systems to evaluate their reliability and assess the risk of uncertainties. They need to ascertain the intentions of information providers and consider the validity of conditions for estimation. They learn a method of risk assessment and understand that it is important to see not only the averages but also deviations in a data set, and also to consider the worst case scenario.

During the goal setting process, students need to clarify the factors to be considered in the problem, as well as their trade-off relationships. To this end, they need to collect information as we mentioned previously. The game evaluates their activities with a focus on the selection of information providers, the appropriate estimation of their intention, and the adequacy of the reliability evaluation, as well as the quantity of collected information; the results are then recorded as behavior points. In the game developed in this study, students understand that there are two factors, cost and environmental influence, and their trade-off relationship with collecting information from the panel supplier, who wants to sell panels, and the electric power company, which wants to keep selling electricity.

During the technical understanding process, students create alternatives focusing on some sub-goals while studying different technologies available to achieve the goal. If they generate sufficient alternatives, they go to the rational judgment process, choose a superior alternative, and make hypotheses such as “plan x is the best because it is…” However, if the behavior point in the goal setting process is less than the threshold value, students cannot make a sufficient hypothesis to build consensus during the consensus building process because of a shortage of reasons. During the rational judgment process, they improve the proposal with more technical knowledge, if they feel that it is necessary. After they repeat these activities and judge sufficiently, they progress to the derivation of an optimized solution process. Concurrently, they are required to predict the opinions of other citizens given in the consensus building process. The numbers of alternatives and counterarguments are evaluated and recorded as behavior points.

In our game, students learn that the installation of solar panels entails maintenance costs but has positive benefits, such as CO_2 reduction, petroleum resources protection, and risk reduction regarding nuclear power generation. Students are required to propose a hypothesis on whether or not to choose solar power, stating their reasons with an aim of achieving important sub-goals student determine, and predicting counterarguments in the consensus building process, such as “although solar panels are good for the environment, they cost more money.”

During the rational judgment process, students analyze data to verify the hypothesis. Because we do not give them sufficient information to verify the hypothesis during the goal setting process, students need to communicate with scientists and administrators within the game in order to acquire the necessary information. This is an example of STC. They should recognize reasons why they require the data, because otherwise they cannot get the expected data. When analyzing the data, they should have the ability to evaluate as mentioned previously. If they cannot verify the hypothesis, they go back to the technical understanding process in order to change the hypothesis. We evaluate data chosen by students for verifying a hypothesis, the method of data analysis, the change of hypothesis, and whether students analyze the worst case, and then record the results as behavior points. If the scores in goal setting and technical understanding are below threshold values, students cannot get the expected data. In our game, the data, such as predictions of the demand for solar panels, the amount of sunshine, and the frequency of malfunctions, are necessary to verify the hypotheses. When students ask for data from administrators, they receive data that is not organized. If they use the data from the solar panel supplier or the power company, they need to analyze the data critically.

During the derivation of an optimized solution process, the students determine the optimal solution from among several evaluated alternatives. In our game, students determine whether or not to install panels, based on data analysis.

After these processes, we continue to the consensus building process. Students explain their proposals to other citizens within the game in order to come to agreement and persuade their opponents. Their ways of explaining the optimal solution and persuading their opponents are evaluated. If they feel their opinions are wrong, they can go back to the rational judgment process and change their opinions based on new hypotheses from other citizens. In our game, students explain to other citizens the reasons why they chose to install or not install panels based on data analysis. Then, they listen to the counterarguments and argue against them. Our material evaluates whether students can communicate to others appropriately using the outcomes of their activities rather than whether they can build consensus. However, if students try to build consensus without explaining to opponents, a feedback message to alert them of their inappropriateness is given.

After a certain result comes out in the consensus building process, students go to the review process and get feedback messages based on their recorded points. We explain that the data presented was from 10 years ago, and students are asked to performing similar activities again based on the current data. After the second cycle, the difference of points between the first and the second cycles are evaluated to examine improvement in the students' activities.

CLASSROOM TRIAL

We conducted experimental lessons at a high school in July 2013. The effectiveness of the instructional material was verified according to the log data. In addition, we administered a pre- and post-questionnaire that asked students to choose not more than five items in order to verify changes in their consciousness about STC (Table 1). We expected that the number of students who chose items 4, 6, 7, and 8 would increase and the number of those who chose items 1, 2, and 5 would decrease in the post-questionnaire.

Based on the above assumption, we analyzed responses from 15 students who had finished the game and answered both the pre- and post-questionnaire (Figure 2), from among 22 students who attended the lesson. The numbers of times items 4 and 8 were chosen increased somewhat and the number of times items 1 and 5 were chosen decreased somewhat, although there were no significant differences.

Table 1: Choices in the pre- and post-questionnaires verifying changes in students' consciousness regarding science and technology communication

1. To become an expert in science and technology, it is necessary to acquire expertise.
2. To understand all that scientists and administrators explain.
3. To acquire detailed scientific and technological knowledge as a citizen.
4. To select a desired technological field using the experts' advice.
5. As a specialist, to clearly provide knowledge on science and technology to citizens.
6. To be able to use science and technology for problem solving in daily life.
7. To be able to communicate between citizens and experts in science and technology.
8. To prompt citizens to communicate with each other for making good decisions.

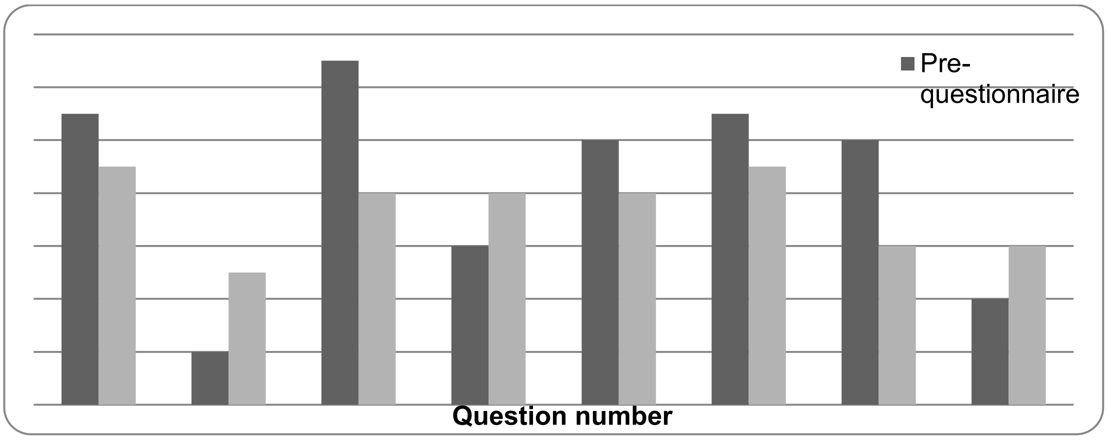

Figure 2: Number of students who chose each item in the pre- and post-questionnaires

Afterwards, we compared the points acquired in the first cycle with the second cycle for the 16 students who finished the second cycle (Table 2). Because many students got more points in the second cycle than the first cycle, the feedback seemed to be effective. However, we believe that some students expected that they could get better points if they performed all actions in the game.

Table 2: Number of students who earned more points in the second cycle than the first cycle.

	Goal setting	Technical understanding	Rational judgment	Derivation of an optimized solution
Process point	8	3	2	2
Behavior point	7	3	5	1

IMPROVEMENT OF THE GAMING MATERIALS AND FUTURE PERSPECTIVES

In this study, we considered the use of a purpose-built game to develop students' ability to critically evaluate data, make an informed decision about the benefits of installing solar power, and communicate with others. Moreover, we developed gaming materials based on the framework. As we could see from the trial lesson, the gaming material had certain effects as students obtained more points in the second cycle than in the first one. However, we realized that we could not change students' opinions about STC. Therefore, we plan to improve the game as follows.

First, in the first cycle, students need to follow the ideal route of the five processes (Figure 1) in order to arrive at appropriate problem-solving processes. Second, the number of times of the action that can be performed in the game is restricted in the second cycle because there are time restrictions in real problem solving. Third, we need to check the validity of the tasks in each process. For example, we believe that the activity involving hypothesize should be moved from the technical understanding process to the rational judgment process, because students generate a hypothesis in order to evaluate alternatives. Fourth, we gave students data on the sunlight panels from the present condition in the feedback so that they could evaluate the hypothesis given in the present conditions; this was intended to motivate them for the second cycle. In addition, we developed new content in our game so that students could consider various alternatives. After revising the game, we will verify its effects.

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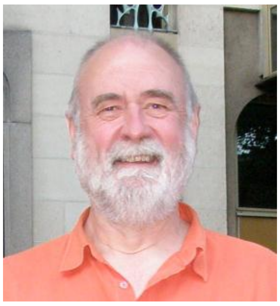
Binarial Hermeneutics for Exploring the Phenomenon of Technology In Support of Design and Technology Education



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ABSTRACT
The phenomenon of technology remains a challenge for philosophers of technology itself let alone for the field of Design and Technology education. Because 'technology' is a complex concept it defies definition and finds itself the object of study of multiple disciplines such as philosophy, sociology, psychology, anthropology, history, and more.

This paper introduces the concept of 'binarial hermeneutics' as a means for exploring, in a non- or anti-disciplinary way, the phenomenon of technology. The concept of binary is clarified and used to locate the kinds of spectra that present themselves when technology is under discussion. Examples of such spectra could be (technology as): arts-science; theory-practice; subject-object; utopia-dystopia; product-process; etc. There is no prescribed set of binaries but a key point is that the binaries are not dualisms, that is, they engage with 'both-at-once' rather than 'either-or'.

Having used a binary to locate a particular spectrum, a hermeneutic approach is then taken. This approach draws upon the field of philosophical hermeneutics which addresses questions of *interpretation*, while resisting Cartesian dualism and serving to develop what Bohman (1999) has described as, '…understanding as continuing a historical tradition, as well as dialogical openness, in which prejudices are challenged and horizons broadened'.

The paper seeks to locate the kinds of discourses that arise in the theorising of Design and Technology Education (and curriculum) as well as in the areas of public and policy-making discourse. It is written to help articulate the identity of Design and Technology Education as a contested, yet distinctive and worthy, educational enterprise.

Keywords: binarial hermeneutics; Design and Technology Education; curriculum theory.

INTRODUCTION

For a variety of reasons, (Design and) Technology (D&T) Education is one of the more problematic and challenging areas of the educational world. While, at one level, this is a matter for internal educational discourse, curriculum theory and political debate, at another level it is a symptom of the designed technological world at large.

What happens in society with regard to Technology (big T, as opposed to multiple individual technologies, little t) is often reflected in education. This paper seeks both to illustrate the richly nuanced and problematic nature of Technology as well as to show how this interplays with D&T Education. The *phenomenon* of Technology is powerful, pervasive and complex yet it remains misrepresented through simplistic and reductionist interpretations and stereotypes found in the public realm. Critiques of technologies and our relationships with them often present themselves as controversial *issues*: the environment; surveillance; waste; obsolescence; communications; production techniques; genetic engineering; xenotransplantation; identity; democracy; inter-species and environmental justice; consumerism; mechanisation; un/employment; urbanisation; robotics; transport; and, privacy are some.

The phenomenon can be expressed thus: Humans cannot 'be' without Technology and Technology 'is' by human intention and action (design). Technologies and humans co-exist intimately. The ongoing problem is that this enormously significant human-technology phenomenon is not matched by an equivalent or appropriate Technology Education. Currently, Technology Education is partial – in at least a couple of senses. First, it is prone to biases. Second, it only partly addresses the whole that is Technology. This analysis suggests that the field is inadequate in a couple of ways.

Accompanying the phenomenon is the 'invisibility problem' – the situation where, for all we live by technologies, are surrounded by them, and use them with little or no reflection, they remain largely invisible to us and our discourses. (The fish-in-water analogy is often used.) How, then, can the rich, complex, nuanced, holism of the phenomenon of Technology be explained and understood? Further, how can it be properly represented in and through education? What follows is a brief overview of a strategy for exploring both the phenomenon and the educational shortfall.

WITNESSING THE PHENOMENON…

The *phenomenon of Technology* is only newly studied and *philosophy of technology* is still emerging as an academic field. There are exciting intellectual challenges opening up for scholars of both Technology and D&T Education, yet, as scholars of the field know, 'technology' not only defies definition but is complex.

It is only sixty years since Heidegger, a seminal influence on interrogating Technology, put the challenge of addressing the phenomenon into context: '…the essence of technology is by no means anything technological. Thus we shall never experience our relationship to the essence of technology so long as we merely represent and pursue the technological, put up with it, or evade it.' (Heidegger, 1954 trans 1977:4)

More recent authors have captured the issue thus:
Pinning down the concept…of technology is like trying to nail jelly' (Green, 1994:xxix)
We speakers of English…seem to be able to tolerate a high level of ambiguity with respect to our use of the term "technology".' (Hickman, 2001:11).
Though we may be competent at using many technologies, most of what we think we know about technology in general is false. Our error stems from the everyday conception of things as separate from each other and from us. In reality technologies belong to an interconnected network the nodes of which cannot exist independently *qua* technologies….It turns out that most of our common sense ideas about technology are wrong.' (Feenberg, 2010:3).

It is no longer possible (or appropriate) to describe technologies simply as 'things', or as 'hi-tech', or as 'applied science', or as 'tools', or as only that which is 'new', or as their being 'neutral'. Such are the popular myths of Technology. Whilst there is an obvious need to bring the complexities of Technology into manageable forms for educational practice, simple reductions, soundbites or stereotypes are unhelpful.

SOME EMERGENT THEORETICAL APPROACHES

There have been many scholarly engagements with Technology and there is no 'right answer' or 'one way' to approach the phenomenon. Explorations can be descriptive, analytical, personal, political, social, and so on. Four differing theorisations, *very* simply presented, illustrate the phenomenon's challenges:

Critical theory (eg Habermas, 1971) suggests that we not only look at what counts as knowledge in any situation (eg what is technological knowledge) but we should also look to *whose interests* are served by the knowledge. (Critical theory underpins the conceptualisation of technological literacy used in the South Australian Design and Technology curriculum [DETE, 2001]).

Actor-network theory (ANT) (Latour, 2007) developed out of studies of complex technological systems. Human and nonhuman components are attributed equal respect in terms of their significance. Two forms of relations are explored within systems – the material (things) and the semiotic (concepts) – both key to understanding technologies.

Ihde's (1979) phenomenological approach advocates *variational theory* (Ihde & Selinger, 2003; Sobchack, 2006; Ihde, 2009): '…a series of multiple perspectives to recognise the shape, structure, and complexity of the phenomenon (being investigated)' (Eason et al,, 2003:125). Hermeneutics, simply put as the business of interpretation, is key to phenomenological work.

Narrative theory (Kaplan, 2009) 'reads' the 'narrative' or 'story' of technologies. Kaplan argues: '…a critical reading of technology evaluates technical things and systems in terms of their role in achieving social justice and happiness. Technology should…(be)…read in relation to universalist concepts, such as truth, impartiality, and equality' and he talks of: '…narrating things differently to create new ways of seeing the world so that we might imagine, argue for, and create new ways of being in the world.' (Kaplan, 2009:96).

All such theorisations offer ways of 'seeing' technologies and, collectively, their methods embrace critique, translation, interpretation, reading, describing, and explaining – all of which are educationally invaluable.

TOOLS TO ENGAGE THE PHENOMENON

What tools might help us not only *see* Technology but also to *better understand* the phenomenon? Might it be possible to develop a method of enquiry that is accessible to researchers and educators alike? One starting point is philosophy itself. As Hickman says: '…philosophy is one of the most effective tools we have for tuning up technology.' (Hickman, 2001:41).

A second tool, coming from within philosophy's toolbox is that of *hermeneutics* (the theory of *interpretation* and *understanding*). Historically, hermeneutics was concerned with the interpretation of religious texts to establish what meaning they carried and what the whole-parts relationships might be. Over the past century hermeneutics has moved beyond texts and has refined and deepened its methodological approaches (see eg Palmer, 1969; Habermas, 1971; Gadamer, 1976, 1975/2004; Mitcham, 1994; Bohman, 1999).

To work hermeneutically is not only to explore holistically and analytically but is also to look to cultural, historical and political relationships. Hermeneutics becomes an existential event for the interpreter. That is, hermeneutics today is seen as much for how the hermeneutic act itself shapes us as for how it serves as an interpretive tool. When we work hermeneutically, understanding comes of one's own historical and cultural positioning and new possibilities present themselves to us. In hermeneutics, all of analysis, synthesis, critique, judgement, dialectical and logical reasoning, and reflective conversation (with oneself and with others) combine to bring new understandings. The familiar is made strange and new ways of seeing emerge. Hermeneutic work can challenge the popular myths of Technology and fresh possibilities emerge to develop new language, theories and analyses.

Given the complexity of Technology and the multiplicity of technologies, where could appropriate hermeneutic investigations begin? A clue comes from Gadamer (1975/2004) who reminds us that 'Hermeneutic work is based on a polarity of familiarity and strangeness;' and that '*(t)he true locus of hermeneutics is (the) in-between.'* (Gadamer, 1975/2004:295. Original italics). This brings us to the use of binaries.

USING BINARIES TO LOCATE HERMENEUTIC WORK

It is important to note that binaries are not dualisms. Whilst 'binary' in mathematics means 'having a base of two' it has also acquired a popular (and inaccurate) sense of *either-or* which is in fact what dualism means. Dualism in philosophy means two *distinctly exclusive* things such as mind and matter (after Descartes). In contrast, binary means *both-at-once, two-together*, a *compound* or, perhaps, a *co-dependence*. Where dualism is about distinction, binary is about indistinction. This validates the hermeneutic approach.

While hermeneutics offers *engagements* with complex phenomena, binaries can locate sites to expose or invite hermeneutic enquiry. Using binaries allows us to capture or signal a range of issues that we may wish to address. The nomination of any binary intentionally *foregrounds one aspect of Technology* while backgrounding (but still accommodating) others. In short, the binaries locate spectra of issues while hermeneutics facilitates interpretations.

To give an example… We can set up a binary of 'Technology as *at-once-both arts and science*'. If we try to say that technology is *only* arts (eg as crafting and creativity) or that it is *only* science (eg as objective study) we come unstuck because we cannot argue the exclusivity of one over the other. On the hermeneutic journey we might explore: what constitutes a science or an art; in what ways technology reveals itself to us as art, as science; whether technology is 'applied science', a branch of science, or (after Lueckenhausen, 1989) is 'art made useful'; investigate Mitcham's (1994) juxtaposition of engineering with humanities; ask whether/how art and science meet in technology; consider how a technology can be both science and art at once; and so on.

The educational point is not to resolve a dualism but to learn from the understandings and meanings that develop from the hermeneutical practice – to interpret fruitfully. Subsequently, understandings gained from the hermeneutic explorations of any (big-T) Technology binary can also be *tested and refined* by applying case studies of particular technologies (eg a washing-up brush, an aeroplane or a bridge).

PUTTING BINARIAL HERMENEUTICS TO WORK

When the three tools of philosophy, hermeneutics and binaries are combined the term given for the practice is *binarial hermeneutics*. The following (illustrative) binaries signify Technology discourses in which there are multiple possible positions – they echo the *arbitrary* nature of the phenomenon of Technology and the notion of technologies being *multistable* (Ihde, 2002; Ihde & Selinger, 2003) or *polypotent* (Sclove, 1995). There is nothing sacrosanct about the binaries – they are starting points and other candidate binaries could be nominated. The binaries are not qualitatively the same – some allude as much to informed (or ill-informed) public discourse as they do to orthodox philosophical enquiry.

The arch-binary of at-once-both Human and Technology

It occurs that there is one *arch-binary* that epitomises the challenges under investigation as it is the arena for the acting-out of all other binaries. As expressed in the paper's introduction, it is the binary of *at-once-both human and technology*. Starting points for hermeneutic explorations could include:

- how human are technologies, how technological are humans?
- degrees of identity, free will and the ways in which technologies and humans shape each other;
- examining *transhuman* and *posthuman* (technological) scenarios in light of unknown futures (Broderick, 2001; Kurzweil, 2005; Bostrom, 2009);

- reflecting on Foucault's (1989/2000:28) postmodern reminder that 'man' is 'a recent invention';
- considering whether *humanity*, *human-beingness*, and *humanism* are constructs that may not be sustainable (posthumanity in the postmodern sense, Badmington, 2000);
- critiquing Kurzweil's (1999) argumnet that 'technology is evolution by other means'.

At-once-both visible and invisible
When technologies become so accepted, so unquestioned that they become almost invisible (that they are everywhere yet nowhere at once) does a taken-for-grantedness occur? What are the disruptions to such circumstances that remind us of what has become invisible – major catastrophes, shortages, climate issues, disruptive technologies? Is the invisibility of the everyday matched by an invisibility of our evolution?

At-once-both positivist and antipositivist

The *seemingly* tangible nature of technologies and traditional positivist ways of assessing them ('Does it work/does it do the job?') frames Technology as instrumental, material and aligned with science. Antipositivist critiques have offered antidotes to this but have been charged with creating mires of difficult-to-penetrate relativism.

At-once-both utopian and dystopian

Technology is basically good. Technology is basically bad. Here philosophical questions arise around values, existence, ethics, post/humanism, determinism, and eco-philosophy.

At-once-both democratic and non-democratic

How do technologies promote or deny democracy? At what point in any technology's development is ethical critique or democratic engagement allowed eg at pre-conception, at the design phase, during creation, after realisation? (Keirl, 2009).

At-once-both modern and postmodern

Post-modernism questions many of the 'givens' of Technology: the idea of 'progress'; of technological determinism; that there is one form of technological knowledge rather than multiple knowledges; that rationalism and optimism guarantee outcomes; and that there are no 'grand narratives' (Lyotard, 1979/1984) so far as Technology is concerned.

At-once-both natural and artificial

While it seems 'natural' for us to be creative and to act technologically upon the world there are clearly ways that such actions work against nature. Once we have created a technology is the creation an artificial entity? Taking Franklin's (1990/2004) lead, how should we consider the biosphere-bitsphere relationship?

TECHNOLOGY EDUCATION BINARIES

In turn, the idea of binarial hermeneutics can also be used for considerations of curriculum design and delivery. In some ways the educational binaries reflect those for *Technology* and *technologies* but their resolution is now towards curriculum action rather than philosophical-hermeneutic reflection alone. However, the better the philosophical-hermeneutic homework in the Technology-technologies arena, then the better the preparation for the educational challenges.

Some of these binaries apply across the curriculum, that is, beyond D&T but they matter because of the particular way that they apply to D&T Education. This is an important part of building the integrity of Design and Technology in educational circles – as a field of special challenges and special circumstances which cannot be dealt with en masse with other subjects. These points made, what are the Technology Education binaries that present themselves for hermeneutical enquiry? The following, as with the Technology binaries, is a selection, they interplay, and are not exclusive.

At-once-both product and process (for the teacher)

An example technology education binary engages the pedagogical perspective of the teacher. This explores the both-at-once of product and process. Here, starting points for hermeneutic explorations might include:

- is production of artefacts warranted because of pupil motivation and identity-formation - the "I made that" syndrome of pride and satisfaction?
- is learning best addressed through the creation of products - emphasising, say, technique, efficiency, quality, and standards?
- is D&T learning best addressed through process/es where students learn designerly behaviours and dispositions to be creative and to develop strategies such as working in teams and alone?
- is the 'output' of education to be the capacity to (re)produce or the capacity to adapt and (re)imagine new possibilities?
- in what sense is the educational process itself a product?
- are students themselves products for markets?
- how do the hermeneutics of the both-at once of process and product inform the question of assessment of D&T learning?

At-once-both status quo and change agent

Is the role of the school to maintain the status quo or to bring about change? Technology Education has its own special challenges here with shifting social and workplace practices and new technologies constantly evolving. Which techniques and technologies are to be valued or abandoned? Should Technology Education be taught uncritically or critically?

At-once-both local and global in perspective

Is the curriculum inward- or outward-looking? Does a purely local curriculum operate? Is curriculum determination centralised and controlled? What international and global perspectives are articulated by the curriculum?

At-once-both traditional and emergent technologies

Is the curriculum crafts-based, existentially affirming, low production and low-tech or hi-tech, existence-changing and emergent technologies. What comparisons can be made between established and emergent technologies on the basis of costs, uses and consequences?

At-once-both technical and designerly (for the student)

Is Technology Education about technical skilling alone – focussing on learning how to use tools or software? Or is it about a more embracing curriculum of critical-designerly behaviours for being in the world – those that would serve the hermeneutical dispositions of the students? Is Design and Technology education a seeding ground for student self-expression and identity formation?

At-once-both instrumental and liberal (for society)

After Layton's (1994) research into the stakeholder interests in Technology Education, is the primary aim to serve the needs of the economy or is D&T: '…a distinctive form of cognition, unique and irreducible. As such, all children should have access to it, as a matter of right and in order to develop their full human potential.' (Layton, 1994:17)? Are some goals for short-term employability and specific industrial and business needs while others are to create an educated citizenry?

At-once-both academic and practical

Although this framing should be a quirk of history by now, in many societies the hands-head divide (a dualism with no place for heart?) remains embedded in educational culture.

At-once-both cross-curricular and subject

Several of the preceding binaries resonate with this curriculum organization binary. The arguments for schools to deliver some kind of technological literacy for all students are gaining strength but understandings of 'technological literacy' vary widely - from the technical to the critical-emancipatory (see e.g. Dakers, 2006; Keirl 2006). Can/should D&T literacy be managed through a single subject, or a learning area, or should it be the business of everyone in a school?

CONCLUSION

To reiterate, it is erroneous to see any binary as a dualistic 'either-or' – that would be a form of reductionism. Design and Technology's curriculum challenge is the management of Technology as holism whilst also addressing what is appropriate so far as individual technologies/techniques are concerned. Binarial hermeneutics offers one approach to understanding and managing the holism of Technology's/technologies' complex and contested values. It builds on what Bohman (1999) has described as, '…understanding as continuing a historical tradition, as well as dialogical openness, in which prejudices are challenged and horizons broadened'.

It is argued that the issues this paper identifies cannot be engaged through traditional disciplines. The issues are a matter for the D&T community to address. Disciplines either try to colonise Technology Education on their own terms or are inadequate for engaging the phenomenon. But such matters warrant a separate paper. If D&T Education is to develop its identity and credibility it must be able to do so on several fronts – from the philosophical to the pedagogical. If literacies of design and of technology are to blossom then rich understandings of, and opportunities for deep interpretations of, Technology will be needed. Perhaps binarial hermeneutic journeying can help all concerned.

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Motivational Factors in Female Senior Secondary Students: Staying and Thriving on the Technology Education Pipeline

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ABSTRACT
Learning is an active process that functions optimally when student's motivation is autonomous. This paper will critique elements of motivation that impact on students' engagement in technology education subjects with an emphasis on female students in senior secondary years of schooling.

After defining technology education and motivational factors, the critique will examine elements identified by various authors as those which motivate modern day youth to engage in non-compulsory education. In fact, the origins of personal and group motivation need to be explored in terms of how youth utilise self-values to engage in practices that schools program for them. Of particular interest are the steps taken by schools to engage females in technology centred programs. Australian data show that young female learners are not articulating through to maths, science, or technology classes and in turn not enrolling in tertiary courses such as Engineering.

The critique takes a feminist constructionist view and will draw on research undertaken in senior secondary schools in 2013. Earlier studies have claimed that the artefacts to be made and freedom of choice in the learning process had the most effect on the motivation of students as participants in technology education. For some students these elements have affected their intrinsic motivation by expanding their reflectivity and feelings of autonomy. By providing an apparent freedom of choice in materials, techniques, and products to be made, student motivation appears to rise.

In examining the research studies on what motivates youth - values are seen to be inextricably linked to the interests and motivation of both individuals and groups. Thus, values will be explored in the context of educational settings of students in the secondary years, with a focus on Technology education.

The implications of the findings in the paper will provide practitioners with strategies to alter the ecology of classrooms for female participants in technology education programs in the long term. Those strategies are not about plugging the leaks in the pipeline, but rather about building a gendered pipeline where girls feel at home doing technology regardless of whether their school or class is co-educational or single-sex.

Keywords: Technology education, motivation, females, youth.

INTRODUCTION

This paper explores elements of motivation that impact on students' engagement in technology education subjects. It is posited that learning functions optimally when students' motivation is an active and autonomous process. The focus stems from a current research study on factors that influence the participation of female students in the senior secondary years of schooling (Knopke, 2012).

In examining elements which motivate modern day youth to engage in non-compulsory technology education the origins of personal and group motivation have been explored in terms of how youth utilise self-values to engage in technology education practices that schools program for them. Of particular interest are the steps taken by schools to engage females in technology centred programs. Australian data, in line with European data, show that young female learners are not articulating through to maths, science, or technology classes into STEM (Science, Technology, Engineering and Maths) related tertiary fields (Boe, Henriksen, Lyons, & Schreiner, 2011; Engineers Australia, 2012). Despite long term goals of educators, females are still not enrolling in senior secondary technology courses that will lead to tertiary courses such as Engineering, Mathematics or Technology Studies. The figurative pipeline mentioned earlier refers to the point where students commence in technology education and then continue to engage along a continuum of studies related to technology education with a view to a post school pathway. Given that all students in lower secondary high school (Years 8 and 9 in Queensland), participate in some studies in technology female students need to be encouraged to remain in this learning pipeline and to thrive to reach senior secondary levels and beyond.

Technology has been defined as the innovation, change or modification of the natural environment to satisfy preconceived human needs and wants (International Technology Educators Association (ITEA), 1996, 2006). Technology education encompasses all subjects that have design processes as the key learning activity. In the Australian context subjects such as agriculture, business studies, industrial arts and design, graphics, home economics, hospitality, information and communication studies, technology studies, engineering studies, fall into this definition. Whilst there is currently much debate surrounding the term it links to past and present syllabus practice in the Australian education system.

ACARA (Australian Curriculum Assessment and Reporting Authority) currently developing the Technologies syllabus for Australia requires that students engage in technological capabilities and with technological and computational thinking (Australian Curriculum Assessment and Reporting Authority, 2012). Less of a definition, but rather a concept which is not centred on objects but focussed on capabilities those students will achieve.The social constructionist view used in this paper is defined by Shotter and Gergen (1994) in Potter (1997).

[Social constructionism] has given voice to a range of new topics, such as the social construction of personal identities; the role of power in the social making of meanings; rhetoric and narrative in establishing sciences; the centrality of everyday activities; remembering and forgetting as socially constituted activities; reflexivity in method and theorising. The common thread underlying all these topics is a concern with the processes by which human abilities, experiences, common sense and scientific knowledge are both produced in, and reproduce, human communities.

A feminist constructionist stance which sees gender as a construct that is not created by nature as a result of biology but rather created by and contingent on social and historical processes (Oldenziel, 2003; Stanley, 1993). To prepare students for the future, technology educators must seek alternative ways to conceptualize their subject matter to reach the diverse population of citizens in society (Wright, 1992). Technology educators must rethink the way in which they legitimize the knowledge of technology education for students in order to meet their needs and wants. Wright, stated, the social commitment must legitimize the principle of difference, to encourage and multiply different kinds of people and positions and values for their own sake, within the bounds of social order. It is through the legitimacy of difference that new and necessary forms of rationality will emerge and a motivation to engage will occur.

In examining the literature on what motivates youth - values will be explored in the context of educational settings of secondary school students, with a focus on Technology education.

MOTIVATION THROUGH VALUES

Motivation is defined in the broadest sense as 'the process whereby goal–directed activity is instigated and sustained' (Pintrich & Schunk, 2002). Values, argues Rokeach have a motivational function: to guide human activity in daily situations, their more long-range function is to give expression to basic human needs. Values' components include motivational, cognitive, affective and behavioural elements. Instrumental values are motivating because the idealised modes of behaviour they are concerned with are perceived to be instrumental to the attainment of desired end goals. Terminal values are motivating because they represent goals beyond the immediate, biologically urgent goals. They are the conceptual tools that we employ to maintain and enhance self-esteem (Rokeach, 1973). Terminal and instrumental values are relevant when considering types of behaviour students engage in in classrooms.

Values that are internalised as a result of cultural, societal, and personal experience are psychological structures that, in turn, have consequences of their own (Rokeach, 1973). Values are determinants of all kinds of social behaviour – of social action, attitudes and ideology, evaluations, moral judgements and justification, comparisons and presentations of self and others, and attempts to influence others. Klapwijk and Rommes (2009) note values in their use of the phrase 'career anchors'.

A person's actions may then vary depending on the priorities they place on social and personal values. Their actions will vary depending on whether their social or personal values have priority. An increase in one value may see a decrease in the opposite, e.g., social or personal. Personal values arise from participants in relation to their learning within technology classrooms and about artefacts that students interact with on a daily basis. Terms such as personal and social ambition, self-control, capability, imagination and independence can be identified by participants in terms of which aspect motivates them to succeed. Pavlova & Turner (2007) examined the critical issue of values in technology education and discussed the design process as a starting point for internal and external values. Custer (2007) argues that values and technology are intimately connected.

In the modern world, it has become virtually impossible to disentangle technology, in its variety of forms from ethical implications. Ethics and values shape and drive demand of new technologies. New technologies in turn mirror and reflect what we value. The two have become inextricably woven together (Custer, 2007).

A value system is thus defined as an enduring organisation of beliefs concerning preferable modes of conduct or end states of existence along a continuum of relative importance. Values, like all beliefs have cognitive, affective and behavioural components.

FEMINIST CONSTRUCTIONIST VIEW

This paper takes a positivist perspective in unearthing the voices of females in technology education. Modern socio-cultural liberal feminism and awareness of gender issues enables young women to move past their historic roles in society to achieve some degree of equality in learning. It is awareness and a willingness to achieve that is sustaining a change in the state of the technology education pipeline.

Socio-cultural approaches to learning provide instruction which recognizes and empowers linguistically and culturally diverse students. Socio-cultural theory describes learning as distributed, interactive, and contextual and the result of a learner's participation in a community of practice. The collaboration of thinking that results from these processes opens up access to research data on thought processes and provides avenues to uncover distinguishing characteristics that can lead to change and transformation.

Learning within a techno-social sphere may be the best environment for females. Bijker (1995) claims that there is a process of closure, reflecting on aspects of technical change and stability over time which shows that everything can fit into a technological frame comprising of knowledge, goals, and values as well as artefacts (Bernstein, 2003 ed.).

Postmodernist theories such as Wright's feminist theories encourage diversity in their view (Wright, 1992). Feminist theories, like other forms of postmodernism, encourage us to tolerate and interpret ambivalence, ambiguity, and multiplicity as well as to expose the roots of our needs for imposing order and structure….If we do our work well, reality will appear even more unstable, complex, and disorderly than it does now (Flax, 1990). Both postmodern and feminist theories point to diversity as a direction for the future and can provide some of the ideology for technology educators' avoiding a restricted cultural view and creating change in the profession (Zuga, 2007).

The research of Zuga (2007) and Wajcman (2004) has examined the stigma of artefacts and highlighted the sociotechnical constructivist approaches born of but modified from social studies of technology. It was the characterisation of Wacjman's 'techno-feminist' which represented a major development in theorising the gendered character of technology. Haraway's cyborg-feminists and socialist feminist inquiry was pivotal in exposing the gender blindness of main stream techno-science studies in order to show the possibilities this area offers women and how they could strategically engage with techno science (Wajcman, 2004).

Recent studies have claimed that the artefacts to be made and freedom of choice in the learning process had the most effect on the motivation of students as participants in technology education (Boe et al., 2011; Thaler & Zorn, 2010). Authors such as Campbell and Jane have demonstrated that for some students, elements of individual choice have affected their intrinsic motivation (2012). By expanding the amount of internal feedback, their feeling of high levels of autonomy, choice and self-direction, providing an apparent freedom of choice in materials (autonomy), techniques, and products to be made, student motivation appears to rise through more active engagement and a willingness to persist. Similarly, Autio (2013) claims self-confidence and expectations for success give value to the options available to females in technology education today.

In order to bring about change the approach must be to raise the consciousness of gender and the feminist uses of the construction of ideas and the delivery of programs in the broad area of technology education. Biological differences between sexes do not determine gender, gender attributes, or gender relations. Gender, is a constitutive social construction, a social category whose definition makes reference to a broad network of social relations, not anatomical differences (Durack, 1997; Haslanger, 2005). Motivation can be championed through pedagogy that suits not just girls but many boys who are themselves not a single homogenous group (Klapwijk & Rommes, 2009).

In exploring the perceptions held by students, Technology education continues to be perceived as masculine in nature, procedural in delivery and lacking conceptual dimension. Such an enduring perception serves to restrict female interest in the subject (Dakers, Dow, & McNamee, 2009). Similarly, Klapwij & Rommes (2009, 406) note the problem with stereotypes - *that women prefer working with people and men with things – that if we repeat it often enough it becomes the norm….. Repetition makes it impossible to loosen the unilateral connections….*

Research studies suggest that motivation can be raised through addressing technology education as a positive concept which they (females) come into contact with often and hence develop skills and knowledge. Frequency of exposure and role models can be the link between Technology and femineity (Dakers et al., 2009; Kolmos, Mejlgaard, Haase, & Holgaard, 2013). Wacjman (2004) would say this links back to a masculine definition of technology.

MOTIVATIONAL STRATEGIES AND GENDER

The following provides strategies for increasing participation of female students through early observations of research undertaken in high schools in 2013.

SOCIAL VALUES

Women are attracted to careers that help and work with people and enact communal goals. If females are provided with more knowledge of how careers in the STEM fields could be a vehicle to enact altruistic goals and values, they could be prepared to go along the STEM pathway (Colvin, Lyden, & León de la Barra, 2013). Social values are ranked highly by female students. Research in secondary schools in Queensland has shown that values can and do motivate students in technology education classes. Internal and external values as noted by Pavlova and Turner come into play at different points of learning for students (2007). Instrumental values meant more for students starting in Technology education classes. Learning for fun or for life skills was important to begin with. As students matured over time the terminal values of life and career goals came into play and the purpose for participating in technology education changed. Driven by internal values students were self-motivated to achieve in order to reach their end goal.

SELF-EFFICACY

Self-efficacy is a second strategy in motivating female students in technology education. A belief that one has the capabilities of exercising courses of action to manage certain situations has been seen as a positive predictor of achievement in task specific goals and success for women in non-traditional career areas. Cognitive and metacognitive skills focussing on self-efficacy provide motivation to learn. Marra, Rodgers, Shein & Bogue (2009) examined positive outcomes that were achieved with women to understand student satisfaction, achievement and ultimately, retention in engineering programs. Influencing environments, in turn sustained persistence and enabled mastery experiences in complex design projects via strategies of instructional demonstrations and encouragement. Positive success leads to long term participation.

LEVEL OF CHALLENGES

Self-regulation and the level of challenge females set themselves, the amount they mobilise and persist in the face of difficulties comes back to level of self-efficacy, confidence and support provided by both peers and teachers. Ultimately their achievement in the design task was the motivational factor.

PROCESS OR PRODUCT

The process of transmission of technology, the use of aids and the pedagogic interest which an artefact or object creates can be questioned in terms of a balance point of view with regards to gender (Chatoney & Andreucci, 2009). Process or product can make a difference to the motivation of girls. Not all teaching devices are viewed as neutral and females are more sensitive than males to study aids; they will use more creativity and inventiveness and take more risks than boys on items they are familiar with. Perhaps there could be a reuniting of girls with Technology through changing approaches. Feminising the pedagogy with habitat, clothes, inventive and creative skills, and informal learning interactions may in the long term attract more females.

ONE FOR ALL- ALL FOR ONE

One school in the 2013 research study motivated students to a higher degree than others (Knopke, 2012). Competition to gain entry into the technology education classes began in Years 8 and 9. Students were taught to excel via an encompassing school culture. The essence of achieving was to not only gain great personal results but to uphold those averages of all the fellow students in a year cohort and keep the school as an academic entity. A discussion with one boy was about his potentially letting the cohort down and how hard he needed to work not for himself, but for his peers. His determination demonstrated how important this was as a motivational factor for students to produce high quality work. The self-efficacy notions of Marra, Rodgers, Shein & Bogue (2009) have proved through the early research study to stand true in what remains a non-traditional area of learning.

In elaborating on the early findings from the current study, terminal values and career aspirations were a key factor that motivated students in the classes. The second factor that heightened participation and, in turn, motivation was choice of design tasks. Freedom to select what an artefact would look like was important to the students. Once the female students made a design choice they were rarely swayed from that decision. Once they understood the task they are able to project manage, plan and then execute the task. This does not imply they personally completed all the steps but they are able to plan to have them done to reach an outcome.

The pedagogical approach of the teacher in the context of the classroom ecology was the third factor that motivated the female students. A relaxed working atmosphere where students shared ideas, learned from one another, and collectively solved design problems added to the independent drive of students in the classes that were observed.

CONCLUDING REMARKS

The implications of the early findings send a message to practitioners. There are strategies to alter the ecology of classrooms to accommodate female participants in technology education programs. This paper has shown through current empirical and theoretical research that strategies to promote female participation involve long term planning, short term immediate support and constructionist considerations.

The short term strategies are important but it is the long term planning and human resource component that appears to be making key impacts on female participation and motivation in secondary schools. Role modelling, peer supportive environments, elements of choice and sustainability and the processes to achieve artefacts are the factors which will bring about further changes. The longer term strategies are about changing the phenomenon that is socio-culturally and psychologically rooted and constructed - 'Women need to be given the explicit message that technology, in all its aspects, is suitable for women' (Klapwijk & Rommes, 2009).

These strategies are not about plugging the leaks in the pipeline, but rather about building a 'gendered pipeline' where girls "feel at home doing technology".

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An Overview of an Ethnographic Case Study of Female Students in Senior Technology Education Classes in Queensland

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ABSTRACT

This paper provides early findings from a research study undertaken in 2013 in a number of Queensland high schools. The study examines some factors that could heighten the participation of female students in technology education classes, and focused on female students in senior secondary schools.

The research design used an ethnographic case-study methodology. This design allowed the research to unpack a credible, rigorous and authentic story of female students' involvement in different design and technology contexts across different schools.

The study was intended to give a voice to female students in order to understand the nature of their involvement in design and technology subjects. The researcher was seeking to understand the reasons why female students had undertaken courses in design and technology education, and explored the realities of each classroom environment. The culture sharing group was identified as Year 11 girls participating in the early stages of technology education courses. Field data was collected in an authentic setting and included audio recordings of language and interactions. Recordings of interviews with students and adults were made. Both situations were designed to allow for the use of verbatim quotations and thick descriptions of the context and events in order to understand and unpack the female voices in the study. Artefacts became a key component of the discussions. Triangulation of the data in the research design aimed to overcome any research bias and allowed the researcher to more fully understand the social and cultural scene.

The study investigated such aspects as the social construction of reality, the nature of teaching and learning in context, the values that motivate participants and the ecology of the learning environments from a gendered perspective.

Keywords: technology education, females, pedagogy.

INTRODUCTION

Three aspects of the research will be examined in this paper. The first aspect is the nature of gender and the learning construct, and the links to the theoretical aspects of the study. The second is the learning environment in the context of values and language. Finally one case study will outline some of the issues relevant to females involved in technology education.

This paper presents preliminary findings from a research study conducted in one high school in South East Queensland during semester one of 2013. The study aimed to examine what factors could heighten the participation of female students in technology education classes. The focus was on girls, predominantly in the senior secondary years of schooling, studying within a school's industrial technology department. The aim of the study was to give a voice to female students in order to understand the nature of their involvement in design and technology subjects. The study also sought to gain an understanding into, the reasons why, the female students had undertaken such courses, and explored the realities of each classroom environment.

METHODOLOGY

An ethnographic case study approach was used to analyse the learning in the design and technology classroom which is the focus of this paper. This approach allowed the voices of the girls to be heard during the research, which was conducted over fourteen weeks. The researcher became a participant observer in two classes in an independent school in the western suburbs of Brisbane.

Data was collected from students, teachers and the Head of Department. The professional subject association, school administration and staff provided access to timetables and classes. Artefacts that students were designing and constructing were a key component of the discussions around what the students were engaged with in the technology classes. Observations were triangulated with responses collected from both staff and students at the site. This paper reflects some early findings.

BACKGROUND AND THEORETICAL FOUNDATION

The topic of the study has been under-researched in Australia, especially in the post – compulsory years of schooling. The use of language, its implied knowledge and gendered nature, added a further dimension to the analysis. Feminist writers have claimed that the connection between masculinity and technology, reflected in women's underrepresentation in the STEM (science, technology, engineering and mathematics) areas, continues to diminish the worth of females in these occupations and professions. Studies such as this are aimed at identifying factors which will provide success for female students in technology education. The findings of this research will have long term flow on effects for females transitioning into higher education institutions, with the aim of making the STEM pipeline more sustainable.

Despite the fact that a body of literature on gender and technology has existed from the mid-twentieth century onwards, few in-depth studies into gender and values in technology education have been completed in recent decades (Lerman, Oldenziel, & Mahun, 2003). Even fewer studies have taken place in the secondary school domain. In an Australian context, no research to date has examined the National Syllabus in Technologies and the fit with females in senior secondary education (Australian Curriculum Assessment and Reporting Authority, 2012). Whilst there has been much written about females in education and technology historically, and the sociological relationship of women to technology, there is an absence of research in this area (Stanley 1993, Lerman, et al., 2003). Writers suggest that research has been fragmented or at times relegated to the 'black box' (Crilly, 2010). During the last decade there have been calls for gender research, but few in-depth studies have been undertaken. Williams (2011) argues that the move to a more sociological view which considers the cultural context and interactions between people, will impact on future research in technology education.

THE NATURE OF GENDER AND LEARNING CONSTRUCT

Learning within a techno-social sphere may be the best environment for females. Bijker (2003) claims that there is a process of closure, reflecting on aspects of technical change and stability over time, which shows that everything can fit into a technological frame comprising knowledge, goals and values, as well as artefacts (Bernstein, 2003 ed.). Social constructionism is a social concept, a practice that is the construct of a particular group. Social constructs are not those given by nature but ones that must be constantly maintained and re-affirmed in order for them to persist.

Social constructionism in the post-modernist movement defines gender as being socially constructed. Gender is not created by nature as a result of biology but rather is created by, and contingent on, social and historical processes (Oldenziel, 2003; Restivo & Croissant, 2008; Stanley, 1993; Vygotsky, 1986). Sex is a descriptive category used to designate female and male. Rothschild (1988) argues that gender is a social category (Rothschild, 1988), while Petrina (2007) claims that differences are not determined by biological sex. It is argued then, that by changing the social and environmental factors from ones that reinforce stereotypical behaviours to ones which better suit girls, their interactions, engagement and learning will substantially improve in technology education classrooms. By making the environment more female friendly, we improve the social and cognitive ability of female's learning. These actions, it is argued, will improve retention and participation rates of female students. In the longer term this may influence the uptake and flow on to tertiary courses in fields such as technology and engineering (2007).

Ehrhart and Sandler (1987) noted that upbringing and socialisation play powerful roles in forming a child's abilities and confidences, reinforced not only by parents and teachers, but also by the media that teaches children roles, attitudes and behaviours thought to be 'appropriate' for each sex . Boys are encouraged to be active and independent, to explore and to learn how things work. Girls are taught to be passive, verbally oriented, and dependent. Boys receive chemistry sets, building toys, trucks and sports equipment; girls receive dolls, kitchen equipment, and sewing and embroidery kits. Parents' expectations that their children's interests and achievements will follow traditional sex roles could steer girls away from certain curriculum areas. In contrast, encouragement from parents for boys to succeed in maths, science and technology is crucial in students' decision to take these courses in high school (Fleer & Jane, 1999, 2004; Petrina, 2007).

THE LEARNING ENVIRONMENT IN THE CONTEXT OF VALUES AND LANGUAGE

To move forward, Wajcmen says

We need to bridge the common polarization in social theory…..Technology must be understood as part of the social fabric that holds society together; it is never merely technical or social. Rather, technology is always socio-material product – a seamless web or network combining artefacts, people, organizations, cultural meanings and knowledge (Wajcman, 2004).

In her techno-feminist framework Wajcman talks of the mutually shaping relationship between gender and technology that is a source and consequence of gender relations. It naturally follows that space is created for transformations of women's agency in education. 'Socio technical networks provide a path forward for women who are reflexively aware – able to choose their own lifestyles and identities' (Wajcman, 2004, p105).

Petrina (1998) in discussing teaching methods claims that some groups may require differential treatment to have a fair chance of participating and performing. Equal outcomes may require differential treatment, as he stated:

We have to attend to the barriers as well as intervene in the status quo conditions to achieve equity and equality in technology studies. Biases are hidden and subtle as well as obvious. Sex-bias or sexist curriculum materials in technology tend to give girls the message they are not important. Language that is not consciously gender- specific tends to default to the male in technology courses (Petrina 1998, p.335).

Values, which are often treated as gender neutral, have been examined as part of this research. Pavlova's (2009) research addressed notions of values in terms of sustainability and access. It is the issue of personal values which underlines the feminist perspective, and the way in which this translates into education at the local level, which relates to this study.

The empirical work of Rokeach (1973) underpins the values, explorations and the definitions which have endured over time, as well as applicability across contexts of learning and human endeavour. A value is an enduring belief that a specific mode of conduct or end state of existence is personally or socially preferable. Values, like all beliefs have cognitive, affective and behavioural components. Two types of values – instrumental and terminal – are identified, the latter resulting in activity with an end goal in sight. This applies to students who had already made career choices in terms of subjects, such as technology.

LEARNING ENVIRONMENTS FROM A GENDERED PERSPECTIVE

Technology as a system has the potential for the distribution of power. It is the importance of context in understanding technology, and the importance of technology in understanding society, that takes us past the 'old' boundaries that we have been burdened with in the past (Lerman, et al., 2003). Environment and language are two aspects which are examined in this study. The supportive nature of teaching, and teacher allowance for flexible learning, cater to female learning styles.

An awareness of the feminist issues is critical to assist educators in overcoming the stereotyping that still occurs subliminally in language discourse and enactment. One off programs to promote STEM and entry into engineering programs have not proved to be solutions in the long term. A recent study by Riegle-Crumb and Moore (2013) which examined Texan high school students entering engineering courses observed similar patterns to those in post- secondary engineering. Despite the fact that their study covered a new engineering course, the female attitudinal results of the year-long study showed less favourable attitudes toward engineering in an environment that was less inclusive than that of their male counterparts.

Language can convey the essence of the subject. It can provide a particular message which females use to form an opinion of the subject and its applicability to themselves, and subsequently of their engagement. The concept of gendered language, as expressed by Spender (1985 ed.) was a consideration in this study. The cultural norm of language, expressed in the various ways in which teachers address students, are indicative of the masculine language of invention (Odenziel, 1999, Bijker, 1995). Fox-Turnbull's (2010) research on peer and quality conversations may assist in drawing conclusions in relation to female participation and dialogue.

The technology education curriculum, using the language of technology, needs to incorporate the diversity of people, positions and values in order to reach all students. It can serve as a socially valued subject in the school curriculum (Zuga, 2007). Technological literacy and its links to language, values and understanding will provide the criteria and links to teasing out actions in the classroom.

The second aspect of language is the question of when opinions are formed by females about what they will study. Ford's (2011) study found that it is during the early years of education that gender and career decisions are made. Female students' opinions are formed via the language used at home. Curriculum enactment which shapes the engagement of girls in the subject, along with confidence gained through the language of achievement, makes some difference. In examining the data from female participation and performance in technology education, it is found that less than ten per cent of enrolments are females. Nonetheless, those girls who do enter technology classes achieve higher level results compared to their male counterparts.

THE CASE STUDY AND EARLY FINDINGS: DISCUSSION

The researcher was a participant observer attending Years 11 and 12 classes consisting of three female students and a balance of 15 to 17 males. The study followed one unit of work from the design phase to realisation of the artefact.

Data collection included observation checklists, field notes, written reflections after each class visit and audio recordings in the classrooms. Interviews were conducted with the Head of Department, the teacher and the female students. A set of open ended questions were provided to participants. A reparatory grid was completed, based on the designed and constructed artefact. The researcher viewed the students' folios and discussed the results with the teacher. Photographs were taken during each lesson.

THE NATURE OF GENDER AND LEARNING CONSTRUCT

Teacher support was critical in the classes observed. The teacher was encouraging and supportive, demonstrated techniques and made time for the girls in the class. 'I want you all to get top results,' said the teacher. The female students lacked the hand skills and technique of many of the male students. None of the girls studied the full range of technology subjects available.

In the workshops the girls tended to cluster in a workspace or with a supportive male peer. When asked about their location in the classrooms, students did not see this as a conscious decision.

The school's timetable was a discriminatory factor. By timetabling a creative arts/ fashion subject in the same slot as a technology subject, a gendered division appeared to be reinforced.. Ford's (2011) research showing why female students do not remain in technology classes would appear to be substantiated. When selecting subjects, the social beliefs of the parents and students appear to keep some of the females out of technology classes at this school.

THE LEARNING ENVIRONMENT IN THE CONTEXT OF VALUES AND LANGUAGE

The female students worked hard to achieve their goals. The teachers supported the development of their ideas in the theory classes, and these were later translated into the workshop settings for the development of artefacts and for the completion of assignments, reports and folios.

The supportive nature of the classes and the lack of same gender competition was one of the significant observations made in this setting. The social nature of learning, as against the competitiveness of the male students, meant that the females enjoyed the learning environment.

Teacher pedagogy catered to the particular girls in the workshops, however the girls required more female oriented projects and approaches in order to become motivated and engaged. Specific terms were explained and discussed, and were clearly directed at the females. The girls' lack of background experience was acknowledged by staff members, along with the need to explain terms and specific tools required to complete a task. These included explanations about the differing requirements for the pitch of a roof, instructions on how to use the aluminium bending machine, and how to link a rocker switch wiring with solder. The language used was pivotal to the task at hand.

The girls in this study did not see any gender bias in their classes. The boys who were interviewed felt that there should be more girls in technology classes. The boys noted that they had some advantage through experience during hands-on and graphic design courses in the early years of high school.

One observation made was of the confidence built through successful activity in the technology classes. While the females were encouraged, they were not sheltered from having to problem solve, create a prototype, and at times fail at a task. Their willingness to engage and take on more difficult concepts expanded during the course of the study. The presence of the female researcher in the workshop made a difference to one participant, who as the teacher said, 'felt special' when the researcher arrived.

Promotion of the benefits of the subject to potential participants through female oriented projects, female role models and the long term utility of technology itself, will serve to heighten participation.

IN CONCLUSION

This paper has provided one set of findings from the study. Females clearly want to engage in technology education.

There are many avenues for research in this area and many practitioners who are willing to assist. Teachers and academics acknowledge the issue of the leaking pipeline. Technologically minded females are being encouraged through teaching methods, accommodation, and freedom of choice in technology classes. The use of female teachers in the junior school classes has provided role models for female students. The family social constructs which limit girls' ambitions towards technology education appear to be the first break in the pipeline while educators are addressing the leaks at the opposite end. It is the aspirational middle students that schools need to be addressing in order to create a sustainable long-term pathway for more females to enter senior technology education.

With the implementation of the Australian Technologies syllabus there will be a change in how teachers approach design and technology teaching in secondary schools. The implied use of a design process, whether learned through information technologies or design and technology, will mean that teachers and students will have a longer span of education to learn about technological processes. This in itself will make technology studies more self-sustaining, as well as changing the optional nature of the subject against other post-secondary options.

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Technology Teachers' Attitudes toward Nuclear Energy and Their Implications for Technology Education

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ABSTRACT

The purpose of this paper was to explore high-school (grades 10-12) technology teachers' attitudes toward nuclear energy and their implications to technology education. A questionnaire was developed to solicit 323 high-school technology teachers' responses in June 2013 and 132 (or 41%) valid questionnaires returned. Consequently, the following five conclusions can be made: (1) Most high-school technology teachers in Taiwan are keen on news about Japan's Fukushima nuclear disaster. (2) The majority of high-school technology teachers oppose more nuclear power plants in Taiwan, are now "less supportive of expanding nuclear power plants in Taiwan after Japan's Fukushima nuclear disaster, oppose to extend the operating lifespan of the operating nuclear power plants in Taiwan, and oppose the construction of a new nuclear reactor within 80 kilometers of their homes. (3) The majority of technology teachers in Taiwan are now more supportive than they were before Japan's Fukushima nuclear disaster of using clean renewable energy resources – such as wind and solar – and increased energy efficiency as an alternative to more nuclear power in Taiwan, and support a termination or moratorium on new nuclear power plant construction in Taiwan if increased energy efficiency and off the shelf renewable technologies such as wind and solar could meet our energy demands for the near term. (4) Nearly a half of high-school technology teachers in Taiwan do not know the evacuation route and what other steps to take in the event of the nearest nuclear power plant emergency. (5) The majority of high-school technology teachers in Taiwan includes nuclear energy in their technology courses, and will enrich nuclear energy in their technology courses.

Keywords: nuclear energy, nuclear waste, technology education, technological issue

BACKGROUND AND PURPOSE

We are pursuing sustainable energy sources that are available to supply the world's expanding needs without detriment to our future generations. Although considered as a low carbon power generation source, nuclear energy has been the subject of debate because its radioactive wastes remain a major issue and its safety becomes a global concern. Since the world's first nuclear power plant was set up in 1954, the three worst nuclear disasters occurred as follows: Three Mile Island in the United States, 1979, Chernobyl in the former Soviet Union, 1986 and Fukushima in Japan, 2011. This history unfolds that the nature of nuclear energy could be unsafe and unethical. However, Kubota (2012) examined public attitudes toward nuclear energy after the Fukushima nuclear accident and reveals that the need for the efficient production of nuclear power outweighs concern for the potential danger of a nuclear incident.

Taiwan imports 99% of its energy and nuclear power has been a significant part (about 20%) of the electricity supply. There are three operating nuclear power plants with six reactors and the fourth one with two reactors is under construction in Taiwan. Taiwan authorities argue that nuclear power is considerably cheaper than alternatives. However, due to Japan's Fukushima nuclear disaster, the anti-nuclear movement has grown and the public (or technological) issue in favor of or against nuclear power has become controversial in Taiwan.

Energy and Power, including nuclear energy, is a content area of the official high-school technology education curriculum in Taiwan. One of the goals of technology education in Taiwan is to facilitate students in dealing with technological issues critically and intellectually. Social psychologists' attitude-behavior consistency theory argues that our attitudes (predispositions to behavior) and actual behaviors are more likely to align if our attitude and behavior are both constrained to very specific circumstances (Changing Minds, u.d.). Accordingly, technology teacher's attitudes influence what students are taught and how they are taught. An exploration of technology teachers' attitudes toward nuclear energy can help technology teachers understand their own as well as their peer's attitudes and to further develop curriculum and instruction. Thus, the purpose of this paper was to explore high-school technology teachers' attitudes toward nuclear energy and their implications to technology education.

METHOD AND PROCEDURE

In order to attain the purpose, a questionnaire survey was conducted. We administered a survey using a questionnaire modified from the ORC International (2011) and distributed it to all 323 high schools offering technology education courses. In June 2013, the modified questionnaire was sent to the Director of Academic Affairs of each school who was asked to pass over the questionnaire to a technology teacher. Technology teachers directly sent back the questionnaire when they complete it. As a result, 132 (or 41%) valid questionnaires were obtained.

In addition to descriptive statistical analyses, the inferential statistical analysis, Pearson's Chi-square test, was employed to test how likely it is that the questionnaire respondent's answer and his/her gender, school as well as location affiliation, respectively, are completely independent.

FINDINGS AND CONCLUSIONS

As shown in Appendix, in the 30 Chi-square tests, only three Chi-square values are statistically significant. This indicates that there are few significant differences between the gender, school, and location affiliation among our samples. Hence, the findings of this survey can be highlighted as follows:

1. 97% of technology teachers are "following news about Japan's Fukushima nuclear disaster."
2. 61% of technology teachers oppose more nuclear power plants in Taiwan.
3. 70% of technology teachers are now "less supportive of expanding nuclear power plants in Taiwan after Japan's Fukushima nuclear disaster."
4. 79% of technology teachers say they are now "more supportive than they were before Japan's Fukushima nuclear disaster in using clean renewable energy resources – such as wind and solar – and increasing energy efficiency as an alternative to more nuclear power in Taiwan."
5. 71% of technology teachers support a termination or moratorium on new nuclear power plant construction in Taiwan if increased energy efficiency and existing renewable technologies such as wind and solar could meet our energy demands for the near term.
6. 66% of technology teachers oppose to extend the operating lifespan of the operating nuclear power plants in Taiwan.
7. 85% of technology teachers oppose the construction of a new nuclear reactor within 80 kilometers of their homes.
8. 46% of technology teachers do not know the evacuation route and what other steps to take

in the event of the nearest nuclear power plant emergency.

9. 61% of technology teachers include nuclear energy in their technology courses.
10. 65% of technology teachers will enrich nuclear energy in their technology courses.

Based on the above findings, the high-school technology teachers prefer increasing energy efficiency and existing renewable technologies to constructing more nuclear power plants or extending the operating lifespan of the operating nuclear power plants. They also consider a nuclear plant as a NIMBY (Not In My Back Yard) object. In addition, they intend to include more nuclear energy issues in their technology education courses. According to the attitude–behavior consistency theory that attitudes can predict behavior, against nuclear power will be stronger than in favor of nuclear power in the circumstance of high-school technology education in Taiwan.

Based upon the above findings and discussions, the following conclusions can be drawn:

1. Most high-school technology teachers in Taiwan are keen on news about Japan's Fukushima nuclear disaster.
2. The majority of high-school technology teachers oppose more nuclear power plants in Taiwan, are now "less supportive of expanding nuclear power plants in Taiwan after Japan's Fukushima nuclear disaster, oppose to extend the operating lifespan of the operating nuclear power plants in Taiwan, and oppose the construction of a new nuclear reactor within 80 kilometers of their homes.
3. The majority of technology teachers in Taiwan are now more supportive than they were before Japan's Fukushima nuclear disaster to use clean renewable energy resources – such as wind and solar – and increased energy efficiency as an alternative to more nuclear power in Taiwan, and support a termination or moratorium on new nuclear power plant construction in Taiwan if increased energy efficiency and off the shelf renewable technologies such as wind and solar could meet our energy demands for the near term.
4. Nearly a half of high-school technology teachers in Taiwan do not know the evacuation route and what other steps to take in the event of the nearest nuclear power plant emergency.
5. The majority of high-school technology teachers in Taiwan includes nuclear energy in their technology courses, and will enrich nuclear energy in their technology courses.

IMPLICATIONS

Based on the above conclusions, the implications of teachers' attitudes toward nuclear energy to technology education can be made as follows:

1. Training and development opportunities, such as workshop and discussion forum, should be offered.

Being keen on news about nuclear energy is not enough. To ensure technology teachers' knowledge regarding nuclear energy is updated and accurate, appropriate training and development opportunities should be offered.

2. Best practices of nuclear energy education should be identified and benchmarked

The majority of technology courses have included nuclear energy. Best practices of nuclear energy education should be identified among them for further promotion.

3. Both energy saving and development should be valued in high-school technology courses.

That is to say, the strategies and possibilities to increase energy efficiency and develop clean renewable energy resources should taught in high-school technology courses. However, to high-school student increasing energy efficiency has higher priority than the development of new energy resources.

4. A debate can be served as a strategy for high-school students to clarify the controversial issue of nuclear energy.

To help high-school students to become informed critical thinkers and decision makers, technology teachers can adopt a debate as an instructional strategy. In addition, the debate activity can be collaboratively conducted with other subjects, such as sciences, moral education, and so on.

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APPENDIX: THE CONTINGENCY TABLE OF CHI-SQUARE ANALYSES

Question	Answer	Total	a. Gender		b. School		c. Location--Living within 80 kilometers of a nuclear power plant site?		
			Male	Female	Pubic	Private	Yes	No	Don't Know/ Not sure
1. How closely are you following news about Japan's Fukushima nuclear disaster?	Very closely Somewhat closely Not very closely Not following it Don't know/Not sure Total a.$\chi^2(4)$= 4.063 b.$\chi^2(4)$=8.185 c.$\chi^2(8)$=6.707	22（16.7%） 82（62.1%） 25（18.9%） 3（2.3%） 0（0.0% 132 (100%)	16（72.7%） 66（80.5% 19（76.0%） 1（33.3%） 0（0.0%） 102 （77.3%）	6（27.3%） 16 （19.5%） 6（24.0%） 2（66.7%） 0（0.0%） 30 （22.7%）	17（77.3%） 43（52.4%） 18（72.0%） 3（100.0%） 0（0.0%） 81（61.4%）	5（22.7%） 39 （47.6%） 7（28.0%） 0（0.0%） 0（0.0%） 21 （38.6%）	5 （22.7%） 14 （17.1%） 3 （12.0%） 0（0.0%） 0（0.0%） 22 （16.7%）	16（72.7%） 65（79.3%） 20（80.0%） 2（66.7%） 0（0.0%） 103 （78.0%）	1（4.5%） 3（3.7%） 2（8.0%） 1（33.3%） 0（0.0%） 7（5.3%）
2. Would you say that you support or oppose more nuclear power plants in Taiwan?	Support strongly Support somewhat Oppose somewhat Oppose strongly Don't know/Not sure Total a.$\chi^2(4)$=7.313 b.$\chi^2(4)$=6.350 c.$\chi^2(8)$=4.070	6（4.5%） 30（22.7%） 35（26.5 %） 46（34.8%） 15（11.4%） 132 (100%)	6（100.0%） 25（83.3%） 27（77.1%） 36（78.3%） 8（53.3%） 102 （77.3%）	0（0.0%） 5（16.7%） 8（22.9%） 10 （21.7%） 7（46.7%） 30 （22.7%）	2（33.3%） 17（56.7%） 21（60.0%） 28（60.9%） 13（86.7%） 81（61.4%）	4（66.7%） 13 （43.3%） 14 （40.0%） 18 （39.1%） 2（13.3%） 51 （38.6%）	2 （33.3%） 5 （16.7%） 4 （11.4%） 9 （19.6%） 2 （13.3%） 22 （16.7%）	4（66.7%） 23（76.7%） 28（80.0%） 36（78.3%） 12（80.0%） 103 （78.0%）	0（0.0%） 2（6.7%） 3（8.6%） 1（2.2%） 1（6.7%） 7（5.3%）
3. Are you now more or less supportive of expanding nuclear power plants in Taiwan after Japan's Fukushima nuclear disaster?	Much more supportive Somewhat more supportive Somewhat less supportive Much less supportive No change Don't know/Not sure Total a.$\chi^2(5)$= 8.813 b.$\chi^2(5)$=6.688 c.$\chi^2(10)$=8.320	3（2.3%） 5（3.8%） 38（28.8%） 54（40.9%） 28（21.2%） 4（3%） 132 (100%)	2（66.7%） 4（80.0%） 29（76.3%） 41（75.9%） 25（89.3%） 1（25.0%） 102 （77.3%）	1（33.3%） 1（20.0% 9（23.7%） 13 （24.1%） 3（10.7%） 3（75.0%） 30 （22.7%）	2（66.7%） 1（20.0%） 25（65.8%） 33（61.1%） 16（57.1%） 4（100.0%） 81（61.4%）	1（33.3%） 4（80.0%） 13 （34.2%） 21 （38.9%） 12 （42.9%） 0（0.0%） 51 （38.6%）	0（0.0% 1（20.0% 6 （15.8%） 10 （18.5%） 5 （17.9%） 0（0.0%） 22 （16.7%）	3（100.0% 3（60.0% 30（78.9%） 43（79.6%） 21（75.0%） 3（75.0%） 103 （78.0%）	0（0.0% 1（20.0% 2（5.3%） 1（1.9%） 2（7.1%） 1（25.0%） 7（5.3%）
4. Would you say that you are now more or less than you were before Japan's Fukushima nuclear disaster in using clean renewable energy resources – such as wind and solar – and increasing energy	Much more supportive Somewhat more supportive Somewhat less supportive Much less supportive No change Don't know/Not sure Total a.$\chi^2(5)$=10.008 b.$\chi^2(5)$=2.977 c.$\chi^2(10)$=25.064	50 （37.9%） 54 （40.9%） 4（3%） 1（0.8%） 22 （16.7%） 1（0.8%） 132 (100%)	40（80.0%） 39（72.2%） 4（100.0%） 0（0.0%） 19（86.4%） 0（0.0%） 102 （77.3%）	10 （20.0%） 15 （27.8%） 00.0%） 1 （100.0%） 3（13.6%） 1 （100.0%） 30 （（22.7%）	31（62.0%） 32（59.3%） 2（50.0%） 0（0.0%） 15（68.2%） 1（100.0%） 81（61.4%）	19 （38.0%） 22 （40.7%） 2（50.0%） 1 （100.0%） 7（31.8%） 0（0.0%） 51 （38.6%）	10 （20.0%） 9 （16.7%） 0（0.0%） 0（0.0%） 3 （13.6%） 0（0.0%） 22 （16.7%）	39（78.0%） 41（75.9%） 3（75.0%） 1（100.0%） 19（86.4%） 0（0.0%） 103 （78.0%）	1（2.0%） 4（7.4%） 1（25.0%） 0（0.0%） 0（0.0%） 1 （100.0%） 7（5.3%）

efficiency as an alternative to more nuclear power in Taiwan?									
5. If increased energy efficiency and existing renewable technologies such as wind and solar could meet our energy demands for the near term, would you support a termination or moratorium on new nuclear power plant construction in Taiwan?	Yes No Don't know/Not sure Total a.$\chi^2(2)=0.865$ b.$\chi^2(2)=10.216$ c.$\chi^2(4)= 7.387$	93 (70.5%) 20 (15.2%) 19 (14.4%) 132 (100%)	71 (76.3%) 17 (85.0%) 14 (73.7%) 102 (77.3%)	22 (23.7%) 3 (15.0%) 5 (26.3%) 30 (22.7%)	61 (65.6%) 6 (30.0%) 14 (73.7%) 81 (61.4%)	32 (34.4%) 14 (70.0%) 5 (26.3%) 51 (38.6%)	16 (17.2%) 4 (20.0%) 2 (10.5%) 22 (16.7%)	75 (80.6%) 14 (70.0%) 14 (73.7%) 103 (78.0%)	2 (2.2%) 2 (10.0%) 3 (15.8%) 7 (5.3%)
6. Would you support or oppose to extend the operating lifespan of the operating nuclear power plants in Taiwan?	Support strongly Support somewhat Oppose somewhat Oppose strongly Don't know/Not sure Total a.$\chi^2(4)=4.442$ **b.$\chi^2(4)=9.970$*** c.$\chi^2(8)= 3.896$	2 (1.5%) 31 (23.5%) 40 (30.3%) 47 (35.6%) 12 (9.1%) 132 (100%)	2 (100.0%) 24 (77.4%) 27 (67.5%) 40 (85.1%) 9 (75.0%) 102 (77.3%)	0 (0.0%) 7 (22.6%) 13 (32.5%) 7 (14.9%) 3 (25.0%) 30 (22.7%)	0 (0.0%) 14 (45.2%) 24 (60.0%) 34 (72.3%) 9 (75.0%) 81 (61.4%)	2 (100.0%) 17 (54.8%) 16 (40.0%) 13 (27.7%) 3 (25.0%) 51 (38.6%)	0 (0.0%) 6 (19.4%) 6 (15.0%) 8 (17.0%) 2 (16.7%) 22 (16.7%)	2 (100.0%) 24 (77.4%) 30 (75.0%) 38 (80.9%) 9 (75.0%) 103 (78.0%)	0 (0.0%) 1 (3.2%) 4 (10.0%) 1 (2.1%) 1 (8.3%) 7 (5.3%)
7. Would you support or oppose the construction of a new nuclear reactor within 80 kilometers of your home?	Support strongly Support somewhat Oppose somewhat Oppose strongly Don't know/Not sure Total a.$\chi^2(4)=3.645$ b.$\chi^2(4)=1.659$ **c.$\chi^2(8)= 19.124$***	5 (3.8%) 7 (5.3%) 28 (21.2%) 84 (63.6%) 8 (6.1%) 132 (100%)	5 (100.0%) 6 (85.7%) 23 (82.1%) 61 (72.6%) 7 (87.5%) 102 (77.3%)	0 (0.0%) 1 (14.3%) 5 (17.9%) 23 (27.4%) 1 (12.5%) 30 (22.7%)	3 (60.0%) 3 (42.9%) 17 (60.7%) 52 (61.9%) 6 (75.0%) 81 (61.4%)	2 (40.0%) 4 (57.1%) 11 (39.3%) 32 (38.1%) 2 (25.0%) 51 (38.6%)	3 (60.0%) 1 (14.3%) 7 (25.0%) 9 (10.7%) 2 (25.0%) 22 (16.7%)	2 (40.0%) 6 (85.7%) 17 (60.7%) 73 (86.9%) 5 (62.5%) 103 (78.0%)	0 (0.0%) 0 (0.0%) 4 (14.3%) 2 (2.4%) 1 (12.5%) 7 (5.3%)
8.Do you know the evacuation route and what other steps to take in the event of the nearest nuclear power plant emergency?	Yes No Don't know/Not sure Total a.$\chi^2(2)=1.760$ b.$\chi^2(2)=0.835$ **c.$\chi^2(4)= 19.124$***	34 (25.8%) 61 (46.2%) 37 (28%) 132 (100%)	24 (70.6%) 47 (77.0%) 31 (83.8%) 102 (77.3%)	10 (29.4%) 14 (23.0%) 6 (16.2%) 30 (22.7%)	20 (58.8%) 36 (59.0%) 25 (67.6%) 81 (61.4%)	14 (41.2%) 25 (41.0%) 12 (32.4%) 51 (38.6%)	9 (26.5%) 9 (14.8%) 4 (10.8%) 22 (16.7%)	23 (67.6%) 49 (80.3%) 31 (83.8%) 103 (78.0%)	2 (5.9%) 3 (4.9%) 2 (5.4%) 7 (5.3%)
9.Do you include nuclear energy in your technology courses?	Yes No Don't know/Not sure Total a.$\chi^2(2)=1.849$ b.$\chi^2(2)=0.375$ c.$\chi^2(4)=3.245$	80 (60.6%) 46 (34.8%) 6 (4.5%) 132 (100%)	61 (76.3%) 35 (76.1%) 6 (100.0%) 102 (77.3%)	19 (23.8%) 11 (23.9%) 0 (0.0%) 30 (22.7%)	50 (62.5%) 28 (60.9%) 3 (50.0%) 81 (61.4%)	30 (37.5%) 18 (39.1%) 3 (50.0%) 51 (38.6%)	15 (18.8%) 7 (15.2%) 0 (0.0%) 22 (16.7%)	62 (77.5%) 36 (78.3%) 5 (83.3%) 103 (78.0%)	3 (3.8%) 3 (6.5%) 1 (16.7%) 7 (5.3%)
10.Will you enrich nuclear energy in your technology courses?	Yes No Don't know/Not sure Total a.$\chi^2(2)=0.473$ b.$\chi^2(2)=1.607$ c.$\chi^2(4)=2.683$	86 (65.2%) 18 (13.6%) 28 (21.2%) 132 (100%)	66 (76.7%) 15 (83.3%) 21 (75.0%) 102 (77.3%)	20 (23.3%) 3 (16.7%) 7 (25.0%) 30 (22.7%)	51 (59.3%) 10 (55.6%) 20 (71.4%) 81 (61.4%)	35 (40.7%) 8 (44.4%) 8 (28.6%) 51 (38.6%)	14 (16.3%) 4 (22.2%) 4 (14.3%) 22 (16.7%)	69 (80.2%) 13 (72.2%) 21 (75.0%) 103 (78.0%)	3 (3.5%) 1 (5.6%) 3 (10.7%) 7 (5.3%)

*$p<.05$

An Analysis of Undergraduate Technology & Engineering Teacher Preparation Programs in the United States

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ABSTRACT
This study investigated the curricula of technology & engineering teacher preparation programs offered at all colleges and universities that enroll 20 or more T&E teacher preparation majors throughout the United States. Components of the various curricula such as general education requirements, professional studies requirements and technical studies requirements were investigated. A composite curriculum for Technology Education teacher preparation in the United States was presented based upon the findings of the study. Such a composite model may be useful filling a void in accountability since the International Technology & Engineering Education Association (ITEEA) and the Council on Technology & Engineering Teacher Education (CTETE) recently decided to part ways with The National Council for Accreditation of Teacher Education (NCATE). The NCATE organization in conjunction with ITEEA & CTETE had provided accreditation guidelines for many colleges & universities that prepare technology & engineering teachers throughout the United States up until two years ago. As a result, NCATE no longer has a Specialized Professional Association (SPA) for technology and engineering education to recommend guidelines for teacher preparation programs or to help assess the appropriateness of existing programs.

INTRODUCTION
Technology & engineering teacher preparation programs at colleges and universities in the United States have been in a state of decline since the 1970's. In an editorial published in the Spring 1997 *Journal of Technology Education,* Volk (1997) indicated that the number of undergraduate students graduating in technology teacher preparation declined by nearly two-thirds between the period of 1970 and 1990. Plotting the downward trend in graduates, Volk estimated the demise of technology education teacher preparation in the United States around the year 2005.

While Volk's prediction has not been proven to be entirely accurate, the downward trend in technology teacher preparation has continued. An analysis of the 2002/2003 *Industrial Teacher Education Directory* (Bell, 2002) indicated that there were more than 40 programs nationwide with estimated udergraduate teacher preparation enrollments of more than 20 students. Just one decade later the *2012/2013 Technology & Engineering Teacher Education Directory* (Rogers, 2012) indicated that only 24 programs had an estimated undergraduate enrollment of 20 students or more. Of those programs that remain, another concern is that there is still considerable diversity with regard to the curricula that comprise the various technology & engineering teacher preparation programs. For instance, at one end of the spectrum some programs have retained a traditional approach to technology & engineering education that is deeply rooted in hands-on experiences, often through traditional projects that involve material processing with wood or metal along with courses in graphics, electricity and power technology. On the other end of the spectrum are programs that have evolved through schools of engineering. Some of these programs require teacher preparation students to complete the same course work as any typical engineering major along with additional coursework in pedagogy in order to earn teacher licensure.

In the fall of 2013 a study was conducted to compare the required curricula of the 24 undergraduate programs that maintain enrollment of 20 students or more in order to determine what a composite or 'model' curriculum might look like. A list of the institutions included in the study is provided in Appendix A. Such a model could be useful in the process of updating accreditation guidelines used by the *Council on Technology & Engineering Teacher Education* that have now been in place for more than a decade (NCATE/ITEA/CTTE, 2003).

METHODOLOGY

This study utilized a multi-part methodology in order to create a composite model undergraduate curriculum for technology & engineering teacher preparation in the United States. First, technology or technology & engineering teacher preparation programs having an undergraduate population of 20 students or more were identified using the *2012/2013 Technology & Engineering Teacher Education Directory* (Rogers, 2012). Next, basic information about critical aspects of each program were determined. These critical aspects included the following:

a. Number of credits required to complete the program
b. Number of professional credits required
c. Number of technical credits required
d. Number of general education credits required
e. Highest level of math & science required
f. Technical course work most frequently required
g. Professional course work most frequently required

The composite curriculum that was created addresses several key aspects of all technology & engineering teacher preparation programs in the United States including *professional studies* requirements, *technical studies* requirements and some components of *general education* (sometimes referred to as *liberal studies*), such as mathematics and science, that are most closely associated with technology & engineering content.

LIMITATIONS OF THE STUDY

1. The study was limited to the 24 technology & engineering teacher preparation programs maintaining undergraduate enrollments of 20 students or more and may not be indicative of all technology & engineering teacher preparation programs throughout the United States.

2. The composite model curriculum created as a result of this study was based upon existing curriculum requirements for those programs included in the study. As such, it is simply a model of what exists now, and may not be reflective of the most contemporary or progressive curriculum from a philosophical standpoint.

FINDINGS

Table 1 below shows the findings regarding credit distribution for a composite model curriculum that was determined by reviewing the program requirements for the 24 technology & engineering education programs included in the study.

Table 1: Credit Distribution for a Model Composite Curriculum for Technology & Engineering Teacher Preparation in the United States (n=24)

	Mean	**Range**
Total Credits Required	126	120 - 139
Total General Education Credits Required	45	30 - 60
Total Professional Credits Required (includes student teaching)	33	24 - 49
Total Technical Credits Required	44	27 - 57

The data indicate that a composite curriculum would be reasonably evenly distributed among the three core areas of *general education*, *professional studies* and *technical studies* that comprise all teacher preparation degree programs in the United States. Table 2 addresses mathematical and science requirements for technology & engineering teacher preparation programs in the United States.

Table 2: Highest Level Math & Science Requirements for Technology & Engineering Teacher Preparation Programs in the United States (n=24)

Highest Level Math Required	**Frequency**	**Percentage of Total**
Calculus I	5	21%
Calculus II	1	4%
Pre-Calc Algebra	3	12.5%
Algebra & Trig	3	12.5%
Algebra OR Trig	1	4%
College Algebra	4	17%
Statistics	3	12.5%
Funds of Math	4	17%
Highest Level Science Required	**Frequency**	**Percentage of Total**
Physics II	1	4%
Physics	10	42%
Physics or Bio	2	8%
Physics, Bio or Chem	8	34%
Physics, Earth Science, Chem	2	8%
Undetermined	1	4%

The data indicate a wide range of mathematics requirements with regard to programs. Almost 30% of the programs that were reviewed required no greater math than Statistics, but 25% of the programs required at least one Calculus course. Some form of Algebra was the most frequent type of math required by the greatest number of programs. The data indicated greater consistency with regard to science requirements. At least one Physics course was required more than any other type of science, but many institutions allowed for the selection of any natural science course to fulfill general education and/or major requirements.

Table 3 addresses technical course work required within the curriculum. For the purposes of the study only required course work was considered. Many curricula that were reviewed included optional and/or elective course offerings but these electives were not considered for the purposes of this study since accreditation guidelines typically focus on required coursework.

Table 3: Technical Coursework Required (n=24)

Technical Content Required	Frequency
Energy & Power Energy Power Systems Energy, Power & Trans Electronics (analog & digital) Robotics Automation/System Control Fluid Power	46*
Manufacturing Industrial Organization Technological Enterprise Wood Manufacturing Metal Manufacturing Production Systems	29*
Communication Multimedia Desktop Publishing Graphics Printing	25*
Design Product Design Innovation Problem Solving Industrial Design Engineering Design	24
Material Processing Material Testing & Statics	23
Construction	19
Introductory Drafting/CAD	16
Advanced CAD Architecture CAD/CAM 3-D Solid Modeling Civil Engineering/Arch	10
Transportation	6
Technology & Society	6
Senior Design Project/ R&D	5
Medical/Agricultural/Bio-related	4
Engineering Principles	3

Other	
Computer Networking	3
Technological Systems	3
Computer Integrated Mfg.	3
Gateway to Technology	2
Technological Decision Making	1
Applications in STEM	1
Exploring Technology	1
Technology Systems II	1
Dynamics	1
Solids	1
Thermal	1
Machine Design	1

*Some programs required more than one course in some areas

With regard to technical content, many institutions have designed their curriculum to reflect the *Standards for Technological Literacy (SfTL)* (Dugger, 2000) and more specifically the portion of the *SfTL* referred to as the *Designed World*. The *Designed World* specifically identifies sectors of technology and the economy as communication, transportation, manufacturing, construction, energy and power, and biological, agricultural and medical technologies that are worthy of study towards the goal of technological literacy. Other aspects of the *SfTL* are reflective of the required course offerings indicated in Table 3 as well. For instance, the *SfTL* recognizes design abilities as essential to becoming technologically literate and as a result many institutions require some type of course dedicated to design in addition to teaching about aspects of design through other technical courses.

The information provided in Table 3 also indicates that traditional courses continue to be required in most programs, but often for good reason. For instance, material processing courses are still prevalent, but in the current era they are often used as prerequisites to courses such as manufacturing, construction or product design. Also worthy of note is the lack of wide-spread acceptance of knowledge and skills relevant to agricultural, biological or medical technologies, which do not have a longstanding history within the field like manufacturing or communication or construction. Similarly, more references to courses with *engineering* in the title might have been anticipated given the profession's recent turn toward engineering in the United States. Finally, it is worth noting that the data collection method used may have done an injustice to subjects like electronics and transportation. These subjects were not separated out from the Energy & Power category the way that Drafting was reported separately from courses in the Communication category. Many of the programs reviewed did require courses in electricity/electronics, and many others taught aspects of transportation in conjunction with energy & power courses, requiring a judgment call as to where to record these courses in Table 3. Disappointingly, few tertiary institutions required specific coursework in robotics or automation even though these subjects are very popular in middle schools and high schools throughout the United States.

The final area of curriculum that was reviewed was the professional course sequence. This area yielded more diversity in the required courses across institutions was anticipated, given that many of the requirements for teacher preparation, such as teaching methods courses, are similar for all teacher preparation subject areas. Some of the variation can be explained by the fact that in the United States, education guidelines are a state's responsibility. Therefore, there are no nationally mandated requirements, so teacher licensure requirements can and do vary from state to state. Analysis of the various professional requirements is provided in Table 4.

Table 4: Professional Coursework Required Within Technology & Engineering Teacher Preparation Programs (n=24)

Professional Coursework Required	**Frequency**
Teaching Methods (General) Instructional Techniques Curriculum Development Assessment	45*
Student Teaching Practicum	24
Foundations of Technology & Engineering Education	24
Methods of Teaching TE	16
Educational Psychology	16
Teaching Exceptional Students Students of Special Needs Inclusion English Language Learners	14
Professional/Clinical Field Experiences	10
Student Teaching Seminar	9
Multicultural Education	9
Literacy Through Content	8
Early Field Experiences Observation and Participation Practicum	7
Exploring Teaching Careers	6
Foundations of Education	5
Technology Lab Design/Management	4
Classroom Management	3
Elementary Technology Education Technology for the Elementary Integrative STEM for Young Learners Design, Tech & Engineering for Children	3
Issues in Secondary Education	2
Philosophy of Education	2
Other CTE Student Organizations Standards for Technological Literacy Resources for Technology Integrative Engineering Concepts K-12 Learning & Motivation Portfolio Assessment Key Concepts for Middle Level Ed.	 1 1 1 1 1 1 1

*Some programs required more than one course in some areas

Not surprisingly, teaching methods courses were the most frequently identified required professional courses followed by the student teaching experience, which is a requirement for all teacher preparation majors at all 24 institutions. More interestingly, virtually all of the institutions in the study maintained at least one departmental foundations-level professional course and most maintained and required two professional courses from within the department. The data clearly indicate that courses addressing topics such as Exceptional Children in the Classroom and Multiculturalism are becoming more popular along with increased teaching exploration courses and early field experiences prior to student teaching.

SUMMARY AND CONCLUSIONS

Technology & engineering teacher preparation programs across the United States have been in a state of decline for more than four decades. There are currently only 24 undergraduate technology & engineering teacher preparation programs in the United States with an enrollment of 20 students or more. Among these programs there exists much diversity about what constitutes a required sequence of courses or curriculum to complete a bachelor's degree and earn teacher licensure. Comparing the required curriculum for these 24 programs resulted in the design of the following composite curriculum:

Table 5: Courses that comprise a composite curriculum for technology & engineering teacher preparation in the United States based upon requirements across existing programs.

General Education (45 Credits) Including:	**Professional Studies (33 Credits) Including:**	**Technical Studies (44 Credits) Including:**
College Algebra and 1 additional College Mathematics course	At least 2 general teaching methods courses addressing topics such as instructional techniques, curriculum, and assessment	2 courses in Energy & Power including Electricity/Electronics and Transportation
1 Physics course	At least 1 methods course specifically in technology & engineering education (most programs required 2 such courses)	1 course in Manufacturing
	1 course in Educational Psychology	1 course in Communication
	1 course in Special Needs children in the classroom	1 course in Construction
	Full semester student teaching experience	1 course in Design
		1 course in Material Processing
		1 course in Drafting/CAD

Only courses that were required by at least half of the 24 programs in the study were included in the model curriculum provided in Table 5 above. Most of the courses would align quite well with the *Standards for Technological Literacy* (Dugger, 2000). Yet, notably absent are courses like biological, medical and agricultural technologies that are also referenced in the *SfTL.* These data indicate that more than 12 years after the *SfTL* were published this content has failed to gain widespread acceptance in technology & engineering teacher preparation programs throughout the United States. Similarly, the study identified few courses that specifically embrace the engineering movement by title, although course titles do not speak to the types of activities delivered in existing courses that may help to address engineering content. Lastly, it is important to acknowledge that one significant limitation of this study was that the model curriculum was derived from existing curricula. As such, it is not necessarily representative of a more progressive curriculum that an accrediting body might wish to foster.

RECOMMENDATIONS

1. As a follow-up to this study program coordinators or department chairpersons should be surveyed to determine factors influencing the design of their required curriculum for technology & engineering teacher preparation, along with factors influencing the recruitment of students interested in teaching technology & engineering as a career. Such a survey has been tentatively developed and is provided in Appendix B.

2. The ITEEA's Council on Technology & Engineering Teacher Education (CTETE) should consider updating their accreditation guidelines for teacher preparation programs given recent changes in the field. These guidelines have been in place for more than a decade and were developed in conjunction with the NCATE accrediting agency. ITEEA and CTETE no longer maintain an affiliation with NCATE.

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APPENDIX A

Institutions Included in the Study

1. Central Connecticut State University
2. Colorado State University
3. Illinois State University
4. Ball State University (Indiana)
5. Indiana State University
6. Purdue University (Indiana)
7. University of Northern Iowa
8. Fort Hays State University (Kansas)
9. Pittsburg State University (Kansas)
10. Montana State University
11. Wayne State University (Nebraska)
12. The College of New Jersey
13. State University of New York at Oswego
14. Buffalo State University (New York)
15. Appalachian State University (North Carolina)
16. North Carolina State University
17. California University of Pennsylvania
18. Millersville University of Pennsylvania
19. Valley City State University (South Dakota)
20. Brigham Young University (Utah)
21. Utah State University
22. Old Dominion University (Virginia)
23. University of Wisconsin – Stout
24. University of Wisconsin – Platteville

APPENDIX B

Survey

Factors Affecting Technology & Engineering Teacher Preparation Programs in the United States

Directions: Please answer each question by clicking the circle that represents your response to the question.

Factors Affecting the Design of Technology & Engineering Curriculum at Your Institution

Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree
1	**2**	**3**	**4**	**5**

1. The *Standards for Technological Literacy* have a major influence on the design of our curriculum.

2. The engineering movement has influenced changes in our required curriculum.

3. Increased math and science requirements would be beneficial but could cost us enrollment.

4. Our curriculum is moving toward an integrative STEM approach for Technology & Engineering education majors.

5. Our curriculum has increased its field experience requirements in the last decade.

6. The loss of our NCATE SPA affiliation has negatively impacted the perception of our program with administration.

7. ITEEA/CTETE should work on developing a revised set of accreditation guidelines to more accurately reflect current trends in the field.

Directions:
Please provide a limited response to the question provided below.

8. Please identify the single greatest factor shaping the nature of your curriculum at present.

Factors Influencing Recruitment of
Future Technology & Engineering Teachers

Directions: Please answer each question by clicking the circle that represents your response to the question.

Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree
1	**2**	**3**	**4**	**5**

1. State & district budgets have negatively impacted recruiting efforts.

2. An increase in basic skills requirements in the public schools has led to less need for teachers of elective subjects.

3. There are more employment opportunities than new graduates.

4. Public education is looked upon positively.

5. Program enrollment is increasing at present.

6. Practicing teachers in our region seem less likely to encourage their students to pursue technology & engineering teaching careers today than in previous decades.

7. High stakes testing has negatively impacted all elective subjects including technology & engineering.

Directions:
Please provide a limited response to the question provided below.

8. Please identify the single greatest challenge for your program at present

Theoretical Underpinnings toward Assessing Science Pedagogical Content Knowledge (PCK) of Technology Educators

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ABSTRACT

This paper presents an analysis of relevant strategies used in science education that may be applicable toward assessing technology educator's science Pedagogical Content Knowledge (PCK). If technology educators are viewed as subject integrators of science, technology, engineering, and mathematics (STEM) (ITEA/ITEEA, 2000/2002/2007, p. 8), they must be properly prepared to teach content and practices from these subject areas. The theoretical underpinnings presented in this paper might be considered in future development of an instrument to assess the level of science PCK of technology educators. Research is needed to fully develop PCK in technology education (de Vries, 2003), specifically in the areas of PCK assessment, methodologies, instruments, and application of data derived from these areas for instructional improvement.

The rationale for studying and improving science PCK of technology educators is linked to improving student achievement as found in research within other school subjects (Hill, Rowan, & Ball, 2005; Johnson, Kahle, & Fargo, 2006; Jones & Moreland, 2005; Kanter & Konstantopoulos, 2010). Future implications will discuss the theoretical underpinnings to consider when designing an instrument to assess science PCK of technology educators. This insight may give direction for preparing 21st century technology educators competent in teaching science concepts.

Keywords: Pedagogical Content Knowledge, Technology Education, Assessment, Instruction

INTRODUCTION

Shulman (1987) suggests distinguishing among the knowledge that grows in the mind of teachers as they develop. This includes: (a) content knowledge, (b) general pedagogical knowledge, (c) curriculum knowledge, (d) pedagogical content knowledge (PCK), (e) knowledge of learners and their characteristics, (f) knowledge of educational contexts, and (g) knowledge of educational ends, purposes, and values and their philosophical and historical grounds. Content knowledge and general pedagogical knowledge are most often associated with PCK, however the other knowledge categories can have a significant impact on teaching. It is important to remember that teaching knowledge extends beyond just pedagogical and content knowledge.

Simply stated, PCK is "the blending of content and pedagogy into an understanding of how particular topics, problems, or issues are organized, represented, and adapted to the diverse interests and abilities of learners, and presented for instruction" (Shulman, 1987, p. 8). Since Shulman proposed these categories, PCK has had a major impact on the educational research community and focused attention on the importance of PCK in teaching (Ball, Thames, & Phelps, 2008). He also did not differentiate between PCK among subject areas, yet conceptual distinction is necessary between them and subject didactics in order to analyze interactions between these areas (Bromme, 1995).

Technology educators are viewed as subject integrators of STEM (ITEA/ITEEA, 2000/2002/2007) and numerous studies have been conducted examining teachers' PCK across STEM school subjects (Rohaan, Taconis, & Jochems, 2011; Thorén, Kellner, Gullberg, & Attorps, 2008; Williams, Eames, Hume, & Lockley, 2012; Williams & Lockley, 2012). Some countries have recently mandated that engineering content be implemented in science curricula. Due to its framework, technology education provides the best opportunity to teach science, engineering, and technology concepts in unison (Wells, 2008). Therefore to do this interdisciplinary teaching, technology educators must be adequately prepared to teach the science concepts naturally embedded within technology and engineering content. The ability for technology educators to teach this content in unison could improve the value of technology education within the K-12 education community. Hence, studying science PCK of technology educators could lead to changes in pre-service and in-service teacher preparation, which could enhance teacher's skills and increase student achievement in science and technology education.

High levels of PCK have been linked to increased student achievement (Hill, Rowan, & Ball, 2005; Johnson, Kahle, & Fargo, 2006; Jones & Moreland, 2005; Kanter & Konstantopoulos, 2010). Research has identified a need to improve teacher quality through developing individual teachers' PCK. Studies conducted by Darling-Hammond (2000, 1998, 1990) did not specifically research PCK, but she found that knowledge of teaching and learning as well as teaching experience had positively impacted student achievement. Her research has also found that science teacher quality makes a difference in student learning and recruitment of future science teachers. Hence, these findings support the importance of researching PCK and using it to improve teacher preparation programs. In this paper PCK is examined through the lens of science education: (a) how it is defined, (b) methods that have been used to assess PCK, (c) obstacles associated with assessing PCK, and (d) why study PCK?

DEFINING PCK ACROSS SCIENCE AND TECHNOLOGY EDUCATION

Looking across science and technology education and recognizing similarities in their definition of PCK is a good starting point. PCK is often interpreted in different ways to suit the context of the research (Rohaan et al., 2011). Defining PCK in technology education is difficult because the field lacks a structured epistemology (Williams & Lockley, 2012). The content and pedagogy of technology education varies internationally. The inability to reach consensus in identifying the specific content that comprises technology education has hindered the ability to define PCK within the subject area.

Despite differences in content there are common threads between the definitions of PCK used within science and technology education. Shulman's definition remains the crux of defining PCK. For each subject area PCK is the ability to transfer content knowledge from teacher to student, which is obtained over time through teaching experience. Definitions from both the science and technology education subject areas recognize that PCK requires ample content knowledge to increase student learning, and that PCK and content knowledge are two distinct skills. This supports Shulman's claim that PCK is topic specific.

METHODS TO ASSESS PCK

Science education has conducted the most research on PCK, while less research has examined PCK in technology education. Qualitative methods have been utilized in both science education (Bertram & Loughran, 2012) and technology education (Jones & Moreland, 2004; Phillips, De Miranda, & Shin, 2009) to assess PCK. Qualitative studies have used various methods to analyze a teacher's PCK, including interviews, field notes, curriculum content, ethnographic data, journals, lesson plans, video recordings, student portfolios, and case studies. Quantitative methods have also been used in science (Halim, Meerah, Zakaria, Abdullah, & Tambychick, 2012) and technology education (Rohaan et al., 2011). These studies have utilized either a multiple-choice question format or a 5-point Likert scale format to assess a teacher's PCK.

Building upon the shortcomings of using only qualitative or quantitative methodologies, some studies have used a mixed methods approach to assess PCK. In science education, Mayhunga and Rollnick (in press) utilized multiple-choice questions followed by a supplemental open-ended question to explain the rationale for each answer selection. Other studies specifically used the Content Representations (CoRes) and Pedagogical and Professional-experience Repertoires (PaP-eRs) instruments (Hume & Berry, 2011; Williams & Lockley, 2012) developed by Loughran, Berry, and Mulhall (2006). The CoRes and PaP-eRs instruments help to differentiate and show links between content knowledge and pedagogical knowledge of a specific topic. Specifically, the CoRes instrument provides a synopsis of how the content of a particular subject or topic is conceptualized by teachers. The PaP-eRs instrument assists in unpacking the teacher's reasoning around an element of PCK for a specific topic.

OBSTACLES IN ASSESSING PCK

Abell (2008) posed two challenges for PCK researchers to address: (a) the correlation between PCK and student learning, and (b) shifting from small descriptive studies to larger explanative studies. Most PCK research conducted up to this point has been qualitative in nature. Qualitative studies have added rich descriptive details to the minimal knowledge we have about science and technology education PCK. However, qualitative studies had trouble gaining access to classroom teachers and observing teaching behavior in an environment that is not altered by the researcher's presence. In addition, observing the same lesson from the same content was difficult with various curriculums within each content area. Many details of assessing PCK remain unknown, especially when applied to the larger population. Multiple-choice and Likert scale instruments present the potential to assess the PCK of larger samples but also have drawbacks. When using a multiple-choice methodology, researchers (Carlson, 1990; Renfrow, 1991; Rohaan et al., 2011) found it difficult to write effective items with substantial distracter answer choices to assess PCK. Quantitative methods also had trouble accessing large sample sizes and could not provide the depth nor detail that some qualitative methods provided. One solution to address the lack of detail about teachers' thought processes not seen in multiple-choice assessments is to implement a speak-aloud approach. This would give researchers a better understanding of what teachers are thinking when they make certain decisions.

One of the struggles that technology education has had with assessing PCK is defining the content of technology education. Not only does it vary from country to country, but even region to region within countries. Technology education is also a very broad subject with many topics it teaches. Therefore, many of the PCK studies had to be conducted as topic specific PCK. Choosing which topic to examine PCK within technology education could also be an obstacle.

SUMMARY

Despite differences in how PCK is defined among science and technology education and how it has evolved, Shulman's definition is recognized as the baseline description of PCK. From previous methods used to examine PCK, it is clear that each subject area has a unique content specific PCK that cannot be generalized to the larger population or other content areas. An obstacle that all studies faced was finding the most appropriate method(s) to assess PCK. Many methods were used, both quantitative and qualitative, and each had their own strengths and limitations. For quantitative instruments they had difficulty creating robust instrument items, but these could assess more participants than assessed in qualitative studies. Qualitative studies were often time consuming and had difficulty accessing teachers within a real classroom environment. Small sample sizes made the qualitative studies very limited. However, qualitative research did provide an in depth analysis of teachers pedagogical performance and create the framework for future studies.

Enhancing technology educators' science PCK may significantly affect the level of student achievement (Johnson et al., 2007). Since its inception, knowledge from various research methods has been gained regarding PCK. Despite those efforts, there are still gaps in the knowledge about the development of technology educators' science PCK and it remains a topic requiring further research.

Conversely, science educators' technology PCK is an area that also requires further research. In 1995, Israel established the Science and Technology Administration to teach science and technology education in unison, in order to prepare students for industry and research. Later in 2006, the Dutch government called for the integration of science and technology as a combined subject, housed under the "personal and world orientation" learning domain within their national standards. Their country's seven standards require primary level educators to teach both science and technology education concepts despite little preparation in technology education (Rohaan, 2009). Most recently, the United States of America has called for the teaching of engineering practices and content within the Next Generation Science Standards. As science and technology education continue to converge, science educators' ability to teach technology and engineering practices and concepts must be examined to promote collaboration among STEM education teacher preparation programs.

IMPLICATIONS

Implications for studying science PCK of technology educators is critical for showing the value of technology education within K-12 curricula. Studies by Darling-Hammond (2000, 1998, 1990) have proven the impact that teacher quality has on student achievement. Being able to assess science PCK of technology educators can help show the importance of technology education delivering an integrative curricula. Research in this area can also improve the preparation of future technology educators to be adequately prepared to deliver science content. Integrative teaching and learning across science and technology education is beneficial to student learning. Being able to assess science PCK of technology educators may enhance the quality of education that students receive due to increased integration and the opportunity for students to make connections.

Many researchers have initially used a qualitative approach to assess PCK and contribute to the limited knowledge base about assessing PCK. Problems with a qualitative methodology are that it is time consuming, has a low number of participants, and is difficult to compare methods across studies. In addition, the qualitative methodology of interviewing does not entirely reveal all reasons for teaching behavior (Rohaan et al., 2011). A quantitative approach demands less involvement from the teacher, is time and labor efficient, can be measured objectively, and is able to assess large sample sizes which Abell (2008) identified as a gap in the research (Rohaan et al., 2011). Multiple-choice methodology may serve as a good predictor for behavioral aspects of PCK (Rohaan et al., 2011), and two previous efforts (Carlson, 1990; Kromrey & Renfrow, 1991) provided hopeful outlooks for multiple-choice PCK tests.

Implications of this analysis are to provide the rationale and methodology to create an instrument that can assess science PCK of technology educators in large sample sizes. The Delphi technique could be used to construct an instrument that assesses science PCK of technology educators. Although the Delphi technique is often criticized, it is accepted as a serious research design (Ritz & Martin, 2012; Rossouw, Hacker, & de Vries, 2011). Attempting to assess the science PCK that technology educators possess has many drawbacks since PCK has yet to be effectively assessed within science and technology education. If possible, defining technology education PCK through expert consensus will contribute a foundation for future PCK studies in technology education. This will allow technology education to adapt their teacher preparation programs to provide better prepared teachers and enhance students' STEM learning.

In future research, the following steps are suggested to address the shortcomings of assessing science PCK of technology educators. A panel of experts (researchers, teachers, supervisors, preservice teacher instructors) should be chosen based upon their educational background and experience (Rohaan et al., 2011). They should come to consensus through the Delphi technique (Hacker et al., 2009; Ritz & Martin, 2012) on: (a) a definition of technology education PCK, (b) what science content is foundational to most technology education curricula, and (c) the creation of valid questions assessing science PCK of technology educators. The instrument should be pilot tested and revised based on feedback (Rohaan et al., 2011). Then the instrument should be administered to a larger population and tested for reliability. Per the recommendation of Williams and Lockley (2012), electronic means to facilitate this instrument (i.e., online survey software) could be used to administer it to a large sample size internationally, as well as provide quick data collection for statistical analysis. Creating such an instrument that could successfully measure the science PCK of technology educators may help to inform pre-service teacher program curricula along with in-service professional development to enhance teachers' skills and consequently increase students' achievement.

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The Influence of Life Histories on Shaping the Professional Identity of Beginning Design and Technology Teachers

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ABSTRACT
While literature on teaching emphasises the importance of identity in teacher development, understanding identity can be a complex and challenging endeavour. This paper focuses on one aspect of teacher identity development, the interplay between life histories and the professional demands of the educational contexts in which beginning teachers commence teaching. In examining the development of professional identity for beginning Design and Technology teachers who are "career switchers" (Richardson & Watt, 2006) this paper argues that life histories, and more specifically work histories, can have a positive impact in shaping professional identity because it can lead to an accelerated validation within a community of practice (Wenger, 1998). As a consequence of this validation beginning teachers can be provided with a sense of belonging and professional location (Weeks, 1990) and in doing so are able to overcome the tensions that are generally associated with beginning to teach. Implications for teacher education programs are also identified.

Keywords: Life Histories, Professional Identity, Beginning teachers.

INTRODUCTION
Beginning teachers move through a number of distinct phases as they shape an identity that is acceptable to students, colleagues and the wider school community; that is, as they craft their public identity (Veenman 1984; Furlong & Maynard 1995; Tickle 2000; Feiman-Nemser 2001; Fetherston 2006; Flores & Day 2006). Words such as, transition shock (Veenman 1984); idealism, survival, (Fetherston 2006); tension, anxiety and uncertainty (Flores & Day 2006) are used by the researchers to capture the emotions of beginning teachers as they move through these phases. The first year of teaching is predominantly characterised in the literature as a novice stage with Pietsch and Williamson (2010) stating that opportunities to exercise independence in shaping and maintaining a sense of personal and professional identity appears to be overwhelmed by the need to: navigate the somewhat rough waters and dangerous shoals of beginning to teach (Pietsch &Williamson 2010, p. 331).

Pillen, Biejaard and den Brok (2012, p.2) suggest that: [m]any of the influences in this process [of beginning to teach] may be experienced as conflicting and, at least to some extent, cause or lead to professional identity tensions. In their research into the possible tensions in beginning teachers' professional identity development, Pillen et al. identified thirteen tensions and for the context of this paper the following are highlighted:

1. Feeling incompetent in terms of subject content knowledge versus being expected to be an expert.
2. Experiencing conflicts between one's own and others' orientations regarding learning to teach.
3. Being exposed to contradictory institutional attitudes.

Pillen, Biejaard and den Brok (2012, p.1) argue further that: professional identity tensions stem from an unbalanced personal and professional side of becoming a teacher. That is, beginning teachers may have personal and professional beliefs and aspirations but in reality these may be difficult to put into practice thus causing conflict and tension. It has been argued (Alsup 2006; Olsen 2010) that developing a professional identity is very important to becoming a successful teacher. In developing a professional identity beginning teachers need to be able to incorporate their personal beliefs into the professional expectations of what it means to be a teacher. Coldron and Smith (1999, p. 719) argue further that every aspect of teachers' work has a personal dimension, imbued with feelings and understandings that: 'create patterns of personal meaning' that enable teachers to find their voice and create their own sense of professional identity.

In this paper professional identity development is seen as a process of integrating personal and professional life histories, that have shaped the knowledge, beliefs, attitudes, skills that beginning teachers bring to teaching with the professional demands of the educational contexts in which they commence their profession.

THE PLACE OF PERSONAL LIFE HISTORIES IN SHAPING PROFESSIONAL IDENTITY

When pre-service teachers commence their university study, they bring with them varied narratives about who they believe they will become as teachers (Lortie, 1975; Smith, 2007; Groundwater-Smith, Mitchell, & Mockler, 2007). Unlike other professions, it can be argued that pre-service teachers have a strong sense of what the role of a teacher entails through their own experiences as a student. Cohen-Scali (2003) argues that by the time pre-service teachers commence their study, many have developed a cognitive map of what they think it means to be a teacher. The narratives of professional identity that pre-service teachers hold have been shaped by a range of social, political, and educational constructs that reflect influences of the past, the present, and perhaps a vision for the future (Flores & Day, 2006).

Sixty per cent of the pre-service teachers who commenced study in the Design and Technology undergraduate teacher education program in the year in which this study was situated were mature age or "career switchers" (Richardson & Watt, 2006). The narratives of professional identity that theses pre-service teachers brought to their study were diverse. Design and technology teacher education programs attract a high percentage of applicants who have trade or industry background from a field that is directly related to the subject content knowledge they will be teaching. This paper aims to identify the place that personal life histories, and more specifically work histories had in enabling theses beginning teachers to address the tensions associated with beginning to teach as well as supporting their professional identity development.

THE STUDY

The nature of the study was interpretive, in that it was characterised by a concern for the individual and the schools in which the beginning Design and Technology teachers who were career switchers commenced their first year of teaching. The paradigms (Lincoln & Guba, 2000), worldviews (Creswell, 2007) or the beliefs that guided the research were based on the notion of social constructivism (Lincoln & Guba, 2000; Schwandt, 2007). The beginning teachers were viewed as seeking to understand the world in which they worked and the individually constructed meanings which they made were seen as being subjective. That is, they were related to individual experiences in a particular context and formed through a process of interaction with others.

The research was conducted in the school settings in which the pre-service teachers commenced teaching. The group consisted of one female and seven males. All participants had completed a four year undergraduate Design and Technology teacher education program. The secondary schools in which they commenced teaching represented a cross section of educational systems located in both metropolitan and country settings.

Data were collected via three semi-structured interviews and reflective e- journal entries over a one year period. The type of data analysis adopted for this study was narrative analysis (Yin, 2003). As a distinct form of qualitative research, narrative analysis focuses on the study of the individual or a small group of participants. Data are gathered through the collection of stories that reflect the individual's experiences and data are analysed through the re-telling or re-storying of participants' stories, that is, the narratives of participants are re-told by the researcher. Described as a unique qualitative analytic procedure used only in narrative research (Creswell 2002, p. 52), this analysis through re-told narrative provided the researcher with a deeper insight into the experiences of the individual.

What follows is an analysis of the place of life histories, and more specifically, work histories had on supporting this group of beginning teachers in overcoming the identified tensions associated with beginning to teach.

FINDINGS AND DISCUSSION

In contrast to Pillen et al's research the study on which this paper is based revealed that the identified tensions of; incompetence in terms of subject content knowledge; conflicting orientations in regards to learning to teach; and, contradictory institutional attitudes did not appear to eventuate for the beginning teachers. Findings from this study revealed that where life histories formed a set of values, skills and knowledge that were compatible with existing practices the identified tensions associated with beginning to teach were lessened.

The beginning teachers were able to draw on their life experiences and on the knowledge developed through their technical and trade' background to inform their teaching role once they commenced teaching. For example, Neil, a tool maker, and Peter, a builder, both agreed that their work skills had influenced not only their decision to commence teaching in the field, but also their professional identity. They both suggested that their past trade experiences had provided them with a level of confidence in their teaching ability. They felt they already had some of the specific practical content knowledge needed for teaching.

Cathy, a textile designer, commented that her personal and professional identity was shaped by her understanding of the subject-specific knowledge and the technical skills she believed enabled her to be successful as a beginning teacher: "I see myself as someone who has in-depth subject knowledge and the skills to be able to impart these into the classroom in a professional manner. I like to work with fabrics; it is what I do". As a mechanic, Aaron identified his previous employment and life experiences as having provided him with the ability to manage time and interact with others, and with some of the technical skills on which he could draw when teaching.

This study provided evidence that the subject content knowledge developed from past personal histories provided a knowledge base from which beginning teachers drew. In fact, it provided beginning teachers with a sense of continuity, that is, an aspect of self (or identity) that remained the same over time (Erikson, 1989), and a sense of connectivity with who one is as a person. As a consequence, the beginning teachers demonstrated a heightened level of competence and confidence as they commenced their first year of teaching.

Beginning teachers with prior subject content knowledge also felt that the expectations of their teaching colleagues, and the students they taught, in regard to their technical ability, could be met. This provided them with an opportunity to redirect their professional focus of learning to areas that were new or more challenging, for example, issues of classroom management, extra curriculum activities such as Pedal Prix, or teaching in another subject.

In this study the connections between the past and the immediate created a degree of continuity within what Wenger terms: the nexus of membership (1998, p. 160). When participants in the study commenced teaching the level of their content knowledge, including technical skills and their understanding of safe work practices was immediately acknowledged and validated by colleagues and students. Any disconnect between the expectations of more experienced colleagues and the beginning teachers themselves appeared to be minimal. As evidenced by Jason when he stated that:

'While the first few weeks of teaching were really hectic, staff and students soon realised I had the knowledge and skills to do the job'.

This finding is in direct contrast to the research findings of Flores and Day (2006), and Pillen et. al. (2010) who found that many beginning teachers are confronted with negative school contexts and cultures that work to destabilise and challenge professional knowledge and positive concepts of identity.

This paper draws on the work of Wenger (1998) and his examination of communities of practice to emphasise the close connection between participants' professional identity formation, the relational nature of identity, acceptance by colleagues and the development of supportive professional relationships. Wenger (1998) defined identity formation as a dual process involving both identification and negotiability within a community of practice. The findings of the study concurred with Wenger's view in that it was through identification that beginning teachers were able to create connections with colleagues in schools and, in so doing, they became both identified with the school community and identified as being someone who was accepted within that community.

The study also found that although participants' commenced teaching with aspects of subject specific content knowledge they did not believe that this knowledge was static. All participants stated that ever-increasing changes in technology made specific identification of subject content knowledge complex and dynamic. For example, Simon, who studied a Design and Technology major and Maths minor, stated that:

'I think one of the things that defines us (as Design and Technology teachers) is the range of topics that are now classed under the Design and Technology banner. I am not clear what other subjects have to do in regards to curriculum but we have to learn new things every day to keep up with our subject. I know Maths changes but it is essentially the same mathematical processes. We have got to understand things like advanced manufacturing, electronics and new ICT technologies. What we have to teach is continuing to get bigger and bigger and more complex'.

James elaborated further:
'What we teach includes developing an understanding of technology: we are still required to teach design and technical skills but we need to bring relevant and authentic curriculum and learning into the school environment. What we teach and how we teach it continues to change'.

A significant finding in this study was that commencing teaching with a relevant subject knowledge base did not appear to present a barrier to professional change. However, the timing of the opportunity to teach in ways that participants wanted to teach; that is, to be the teacher they wanted to be appeared to follow a relatively brief period of 'proving oneself' to, or aligning with the practice of colleagues.

However, after six months of teaching all participants demonstrated a capacity to exercise independence and to initiate change. In fact, participants appeared to be encouraged to introduce new subject content knowledge into the learning area and in some instances to adopt innovative pedagogical approaches. For example Peter stated:

'I am lucky enough to have a coordinator who is very progressive. He wants to get away from 'build me a wooden box' and wants to get into [the] true design and technology way of going about it, for instance, talking with the students about their ideas and their solutions to problems. This is the way that I like to work. I know they (the staff in the D&T faculty) are getting to a point where my learning and my experience are recognised as being valuable to the school because I have been trained that way at uni and that is the way they want to go. I feel quite comfortable with this. So, yes, I can be the teacher I want to be to some extent and I know it will be even more so in the future as the school continues to change the way in which in teaches D&T'.

The findings of this study concur with the views of Renzaglia, Hutchinson and Lee (1997) who state that beginning teachers who have an established core of beliefs and practices are more likely to experience not only satisfaction in their roles as teachers but to act as change agents in their classrooms and schools. Renzaglia et al. (1997) argued further that personal beliefs, knowledge and understandings can serve as filters for new information and experiences that confront beginning teachers.

IMPLICATIONS FOR TEACHER EDUCATION PROGRAMS

The implications of this study suggest that teacher education programs need to simultaneously acknowledge and broaden the subject content knowledge base that career switchers bring to their teacher education program. In building the nexus between prior and new knowledge teacher education programs can also provide the opportunity to introduce innovative pedagogy and in doing so enable beginning teachers to initiate change and enable the field of Design and Technology education to continue to move forward.

CONCLUSION

The study on which this paper is based revealed that personal and professional histories are strong mediating factors in shaping the professional identity of beginning design and technology teachers. This paper examined just one aspect professional history, that of work histories. Through drawing on this aspect of their professional histories, beginning teachers who were career switchers felt they already possessed some aspects of professional knowledge needed for teaching and, as a consequence, appeared to commence teaching with a heightened level of confidence in their teaching ability. The technical skills, subject content knowledge, beliefs, and values that these beginning teachers had previously developed provided them with a sense of identity stability as they transitioned into teaching. This stability was further reinforced through the positive acknowledgment and acceptance of their skills and dispositions from teaching colleagues and school students.

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Enhancing Pedagogy Using Web-based Resources in Technology Education

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ABSTRACT

Technology education has unique resourcing needs, some of which can be conveniently and often more effectively met by web-based resources (WBRs) than by paper-based resources or even direct contact with communities of practice. However, despite the acknowledged potential of the Internet to transform education, and increasing access to, and use of, WBRs in schools, teachers are not necessarily well prepared to integrate them effectively into their pedagogy. This is not surprising given the range of specialised skills and knowledge that effective integration requires – what Koehler and Mishra (2009) have called technology, pedagogy, and content knowledge (TPACK). This paper reports on a small research project in which six experienced secondary technology teachers participated in a sustained professional development programme aimed at enhancing the ways in which they integrated WBRs into their technology programmes. The focus of this paper is on the teachers' perspectives of how integrating WBRs enhanced their pedagogy and subsequent student learning. Findings suggest that WBRs have potential to both support and encourage more flexible, interactive and student-centred teaching approaches. Furthermore, it appears that WBRs enabled the teachers to more effectively integrate technological knowledge and nature of technology components into their teaching in a relevant, timely and seamless way.

Keywords: Web-based resources, technology education, professional development, pedagogy, technological pedagogical content knowledge

INTRODUCTION

Technology education has complex resourcing needs, in part because it is a relatively new curriculum area, still cementing itself as a clearly defined discipline with its own subculture internationally and in New Zealand schools. In addition to being a new area, the broad, interdisciplinary and rapidly changing nature of the subject presents a considerable challenge to teachers in providing for the breadth of knowledge students need access to in their technological practice, as well as for expanding their own knowledge as teachers. The Internet – a rapidly expanding, rich repository of multi-modal resources – has the potential to effectively and conveniently meet many of the resourcing needs of technology education. For instance, rapid and flexible access to web-based resources (WBRs) meets the need for 'just in time' access to information to support the diverse knowledge needs of students undertaking technological practice, which often cannot be predicted. Further, the need for technology students to work within relevant and authentic contexts demands currency of information – needs that can often be more conveniently met by WBRs than by traditional means.

Although access to and use of ICTs in schools is increasing, teachers are not necessarily well prepared to integrate them effectively with other classroom resources and in reality their predominant use often focuses on technocentric and teacher-directed applications such as PowerPoint and learner-friendly websites rather than more student-centred approaches (e.g., Harris, Mishra, & Koehler, 2009; Ho & Albion, 2010). Technocentric approaches focus on competencies for using ICT, rather than opportunities for rethinking learning and education in the particular subject (Papert, 1990). This resonates with Hughes' (2005) suggestion that approaches to ICT integration can be grouped into three categories: (a) replacement of previous resources, for example, textbooks, (b) amplification of previous tasks, for example, enhancing presentations or completing tasks quicker, and (c) transformation of teaching and learning. The first two categories, which often tend to predominate in teaching, reflect technocentric approaches and result in little change in teaching and learning. It is the third category, transformative use, that reflects the vision of many educational leaders. It is no longer a question of whether teachers should integrate ICT but how to use it to transform teaching and learning (e.g., Angeli & Valanides, 2009). Simply making computers and the Internet available in classrooms does not change teaching and learning. Knowledge of how to use these resources effectively to enhance learning in particular subject areas is needed for transformative use.

TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE

ICTs are just one component of the classroom environment and how effective they are in enhancing student engagement and learning depends very much on the teacher's knowledge of how best to integrate them with all the other variables in the classroom setting (Kennewell, 2001). The concept of Technological Pedagogical Content Knowledge (TPACK) (Koehler & Mishra, 2008, 2009; Mishra & Koehler, 2006) offers a useful framework for understanding the broad and complex knowledge base required by teachers to integrate WBRs effectively into their teaching.

TPACK expands on Shulman's (1987) PCK construct to incorporate a third core knowledge component – Technology knowledge (T). 'T' knowledge in this construct refers to knowledge of ICTs and their use, and is distinct from technology education as a school subject. Mishra and Koehler argue, for example, that the rapid expansion of digital technologies demands knowledge beyond what is defined in Shulman's construct. Adding 'T' knowledge to the construct introduces three new intersecting areas of teacher knowledge to PCK: *technological content knowledge* (TCK), *technological pedagogical knowledge* (TPK) and *technological pedagogical content knowledge* (TPACK). As with PCK, the TPACK framework recognises the unique and integrated nature of content and pedagogical knowledge in different subject areas as well as the interdependence of each of the TPACK knowledge components. In addition, TPACK acknowledges the critical influence of the individual classroom and school context on teacher actions (Harris et al., 2009).

Viewing the knowledge requirements of effective technology integration through a TPACK lens shifts the emphasis away from technocentric approaches focusing on mastery of specific technology tools devoid of subject and curriculum application, highlighting instead the need for teachers to develop a nuanced understanding of the three sources of knowledge (technology, content and pedagogy) and their complex interrelationship (Mishra & Koehler, 2006).

RESEARCH DESIGN

This research set out to investigate how teachers could be supported to enhance their integration of WBRs in the classroom. The study involved the design and implementation of a sustained intervention programme that spanned one school year. The intervention included an initial one-day teacher professional development workshop in which key ideas from literature on integrating ICT including TPACK, were introduced; the participants' shared their current use of WBRs and analysed this with reference to TPACK, and ways of enhancing the use of WBRs in technology education were explored. On return to their individual schools the teachers planned a new unit of work, or modified an existing one, with a focus on integrating relevant WBRs into their pedagogy to enhance student learning of key ideas in technology education. They implemented the unit of work in their own classrooms and the impact of the WBRs and pedagogical strategies were explored and evaluated through individual interviews with the participants. The intervention programme concluded with a second group workshop in which participants shared and evaluated their experiences using WBRs, how these had impacted on their beliefs about the value of using WBRs and the likely long-term impact on their future practice.

Six experienced secondary technology teachers from three different schools participated in the study. The teachers were from a range of backgrounds, worked in different educational settings, and taught in a range of technological areas, including food, textiles, and structural technology. The study employed an interpretive methodology and a case study approach. Data were generated through three sets of individual interviews at the beginning, middle, and end of the intervention programme, group discussion at workshops, classroom observation, and document analysis.

FINDINGS

Initial findings suggest that when WBRs are integrated in the technology classroom in a planned and sustained way, they have the potential to support and enable change in teacher pedagogy from predominantly teacher-directed to more interactive and student-centred approaches. Changes in teacher beliefs about the value of WBRs for learning, and an increase in teacher confidence using computers and WBRs in the classroom, were also evident.

More student-centred teaching approaches

Teachers reported that using WBRs in the classroom enabled them to step back from a "sage on the stage" approach and take on more of a facilitator role in guiding student learning and fostering student independence. For example, they found they could more readily interact one-on-one with students, which improved teacher-student relationships and allowed them to provide more targeted support. They also no longer felt the need to know and provide all the content and answers for students:

> [Before] they would have been bored out of their tree and it would have been short, sharp and teacher-directed. Now they're asking the questions, not me. I'm doing much more feed forward and encouraging them to do the thinking. So I'm really a support person rather than a teacher. (Margaret)*
> [*pseudonyms are used throughout this paper]

Teachers found that the variety, breadth and depth of WBRs facilitated deeper learning and, together with the speed and flexibility of access, made it easier for them to differentiate and vary the pace of learning for individual students. Hence they were better able to support the range of abilities and student learning needs within one class.

> They bought into it much quicker and they certainly moved up the learning scale and the gifted and talented kids could really then excel … whereas the kids that struggled they reached the end. Whereas when you do teacher directed you either lose one group or you've got to find something else for the other group to do while you spend time with them. (Margaret)

WBRs added another dimension to the classroom that teachers could integrate with other resources and features of the classroom environment to facilitate student learning in a more dynamic and interactive way. As Margaret commented: "It just gave a new dynamic to the learning … it's added variety and I've become enthusiastic and so they're getting a motivated teacher and a variety of teaching styles".

Teachers found they were able to be more flexible and interactive in the classroom. Once they started sourcing and planning ways to use particular WBRs in one unit of work, they found they were able to draw on this knowledge and experience in a range of situations in other classes as well. In particular, they found YouTube clips enabled them to enrich and add relevance to student learning by tapping into other people's knowledge and experience. This could be pre-planned and proactive, or in response to a need or opportunity that presented itself during class. For example, one teacher was able to respond spontaneously to a student's question raised during discussion about veneer to more effectively enhance understanding. He had previously downloaded a YouTube clip for another class, but used it to respond spontaneously to the student inquiry in a more meaningful and memorable way:

> It might have been for a unit on furniture veneering … but I can always locate it and bang it on for them and make it light-hearted and justify their enquiry … and it's great and the response is really good. (Malcolm)

Increase in teacher confidence

The teachers developed greater confidence in their ability to support students using WBRs. They became more aware of the need for teacher intervention to scaffold student learning with WBRs and developed a better understanding of ways they could provide effective support. The teachers became more proactive in providing support for learning by thinking about pedagogical strategies when they were planning rather than leaving it to chance:

> Whereas before I used to say go onto the Web and see what you can find out and then answer these questions. Well now I'm directing them more … and helping them with their research I suppose. I've learnt to have a look and give certain questions and certain sites that I find best for them so you haven't got those kids that struggle. (Margaret)

The teachers found that ready access to a broad range of examples of products, processes and materials, in particular current examples, helped students to see the relevance of what they were learning. This enabled teachers to more readily engage students in authentic and meaningful discussion, challenge student thinking and encourage more critical thinking:

> It's showing that technology doesn't just happen in this classroom like it's really important for them to see that it happens in real life. And to be able to bring that outside in to the classroom certainly helps raise awareness and starts to generate discussion as well and starts getting them thinking. (Carol)

Teachers could quickly and easily integrate a broader range of learning experiences using WBRs to supplement and extend their own skills and knowledge in the classroom where relevant and appropriate. Learning directly from professionals through WBRs gave students and teachers access to a wide range of expertise as well as insight into and comparison with industry practice. The teachers felt more confident in the reliability of the knowledge and skills they were teaching and they were able to expand their own and their students' knowledge at the same time.

> There's a sense of, this is the information I am providing you – my experiences with this particular product or process…let's have a look at how people in industry can utilise it as well. And then they can see … professionals using it. It's made me more confident with the material I'm using because I can back it up. And I'm using the information that I've learnt from that in the workshop anyway through discussion. (Malcolm)

In addition, WBRs better enabled the teachers to intervene in practical classes in a convenient, efficient and seamless way to integrate conceptual and procedural knowledge and scaffold student learning as and when needed by individual students, small groups or a whole class.

> I think … they get tired of you wasting their time because they could be making. And oh here we go again – we're going to have this demonstration and … it would be difficult to show some particular processes and because it's reliable and it's quicker for me as well …. I can get more information out there to the students and it's a media that they're in tune with … And it's … convenient. And I suppose it's that third person in the workshop. (Malcolm)

Teachers were also able to use WBRs to provide access to demonstrations that they may not have specialist materials, equipment, or even expertise to do otherwise.

DISCUSSION AND CONCLUSION

When these teachers implemented changes and experienced positive outcomes they became more confident with using WBRs in their classrooms and were empowered to integrate them more widely. More regular use appeared to change the dynamics of the classroom, fostering more student-centred pedagogies. This represented a breakthrough point where the teachers began to "consciously and unconsciously find ways to orchestrate and coordinate technology, pedagogy, and content" (Mishra & Koehler, 2009, p. 17) in their day-to-day teaching, reflecting their development of TPACK.

These teachers had moved, in varying degrees, along a continuum from *familiarisation* and *utilisation* of WBRs to *integration* and *reorientation* (Hooper & Rieber, 1995). Hooper and

Rieber describe *integration* as the point at which the teacher begins to designate tasks to the technology and it is no longer expendable. *Reorientation* represents transformation from a teacher-centred to a student-centred philosophy, and a point where teachers shift from feeling the technology has to be mastered beforehand and integrated in a controlled way, to encouraging and expecting students to use it in ways that may not be anticipated.

For the teachers in this study, the design and support of the professional development programme were pivotal in providing the initial impetus for change. However, when they reached a breakthrough point in their thinking about WBRs, they were empowered to continue their own learning and also to take a proactive stance within the school hierarchy to improve their future classroom access to WBRs.

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An Instrument Developed through Action Research study: An Alternative Way to Sustain Technology Education Teaching

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ABSTRACT

The aim of this paper is to share a fresh perspective on the challenges facing technology education in Africa today, as well as developed skills and intervention strategies necessary to overcome these challenges. During interaction with technology education teachers through action research intervention strategies of observing, planning, acting and reflecting; an instrument was developed. This instrument is: the six (6) weeks programme to empower under qualified technology teachers from the challenges they faced in their technology education pedagogy and didactics. An instrument was developed as a way to respond to the following research question, 'What are alternative ways to empower technology teachers whom subject knowledge is well below what it should be so as to sustain the teaching of technology? The extend of South African's under qualified senior phase technology teachers has intensified and reinforced that action research (AR) be regarded as a tool for capacity building and professional development in the teaching of technology as apparent from this study. In this paper the findings from the action research activities that took place in selected schools of Limpopo Province will be reported. The following tools were used as a means to gather data: interviews, field notes, and logs of meetings. Many educational changes have taken place in SA for the last 18 years. These changes drastically affected technology education as one of the subject in the curriculum and teachers coping demand on both the subject content and pedagogy. The research was designed from cooperative or collaborative enquiry theory. The paper intends to share an instrument developed during action research interaction with the technology teachers. If this instrument can be well implemented and followed then technology teachers will be equipped to teach technology with confidence and every chance of success. If the participants can as well establish their own technology education cluster committee within their districts or circuits or regions then technology education teaching will be sustainable for a longer time to come.

Keywords: under qualified technology teachers; cooperative or collaborative enquiry theory; technology education pedagogy and didactics

INTRODUCTION

The failure to address the crucial issues of sustainable production and consumption processes, life cycle analysis and design for environment principles within design and technology curricula are symptomatic examples of a benign neglect to address wider environmental concerns from within design and technology education (Elshof, 2005). Sustaining the future of design and technology curricula will be incumbent on technology education teachers. Technology

Education (TE) gives learners the opportunity to develop and apply specific skills to solve technological problems (Department of Basic Education [DBE]/CAPS, 2010) so as to advance a play on TE sustainability. It will be a challenge for TE teachers who are under qualified to cope with the demand on both the subject content and pedagogy. In this study I sought to engage these under qualified TE teachers with an action research. Action Research (AR) is the systematic study of attempts to improve educational practice by groups of participants by means of their own practical actions and by means of their own reflection upon the effects of those actions (Ebbutt, 1985). Travelling with TE teachers through cyclical and spiral activities of AR was taking heed of the call from the United Nations Member State in Brazil. The Heads of State and Government and high level representatives met at Rio de Janeiro, Brazil from 20 to 22 June 2012 as they aim at renewing their commitment to sustainable development and ensuring the promotion of economically, socially, technologically and environmentally sustainable future for our planet and for present and future generations.

Nhamo's inaugural lecture (2013) outlined the fact that the "Rio+20 United Nations Conference on Sustainable Development "has clearly set the ground rules for all countries to adhere to on principles of sustainable development, poverty eradication, job creation and equity. At the centre of those challenges looms the ever present of curriculum review, reform and transformation so as prepares learners' towards technological literacy (Department of Basic education [DBE]/CAPS, 2010). TE as a subject across African countries can serve as key part of improving both human resource development and sustainable development, if technology teachers can understand the concepts and knowledge used in TE and use them responsibly and purposefully. Technology as a general school subject has taken root in developed countries because many scholars say that it's not enough for the youth to acquire knowledge only instead the youth must be able to act effectively and respond appropriately to the outcome of their education. The Member States (2012) further declare that, "While we acknowledge that some progress has been made towards the fulfilment of international related to Africa's development needs, we emphasize that significant challenges remains in achieving sustainable development on the continent". TE has the possibility to offer a multitude of benefits for the continents from improving education and knowledge sharing, to increase exposure for African innovation to improving the living conditions of the continents' residents. Technology or TE deals with human activities that bring about change and sustainability to enhance the environment, create wealth, produce food and entertainment, and generally get things done. This is in line with the aim of TE which is to produce engineers, technicians and artisans needed in modern society, and the need to develop a technologically literate population for the modern world (Department of Basic Education, 2011).

All these listed technology benefits can be enjoyed by the continents residents provided that those directly involved support each other and work collectively and collaboratively. Technology teachers can be very handy, critical and crucial in sustaining the teaching of this technology The challenge is that technology subject was introduced in the school curriculum both nationally and internationally very late (Mapotse, 2012). Most of the teachers in the education system did not know the how of teaching the subject since when they were training as teachers it was not there yet (Potgieter, 2004). Hence I address these type of teachers as under qualified (possessing a teaching qualification but none covers TE). An Action research study was conducted in Limpopo Province of South Africa with selected schools to empower the two identified groups of teachers above. In engaging the TE teachers with Action research (AR) intervention strategies of observing, planning, acting and reflecting the two instruments were developed. This paper intends to share light on how the two frameworks or instruments or tools or guidelines were developed. These instruments can be used to empower both the un- and under- qualified technology teachers or teachers in other subjects. The Department of Basic Education (DBE) is aware of this need mentioned above professionally developing technology teachers within their employees as highlighted in its strategic objectives.

The DBE in its Strategic Objective 3: New integrated plan for teacher development (Motshekga, 2010), avers that, there is a wide agreement amongst education stakeholders that subject knowledge amongst teachers is often well below what it should be and technology is not immune in this regard. South Africa falls within the developing countries and it has introduced Technology Education (TE) in its curriculum. TE has the possibility to offer a multitude of benefits for the continents from improving education and knowledge sharing, to increase exposure for African innovation to improving the living conditions of the continents' residents. TE is fairly new in school curriculum both nationally and internationally (Mapotse, 2013) therefore teachers need to have basic knowledge of few subjects to be competent to teach it. As Grover (2011) explain that TE is applying math, science, and, other school subject areas, solving practical problems, using knowledge, tools, and skills, action based, and increases human potential. Technology or TE deals with human activities that bring about change and sustainability to enhance the environment, create wealth, produce food and entertainment, and generally get things done. This is in line with the aim of TE which is to produce engineers, technicians and artisans needed in modern society, and the need to develop a technologically literate population for the modern world (Department of Basic Education, 2011). This aim could be sustained by engaging under qualified technology teachers through action research spiral and cyclical activities by integrating relevant theory in between. This paper will also offer a suggested programme for transforming technological education to meet the global sustainability challenge through technology education teachers.

There has been a trend of technology education studies conducted both nationally and internationally to address diverse issues around sustainability. Datschefski, (2001); Hoepfl, (2001); Birkeland, (2002). Elshof, (2003); Bawden, (2004); Elshof, (2005) have attempted to raise some aspects of alternative ways to sustain technology education. However, little research has been conducted on technology education teachers using action research methodology as a means to sustain TE. Therefore I want to attempt to fill that gap.

THEORETICAL FRAMEWORK

Theory underpinning the study and paradigm guiding the study

Cooperative Enquiry (Action Research, 2010) also known as Collaborative Enquiry theory was first proposed by John Heron 1971 and later expanded by Peter Reason. The major idea of cooperative inquiry theory is to research 'with' rather than 'on' people. It emphasizes that all active participants are fully involved in research decisions as co-researchers. That was evident in this study since we (the AR practitioner and the technology teachers as co-researchers) were fully involved in outlining the work program to address challenges together. The challenges were identified during reconnaissance study. Action research approach and collaborative enquiry theory were used to engaged TE teachers and unpack the research problem stated below.

Research question and problem statement

The research question which needs to be addressed in this study is that, 'what are alternative ways to empower technology teachers whom subject knowledge is well below what it should be so as to sustain the teaching of technology?' The study was prompted by the curriculum transformation, reform and review that gave birth to TE as a new subject. Teachers were confronted to teach it without prior training during their teacher training hence a reconnaissance study was conducted with a sample from Limpopo Province of South Africa. Non participative observations, reflective interviews and qualitative questionnaires were used to collect data during reconnaissance study. Interpreting and analysing the reconnaissance data yielded the following challenges for technology teachers: "technology-specific teaching experience, technology lesson planning, technology assessment, level of internal and external support for technology teaching, resources for technology teaching and learning, technology curriculum policy interpretation and implementation, and teacher-learner ratio in a technology class". The reconnaissance was named Phase 1 of the study and embarking on action research spiral and cyclical activities to jointly solve these challenges was then called Phase 2. Phase 2 was aiming at empowering these teachers.

Aim of the study

This study aimed at coming up with alternative ways to empower technology teachers whom subject knowledge is known to be well below what it should be and thus affect the sustainability of the teaching of technology. In empowering these under qualified teachers I engaged them in circular spiral sessions following their district technology workschedule. These AR sessions led to the development of six weeks programme as an instrument to empower under qualified technology teachers. It is incumbent upon pre-service technological teacher education programs to address in substantive ways the problematic concerning sustainability and technology (Elshof, 2003).

During AR my role shifted from that of an outsider professional who might provide information and advice (so-called *etic* approach) to an insider's participation and understanding (*emic* approach). Once accepted the technology teaching problem is re-assessed and the process begins another cycle, continuing until the problem is solved. This has been the AR journey that I travelled with the co-researchers

Technology Education: For the Future and a Play on Sustainability

"Sustainability can only be achieved through better design", Edwin Datschefski (2001). The play on sustainability will not be effective without self teaching scrutiny and self reflection. Kemmis and McTaggart (1988) claim that maximizing the effectiveness of regular classroom teaching involves the need for constant studying of one's own situation in order to understand better the teaching process. Within all the definitions of AR there are four basic themes, namely empowerment of participants, collaboration through participation, acquisition of knowledge and social change. In conducting AR, I structured routines for continuous confrontation with the data gathered on technology teaching by senior phase teachers.

Among the sub-Saharan African countries, Botswana and Malawi incorporated TE as a learning area in the curriculum but South Africa's TE for example was modelled on the New Zealand approach but blended with South African culture, values and context. Kufaine and Nyirenda (2013) posit that 'science and technology' as it is called in Malawi, is expected to equip the individual with knowledge, skills, values and attitudes that enable one to perform one's roles effectively in an attempt to promote and sustain the socio-economic development of a nation

RESEARCH DESIGN AND METHODS

Sample of the study

The sample was drawn from Capricorn Region at Mankweng Circuit of Mankweng District. The aim of delineating the scope of the study was to implement some intervention strategies to a manageable sample of 18 technology teachers teaching Grade 8 and 9 at five secondary schools. Pseudo names in Table 1were assigned to the schools to conceal their true identity for ethical reasons.

Table 1: Technology teachers from sampled schools and data gathering instruments

School name	**Sampled Technology teachers**						
	No. per sch.	**Grade 8**	**Grade 9**	**Data gathering Instruments used**			
				Observation	**Interviews**	**Field Notes**	**Logs of Meetings**
KMK secondary	7	3	4	4	3	4	7

School name	Sampled Technology teachers						
	No. per sch.	Grade 8	Grade 9	Data gathering Instruments used			
				Observ ation	Interv iews	Field Notes	Logs of Meetings
VMV secondary	3	1	2	2	3	2	3
RMR secondary	3	1	2	3	3	3	3
BMB secondary	3	1	2	3	3	3	3
WHW secondary	2	1	1	2	2	2	2
Total	18	7	11	14	14	14	18

The choice of Mankweng Circuit was prompted by the lack of technology knowledge and pedagogy observed previously while I was the lecturer within the province at University of Limpopo.

Data collection methods

Data was collected from technology teachers in sample schools. A variety of data collection techniques were incorporated on a small scale for this AR study. Those tools used for data collection were observations, structured interviews, field notes and logs of meetings. Integrated results from different data sources enabled me to explain in greater depth the extent of the challenges faced by technology teachers in their teaching of technology from more than one standpoint (Cohen, Manion and Morrison, 2000). A day was spent at each school to observe technology teachers giving lessons using the observation grid that was designed. Whilst observing the teachers their lessons field notes were jotted down. The field notes was followed by interviewing the teachers using the interview schedule that was designed. The day was wrapped up by having a meeting with the entire cohort of technology teachers from both Grade 8 and 9. This process of engaging TE teachers in AR cyclical and spiral activities took for five weeks hence a six programme was developed.

Action research cycle and spiral activities to develop instruments

Action Research (AR) emphasizes teachers' involvement in problems within their own classrooms and has its primary goal as the in-service training and professional development of the teacher, rather than the acquisition of general knowledge in the field of education (Borg in Ferrance, 2000). AR is a way of learning from and through one's practice by working through a series of reflective stages that facilitate the development of an "adaptive" form of expertise (Riel, 2010). The AR cycle equipped me and co-researchers with a way of learning from experience that was potentially flexible, whilst for Riel (2010) this form of research is an interactive, cyclical process of reflecting on practice, taking an action, reflecting, and taking further action. The AR spiral activities were undertaken repeatedly within AR cycles to address challenges to teaching technology. The preliminary study unravels some challenges the TE teachers are exposed to daily. Some of those challenges are lack of resources, poor support, time constrain, teacher-learner ratio, low level of TE PCK, etc. These challenges were addressed on weekly basis.

SIX WEEKS PROGRAMME TO EMPOWER TEACHERS THROUGH RESEARCH

I argue that teachers can implement and sustain their teaching of technology with confidence and every chance of success in their context only if they can be guided how. The starting point is to identify the areas of their need. That is what this study has sought to do by developing both six weeks programme of AR intervention strategies and guidelines to emancipate incapacitated teachers. The programme can be executed within a minimum of four weeks, which means a week of contact session per term. Six weeks is the maximum duration that the facilitator could intervene and interact with the participants. Tables 2 highlights the six weeks intervention schedule for action research practitioner together with those that need to emancipate.

Table 2: Action research intervention strategies to emancipate teachers

WEEK	ACTION	CYCLE
ONE	▪Access, ethical observations and signing of consent; ▪Identify area of professional development or empowerment or emancipation. Embark on target population discrimination of your participants; ▪Sell action research to the participants; ▪Conduct reconnaissance (include observation) study to confirm the research problem; ▪Analyze data and prepare the findings.	**1**
TWO	▪Share the findings, identify the challenges, convert these challenges into themes; ▪Plan together on how you are going to address these challenges; ▪Be guided by the theory and the action research paradigm(s). ▪Prioritize those themes through action planning;	**2**
THREE	▪Reflect on the action plan; ▪Identify those who can handle some challenges from the participants; ▪Incorporate such as co-researchers and facilitate the process of addressing the challenges; ▪Implement intervention strategies; ▪Reflect on the cycles.	**3**
FOUR	▪Continue to implement action plan cyclically and spirally by observing, planning, acting and reflecting; ▪Reflect on the activities of the cycle.	**4**
FIVE	▪Let the emancipated participants display the sign of empowerment through learners' work.	**5**
SIX	▪Repeat what you have done during reconnaissance so as to confirm the degree of emancipation; ▪Analyze and crystallize data.	**6**
SEVEN	▪ Do member-checking and share the findings.	**7**

Laufenberg (2009) words still hold water as they stresses that, "the teacher is at the heart of good education. If we are going to expand the understanding of students in the field of technology it will be because of the insights and excitement of great teachers. In the end it is creativity that they bring into the classroom. The task of being the great teacher in this complicated world is awesome".

DATA ANALYSIS

Themes developed during preliminary study themes were technology teaching experience; technology planning for teaching; assessment in technology; support in technology; resources in technology; curriculum policy interpretation, implementation and learning outcomes; and teacher-learner ratio. I arranged themes into interpretable form after reconnaissance study. I will integrated themes as challenges for teaching technology with data collected per cycle for 'interim analysis' purposes and reflect what I have learned from those data. This will be classified as 'data set' but the themes are attended to during the implementation stage of this analysis method as displayed in since 'interim analysis' is cyclical or recursive process of collecting data and analyze that data, this is in line with the AR process for each cycle. Since Cycle 1, I engaged the participants in the process of collecting data to resolve their challenges per cycle. I planned to interpret data according to the following 'data set' categories, which explains how I implemented each instrument to gather data.

Interim analysis has been a handy tool in this action research study. This was true in my study as data collection started with reconnaissance study. The analysis of data from the preliminary study brought forth the themes as senior phase technology teachers' teaching challenges. The challenges raised by teachers were resolved by employing AR cycles of contact sessions guided by data sets.

FINDINGS FROM CYCLES AND SPIRAL ACTIVITIES
The participants were engage in PAR so as to among other things relate well and consult among themselves on their areas of expertise. Findings per cycle reveal the benefits of PAR.
The cycles were conducted with the participants as scheduled in Table 3.

Table 3: Schedule for action research cycles their findings

Cycle	1(a week)	2 (a week)	3 (a week)	4 (a week)	5 (two weeks)
Data gathering instruments	Observations of lessons supported by digital still and visual pictures, interviews and questionnaires. Meeting to structure the way forward.	Seminar on technology challenges identified. Field notes were written down. Recording of activities using audio visual camera was done. Interview cycle schedule was filled. Meeting to structure the way forward.	Workshop to address technology challenges as themes were organized. Recording of activities using audio visual camera was done. Interview cycle schedule were undertaken completed. Meeting to structure the way forward.	Workshop to address technology challenges as themes were organized. Recording of activities using audio visual camera was done. Interview cycle schedule. Meeting to structure the way forward.	Observations of lessons supported by digital still and visual cameras, interviews and questionnaires. Included peer and Head of Department (HOD) lesson presentation assessments. Seminar on participants' lesson assessment. Meeting to evaluate the whole AR project.
Findings	Teachers have no text books, no lesson plans, no resources, most under	Teachers did not have a common workschedule, not addressing same themes	Findings from the interview and observations reveals that	At the end of the session teachers confidence was	This was a show case session. Learners project were brought to a

	qualified and many coerced to teach technology.	per term and no technology poster or any project done with the learners.	teachers find it difficult to teach technology drawing, system and control	boasted. They appreciated my intervention. They decided on the project to do with their learners' per grade.	contact session venue. Teachers shared the journey they travelled with their learners. Project portfolios were also displayed. Their HoDs were impressed with the teachers' lesson presentations.

Different instruments for data collection were incorporated in line with the nature of activities per cycle.

CONCLUSIONS AND RECOMMENDATIONS

This paper was dedicated to outlining the instruments to empower teachers teaching technology without any qualification. Data was collected from co-researchers using different tools and were analysed as data set using interim analysis. All the data collected per week were analysed weekly. Participants were useful in their reflection of each and every contact session cycle. Their reflections per week were instrumental to develop the six week programme to empower the under qualified TE teachers. This is a contribution to action research studies to be used to sustain technology education for the under qualified teachers.

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Five Eras of Making and Designing

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ABSTRACT
The subject of design and technology has developed in the UK at an extraordinary pace over a period of two decades. As a consequence, what is prescribed within the statutory curriculum at present (DfE 2013), bears only limited resemblance to the original document (DES 1990). The practice found in schools is, however, quite varied with some of what is undertaken appearing quite similar to what was suggested in the past. In order to try and identify reasons, this paper explores the history of knowledge and skills within making and designing activity in UK schools. It does so by presenting a number of eras through which the subject domain has passed over time, namely; making, personalising, designing manufacturing and valuing. Each era is described in terms of the activities that took place in school, and the demands on teachers, drawing on the author's lived experience as teacher and teacher educator.

The paper also suggests that it is teachers who will have the last word in shaping the future of the subject. In doing so it raises significant questions about the sustainability of a design and technology curriculum and provokes thinking on how best to proceed into the future.

Keywords: curriculum, knowledge, skills, subject, technology

Mike: *'But the subject's changed a lot since you were at school'*
Dave: *'Has it? Surely it's just about making stuff, isn't it?*

INTRODUCTION

From personal experience of being involved with teacher education for nearly 20 years, Dave's view is not uncommon. For those new to the subject it is quite understandable to imagine that the National Curriculum, in England, has always remained the same as it currently is. The conversation also provides a window on to a bigger issue, that of the rapidly changing demands on teachers and the variability of practice now found across the country (Ofsted 2011). Exploring this is timely given the current changes to the school curriculum in England (DFE 2013) .

The approach taken in developing this paper has been autoethnographic in nature, drawing on the lived experience of the author who worked predominately in the secondary sector with materials technology. The concept of eras is used to explore the history of the curriculum with each era being defined by the essential characteristic / feature of the time as interpreted by the author. In using such an approach it is hoped to gain new insights into one of the most changing and fought over subjects in the curriculum.

THE ERA OF MAKING

The roots of design and technology lie firmly in the traditional craft-based work of blacksmiths, carpenters, cooks and seamstresses dating back hundreds of years. The emphasis at that time was on the development of practical skills through an apprenticeship model.

Time was spent with the 'master' to learn the craft over an extended period of time, working through progressively more difficult tasks. The apprentice eventually completed training and was assessed on the quality of their craft skills. These were early examples of workplace learning (Eraut 2007) and developing knowledge within a community of practice (Lave and Wenger 1991)

In more recent years this transmission model of knowledge acquisition, from novice to master, has been used within highly structured apprenticeship schemes. Common in the 1970's and 1980's these were of significance in the education sector . Dreyfus and Dreyfus (1980) identified different stages on the way to becoming truly competent in the area of practice and this progression to 'mastery' is clearly structured.

The advantage of this traditional approach is that there is complete focus on what is required for the job in hand. Quality outcomes can be expected and the measure of success is the extent to which the novice is able to achieve the same quality outcome as the master.

KNOWLEDGE AND SKILLS

With regard to specific content, developing an understanding of the types of materials, and their working properties, was essential. Knowledge about the basic processes that could be used to change their properties, shape or form was also required.

Significantly in this period, the use of procedural knowledge (knowing how) was perhaps more important than propositional knowledge (knowing that). In addition, the use of tacit knowledge (Polanyi 1967) was significant with little being written down in handbooks. Knowledge was passed orally or through practical demonstration.

Over time schools started to take on the role of developing the required skills and knowledge for the professions. The development of qualifications in metalwork, woodwork and domestic science furthered the development of school-based practice (Penfold 1988). For teachers, this highly structured activity was easy to manage with all pupils making the same thing from the same materials. Carrying out the same activity year on year enabled teachers to refine their pedagogy and work with a stable scheme of work, recognised by trades and industry as providing some useful skills.

THE ERA OF PERSONALISING

As has been said above, much of the work undertaken in schools in the 1970's and 1980's under the title of woodwork, metalwork , domestic science and needlecraft was highly regulated with all pupils being given the same working drawing, recipe or pattern. The focus was on development of skills and an increasing use of machine tools. As a result of small scale research projects such as the Keele Project (Penfold 1988: 121) the subject of Craft, Design and Technology (CDT) was created. Whilst this continued to involve pupils working with materials (wood, metal and increasingly plastics), there was also a degree of choice.

One example, from personal experience as a beginning teacher in 1989 was making clocks. Pupils were given a brief to design and make a clock. They were supplied with a ready-made clock mechanism which could easily be attached to any sheet material with a suitable hole. Pupils then had to decide on a shape to make their clock and choose from available sheet materials. The end result was a range of different forms all involved similar manufacturing processes but personalised according to the desire of the individual pupil.

KNOWLEDGE AND SKILLS

In order to facilitate this move away from standard products, additional skills needed to be taught that would help with developing ideas, modelling, evaluating possibilities, drawing up individualised briefs and specifications.

Of significance at that time, in the UK, was the work of the Assessment of Performance Unit (APU) who looked at the assessment of the subject. As a teacher of CDT this was the first time I had read about design education with such books as Design Education: The Foundation Years by Kimbell (1982) making a significant impact on my practice.

With a gradually expanding range of materials there was a necessary increase in the range of knowledge to be acquired by pupils. More than knowledge of forming, shaping and processing materials, it was knowledge about which material or ingredient would be best suited for the product and how it would be processed. Work was very much based around contexts , although exploring the genuine needs of clients was not a significant feature at this time. There was also a focus on investigating, disassembling and evaluating activities (IDEAS) as an important part of the subject.

Although there was an increase in the breadth of knowledge needed for CDT compared to previously through woodwork, metalwork, domestic science etc, the type of knowledge used did not really change and was very much knowing that and knowing why with relatively small amounts of strategic knowledge for decision making being acquired. The range of skills was gradually developed from those focused on hand tools to an increasing use of machine tools such as the pillar drill, sanding disc, food processor and overlocker.

From personal experience, teaching at this time was highly rewarding. With the ability to put limits on the material range that pupils worked with and to provide some notional context to work in made the subject highly manageable. For pupils, they could make products that were unique to them in terms of shape and colour whilst also being assured of success of achieving an end product.

THE ERA OF DESIGNING

As the domain of making and designing developed in England it's role as part of pupils' general education changed. Shifting to a focus on developing a product to meet the specific requirements of a user or client demands a very design focused approach. This starts with needs or wants and only later focuses on the specific skills, tools and materials required to respond. With this approach it could be argued that practical making skills are perhaps less important that developing decision making skills. Acquiring knowledge about manufacturing processes that can be employed along with evaluating ideas, models and the outcome with the client or user become central.

Consider how you might approach a domestic DIY task. Would you only use the materials that you have in the house or would you work out what was required then use the materials and processes best suited for the job?

The development of the first National Curriculum for Technology (DES 1990) suggested a shift towards design-focused practical work with attainment targets. Under this newly created Technology curriculum, several material areas were brought together. Binding them to each other was a common thread of designing and making. Each set of knowledge and skills associated with a material area were perceived as quite different and it was really only the new skills of designing that were common.

KNOWLEDGE AND SKILLS

For an individual pupil, the breadth of knowledge within one subject area became very broad and the skills required to develop products across a range of materials quite considerable.

Hand-skills still featured significantly but design was very much more prominent than previously and understood as a process with different stages. Pupils were therefore required to develop skills in each of the stages from research methods, decisions on manufacturing techniques and evaluating the effectiveness of products against a specification. Teachers were tasked with developing their ability to make informed choices and, not surprisingly, there was some debate about problem solving skills at the time (Liddament 1996).

In addition to knowing about materials and process of things that could be made by hand, pupils were increasingly introduced to the world of industrial process. Significant at this time was the expectation that pupils would explore existing products in a systematic manner. Focused practical tasks were undertaken for pupils to learn specific pieces of knowledge. In addition there were activities focused specifically on developing skills in disassembling and evaluating products.

This was the first time that pupils were expected to express their own personal judgement on the work of others in a way that exposed values issues. Pupils were encouraged to express their opinions and collectively evaluate products using given or self-generated criteria.

Teaching in this era was challenging with pupils having the same starting point but moving on in different directions and at different rates. A climate of risk-taking was necessary to ensure creativity but tempered by the need for pupils to complete some kind of response in the time given.

THE ERA OF MANUFACTURING

Design and technology as a subject in the curriculum has existed for more than 20 years. As can be seen from above it has not, however, kept the same. One of the most significant changes throughout the 1990's was an increased emphasis on manufacturing. This was both in the sense of what pupils were expected to know about processes but also in the ways in which their products were made. Not only were pupils expected to make products but also be aware of how they could be made in batches or with large-scale manufacturing processes.

This change in the curriculum not only reflected the rapidly changing practices in industry but also an increased interest by the manufacturing sector in the content of the curriculum. This was most obvious in the 1992 revision of the curriculum (DES 1992) which was significantly influenced by the Engineering Council with references to British Standards in the Programmes of Study.

KNOWLEDGE AND SKILLS

The addition to the skills set required to be successful now included a much greater use of machine tools and the use of 2D and 3D computer aided design software. This was not an insignificant move in terms of the knowledge needed for success. In particular, pupils needed to be able to make decisions over which manufacturing process they would be using. McCormick (1997) uses the term strategic knowledge to refer to the knowledge which is needed in order to decide what to do next. With a range of designing and making techniques to choose from the skill needed is choosing the right option.

The use of CADCAM technologies has had a profound impact on the ways in which [pupils work when designing and making. It is not possible to design and make a completely functional product without the use of traditional hand tools in a workshop environment. Whilst this is not surprising given the nature of modern manufacturing, it brings into question the role of developing hand skills. Within this context it is more important than ever to be clear about what role the subject has as a part of pupils' general education. What does it mean to be competent at designing and making?

Teaching at this time demanded good knowledge of industrial processes and the ability to manage pupils accessing CAD software. As products could be made in different ways using CAM equipment it became possible to ensure quality outcomes direct from drawings. The demonstration of 2D and 3D drawing using ICT became as important as demonstrating hand-skills and machine tools which challenged many practitioners.

THE ERA OF VALUING

We live in a world of overconsumption and shrinking resources which provides an incentive to shift from considering what we would like to make to what we ought to make. Currently there is a strong sustainability imperative that is beginning to affect the nature of what we make and how we make it. Consideration of the source of materials and their disposal is becoming a significant part of product development and companies are keen to tell us about their efforts. Given the rate of resource depletion this aspect of making is not to be taken lightly. Along with the concern about resources come issues of fair trade and social justice which are becoming important aspects of design and technology education.

As human beings it is important that we are completely aware of the wider effects of product development from cradle to grave. Within children's general education there is surely a need to develop knowledge of this and make them aware of the need to consider the issues when designing and making products.

Since the development of the first National Curriculum for Technology (DES 1990) there has been growing interest in values issues within the subject. Now pupils are expected to understand human need and the extent to which products to meet those needs. Although this was written into the curriculum of more than 20 years ago, it is only at this later period that we see the issue taken seriously.

SKILLS AND KNOWLEDGE

At this time there are great demands on pupils to develop a wide variety of making and designing skills as well as developing their personal judgement about the products of their own making and designing activity and that of others.

In this move for pupils to consider the relationship between technology and human activity, I believe that there is the case for an additional category of knowledge namely '*valuing knowledge*'. The type of valuing knowledge envisaged is one that is particular to technological products and systems and is something that can acquire in varying degrees. Knowledge that technology has an impact on people and the environment would demonstrate a basic understanding. Knowledge of the effects of a similar technology to the one being looked at (almost like case-law) would demonstrate a higher level of knowledge. The following table, adapted from an earlier paper (Martin 2007:), illustrates the idea.

Table 1: Progression in valuing skills and knowledge.

	Designer	**User**	**Context**	**Complexity of product / system**
Progressively harder to evaluate (value) ↓	Self	Self	Home	Single element
	Other pupil	Other pupil	School	Joined elements
	Single designer	Others outside	Community	Multi-material

		school		
	Organisation	Organisation	Commercial	System

TEACHERS HAVE THE LAST WORD

Given the long history of the subject, the breadth of knowledge that could be acquired under the banner of design and technology is vast. Whilst other subjects such as English have quite a narrow portion of the work of English language and literature in the world, design and technology is potentially without limits. Currently in England this overload of knowledge and skills to be developed by pupils is not sustainable and some decisions are required about the way forward.

So what is subject knowledge for design and technology? From experience, it is possible to find two equally resourced schools with similarly capable pupils, that develop different skills and knowledge. Given that the curriculum documentation is the same for all schools, the only conclusion to draw is that it is the teachers themselves who are the variable. Is it possible that teachers can hold on to their practice from earlier eras and are unaffected by changes to the national curriculum? This would certainly account for the variability of practice and the difficulty that beginning teachers can have in working across different schools.

Subject knowledge for design and technology is only constant at the level of the prescribed curriculum (that given to schools by government). Teachers' interpretation of that prescription defines the subject knowledge gained by pupils in schools. It is how teachers value the different areas of knowledge and skills within the domain of the subject that is the critical factor and defines what pupils learn.

As can be seen from the analysis of making and designing into eras, the demands on teachers have changed over time. It is important to remember, however, that these are periods of time and not models of curriculum delivery. If D&T is to be modernised then the response to that criticism lies in the practice of teachers in an educational context of performance tables and performance management. Such a change will be difficult and can perhaps only be achieved by teachers understanding the history of the subject and recognising the need to align their practice with current expectations.

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Designing a Student Model for Developing E-learning Materials and Virtual Lesson Games for STEM Education

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ABSTRACT
My team has developed instructional materials for STEM education in order to cultivate learners' problem-solving abilities. These materials are based on game-type e-learning and emphasize techniques that will teach students problem solving strategies. Based on these features, I have constructed a common framework to design instructional materials for STEM education. I intend to use these materials to provide teachers with a student-like experience that will enhance their understanding of appropriate lesson design. Moreover, I have developed virtual lesson games to assist technology and mathematics teachers in improving their lessons. However, these materials and tools did not sufficiently promote innovative lesson design since the instructors lacked adequate pedagogical knowledge, and were subsequently adverse to change. Therefore, this paper presents a student model for developing e-learning materials and virtual lesson games for STEM education. This model helps teachers to understand how knowledge and ways of thinking affect the problem solving process. Additionally, I discuss how the design framework for instructional materials might be revised to evaluate students' strengths and weaknesses using problem-solving activities. Finally, I examine how virtual lesson games can be enhanced to help teachers clearly understand how and why their lessons require improvement.

Keywords: STEM education, student model, views and ways of thinking.

NECESSITY OF A STUDENT MODEL FOR STEM EDUCATION

The Japanese National Course of Studies for secondary schools emphasizes general education, and subsequently, educators tend to perceive technology education to be skill education or vocational education (Matsuda, 2006). Therefore, the time spent on technology education is considerably less than the time allotted to mathematics and science. Additionally, a connection between technology, mathematics, and science is seldom made. I believe this contributes to students' lack of motivation toward these subjects, and the misconception that they are useless, as several recent surveys, such as 2007 survey of National Institute of Educational Policy and Research, have indicated.

To rectify this problem, my team has developed instructional materials for science, technology, engineering, and mathematics (STEM) education to cultivate learners' problem-solving abilities. These materials have the following common features: game-based e-learning materials, teaching methods that emphasize ways of thinking that should be utilized in problem solving activities, and the avoidance of activities that promote rote memorization, replacing them instead with activities that encourage creation of several alternatives and choice of better one. Based on these common features, my team is constructing a framework to design instructional materials for STEM education.

People do not need to be confined to using the learning outcomes of a specific field, but instead need to utilize all knowledge and ways of thinking for actual problem solving. With that in mind, it is necessary to develop a student model that represents cognitive processes of problem solving while utilizing all learning outcomes of STEM education, thereby heightening the aforementioned framework's validity. The research outcomes and practices derived from learning science by Bruer (1993), Bransford et al. (1999), Sawyer (2006), and so on can be applied to this model.

This model will be very important for Japanese secondary school teachers because they tend to emphasize differences between subject areas and are not familiar with a cross-curricular approach. I have developed virtual lesson games to help technology and mathematics teachers improve their lessons. The games require teachers to present lessons covering a specified textbook topic to computerized, virtual students. Depending on the teacher's actions, the game's virtual students generate appropriate responses. The purpose of the game is to help teachers create learner-centric lessons that do not rely upon the deliberate instillation of knowledge. To increase the tool's effectiveness, I will provide teachers with feedback that demonstrates how their instructions affect students' acquisition of knowledge and use of ways of thinking. This will help teachers understand how knowledge and cognitive processes influence problem-solving skills. The feedback will also help teachers understand how knowledge and ways of thinking affect processes and performances of actual problem solving. This concept is in line with the latest trends at PATT and other conferences that emphasize the importance of STEM teachers' PCK.

PURPOSE

This paper presents a student model for developing e-learning materials and virtual lesson games for STEM education. Because Matsuda (2013) devised a student model for a mathematics virtual lesson game, I have subsequently adapted it to technology education, and specifically extended to STEM education. Additionally, I discuss how the model can be incorporated into the framework of e-learning materials and virtual lesson game design.

REQUIRED ELEMENTS OF THE STUDENT MODEL AND PHENOMENA TO BE EXPLAINED

Bruer (1993) introduced Perkins and Salomon's (1989) theory of intelligence that claims domain-specific knowledge, meta-cognitive skills, and general strategies are all elements of human intelligence and expert performance. On the other hand, Matsuda's (2013) student model for mathematics education consists of domain-specific knowledge, mathematical views and ways of thinking, and knowledge of problem-solving scripts. Views and ways of thinking help students to control the direction of problem-solving activities and self-learning, which are then associated with meta-cognitive skills.

Bruer (1993) illustrated a variety of different general strategies ranging from study skills to means-end analysis (Newell & Simon 1972). Although many consider general strategies too broad to explicitly teach, Bruer noted that they are not easily transferred without "informed" instruction. Similarly, scripts are sets of procedural knowledge that represent appropriate behaviors for situations or places, such as at a restaurant. Learning this type of knowledge depends upon situations; however, when learning in a new situation, some individuals gradually generalize, while others acquire knowledge according to each situation. Therefore, we must consider the trade-off between experiential learning and explicit instruction. In this study, I adopt Hirabayashi and Matsuda (2011)'s problem-solving framework for informatics education: Goal setting→ [Technical understanding←→Rational judgment]→ Derivation of optimized solution. This method corresponds to the design process described by the ITEA (2007). As Matsuda (2013) noted, problem-solving scripts are not instructed explicitly in mathematics education. Therefore, technology education plays an important role in explicitly instructing this kind of knowledge as general strategies. At this juncture, the meaning of "informed" instruction and the differences and similarities between problem-solving scripts in STEM education should be discussed.

In order to apply this model to virtual lesson games, the following phenomena should be explained. Firstly, Japanese technology teachers tend to instill excessive factual knowledge in their students at the expense of expounding upon technology's social dimensions; subsequently, they fail to cultivate students' ability to understand and evaluate new technologies. The ramifications of this instructional style should be explained in relation to the above model. Secondly, although Japanese students scored highly on the PISA survey's math and science sections, adults scored very low. Therefore, the model should account for differing short- and long-term learning outcomes. Lastly, Japanese teachers tend to teach subjects in isolation, without integrating them into other disciplines. The model should highlight the importance of subject integration and its approach in STEM education.

PROPOSAL OF THE STUDENT MODEL: IDENTIFYING NECESSARY IMPROVEMENTS IN TECHNOLOGY EDUCATION

Knowledge of problem-solving scripts

As I mentioned previously, technology education plays an important role in explicitly instructing this kind of knowledge. In order to teach design process as a general strategy, informed instruction that emphasizes commonalities between situations and effectively implementing them should be taken into consideration, and such instruction is in fact necessary for not only technology, but also STEM education. However, in Japanese technology education, many different problem-solving scripts are taught respective to each field of study, such as material processing and energy transduction (Matsuda & Sato 2009).

In order to perform informed instruction of problem-solving strategies in technology education, the following improvements are necessary. Firstly, people learn problem-solving strategies such as trial-and-error experientially. The purpose of teaching a technological method of problem solving is to strengthen such strategies, obtain improved results, and to perform problem-solving tasks more proficiently. In order to satisfy both demands concurrently, information and communication technology (ICT) is applied since the former requires useful information or ideas to generate an ideal solution, while the latter aids collecting and processing the information necessary to solve problems more efficiently. The primary characteristic of the trial-and-error approach is a "think and perform" cycle that occurs repeatedly within a short period of time. On the other hand, a technological problem solving method aims to completely separate the thinking and performance phases. To respond to this demand, computer assisted design/manufacturing (CAD/CAM) was expanded to every field, including medicine, agriculture, manufacturing, and construction. This indicates that general problem-solving strategies utilizing ICT, as asserted in Hirabayashi and Matsuda's (2011) framework, should be taught explicitly and early on.

Secondly, different contexts among technological fields require varied problem-solving strategies. Therefore, it is necessary to explicitly explain how the framework should be applied to varying contexts. Here, the ITEA standard categorizes "understanding of the designed world" as domain-specific knowledge and "understanding of design" as a general strategy. Consequently, differences among technological fields require domain-specific knowledge to generate alternatives according to the Technical understanding process, and to evaluate them in compliance with the Rational judgment and Derivation of optimal solution process. For evaluation purposes, knowledge of each method and its positive attributes is required. However, because knowledge of each method changes rapidly according to technological advancements in manufacturing technology, such as software updates in ICT and migrations away from laser-beam-machining in 3D printing, memorization is unnecessary to explicitly clarify the study of new methods/technologies in the Technical understanding process. On the other hand, knowledge of positive attributes must be applied to technological evaluations in social contexts. While it is possible for new technologies to crossover from one field to another and initiate a technological advancement, memorizing their positive attributes and interrelationships with each field is important.

Thirdly, as my team examined whether Hirabayashi and Matsuda's (2011) framework needed to be changed as for using it not only in technology education but for STEM education, Katto and Matsuda (2013) proposed that Consensus building should be added after the Derivation of optimized solution process to develop gaming materials for teaching scientific and technological communication. They also pointed out that this new process is necessary for collaborative problem solving in all subject areas. I conclude that this process should be added according to the problems that are present.

Views and ways of thinking

According to Sannomiya (1996), meta-cognition consists of meta-cognitive knowledge and activities. The former is knowledge of one's good/poor problem-solving methods and the appropriate application of a method to each situation. Meta-cognitive activities consist of monitoring and control. Monitoring involves evaluating present states, perspectives, and problem-solving results, while control is to conduct goal setting, planning, and improvement of activities. Can we deduce from this that instruction of meta-cognitive activity is equivalent to teach design process? Hirabayashi and Matsuda's (2011) framework explicitly specifies informatic and systematic views, and the ways of thinking required to prompt students to utilize each process. I consider teaching these views and ways of thinking a vital component of cultivating meta-cognitive skills.

For example, the Goal setting process requires one "to consider various good points" while "paying attention to the difference between good results and good methods." The latter details are monitoring viewpoints, and allow controlling activities to operate. Moreover, the Rational-judgment process requires one "to decide whether a high priority alternative should be improved upon because its good points have been altered according to decision makers or situations." This should promote the utilization of meta-cognitive knowledge. Furthermore, during the reflection stage that occurs following the four problem-solving processes, students change their confidence levels according to domain-specific knowledge, and problem-solving methods based upon activity log evaluation. This activity encourages students to update their meta-cognitive knowledge. Therefore, I assume that views and ways of thinking appropriately embedded in a problem-solving script are triggers to cultivate meta-cognitive skills and then problem-solving ability.

In order to make an integrated student model for STEM education, a relationship between views and ways of thinking for all subject areas must be discussed. Informatic and systematic views and ways of thinking are extracted from a methodology of systems approach. Hence, the mathematic and scientific views and ways of thinking proposed by Matsuda (2012) play a role in promoting the appropriate use of methods, which are then applied according to specific situations, for example, when quantitative or causal analysis of relationship is required. Subsequently, the rules should summarize the situation, required views, and ways of thinking in a hierarchical fashion for each process within the problem-solving framework.

Matsuda (2003) has considered twelve re-occurring computer science concepts in relation to informatic and systematic views and ways of thinking. The former includes some core concepts of technology (ITEA 2007) in addition to similar ones, such as system, requirement, and trade-off. Therefore, some new views and ways of thinking could be added based on the consideration of relationships between core technological concepts and existing views and ways of thinking.

Domain-specific knowledge

Knowledge stored in long-term memory is classified as either declarative or procedural. Declarative knowledge is classified as being either episodic or semantic (Anderson, 1976). The semantic network model (Collins & Quillian, 1969) is perhaps the most well-known. Since long-term memory is not lost but temporarily unavailable, a student model should explain how knowledge can be activated and utilized.

Firstly, the capacity of working memory is very limited. A unit of memory is called a chunk and consists of congeries of related information. Bruner's (1960) structure and frame (Barr & Feigenbaum, 1981) used in artificial intelligence are concerned with chunking and explain the varying amounts of activated knowledge among different individuals. Matsuda (2013) stated that it is important for students to memorize a concept with an associated set of properties that may include names, examples, related phenomena, formulas, and reasons/purposes of definition. This assumes that good teachers recognize factors that contribute to students' misunderstandings, and that these factors can be classified consistently within each subject area (Higuchi & Matsuda, 2004). Matsuda (2013) assumed that as many teachers have methods of identifying why a student has erred, students should have methods to fill up a value of these typical slots with using views and ways of thinking.

Secondly, the direction of connection between different knowledge types is very important. In general, domain-specific knowledge is taught using a buildup approach beginning, for example, with principles and then proceeding to methods, or from simple to complex ideas. However, in real situations, people do not use knowledge in this order. For instance, students may design presentation slides by considering the necessary contents, types of expression, and their layout. Although this process involves knowledge of fonts and RGB values, students seldom use knowledge pertaining to the A/D conversion of media while designing slides. According to the ITEA (2007), many students learn best in experiential ways. It further suggests that authentic learning provides students with an opportunity to reconstruct knowledge (re-connection) in a manner analogous to real life situations.

Thirdly, in knowledge activation mechanisms, the strength of knowledge connections and the mechanism used to choose appropriate knowledge in relation to each situation should be considered. Although people must understand both the benefits and disadvantages of technology, the benefits should receive specific attention throughout the Technical understanding process, while disadvantages should be considered during the Rational judgment process. Moreover, because technology is so fluid, teachers should spend less time on specific details and more time on concepts and principles (ITEA 2007). In contrast, students engaged in experiential learning need to use specific details, even though the concepts and principles are not used so explicitly. At this juncture, we should remember Bruer's (1993) emphasis on the importance of informed instruction. Before addressing this type of instruction, however, I believe strengthening the connection between knowledge and situations should be taken into consideration according to Keller's (1987) ARCS model of motivation. For example, relevance is heightened by emphasizing reasons and situations that require the activation of specific types of knowledge, and experience of appropriate use of knowledge to achieve the goal should heighten confidence.

Discussion and Future Perspectives

Here, I discuss how our framework and e-learning materials should be improved based on the student model. Firstly, our e-learning materials are designed to process problem-solving activities according to the framework's sequence. However, students should become able to process these activities without guidance. To achieve this, it is necessary to undergo the problem-solving cycle repeatedly for each material, starting with the directive phase and then shifting toward the learner-centric phase. Secondly, our materials emphasize the utilization of views and ways of thinking in order to choose better methods and pursue superior solutions.

However, my student model requires materials that will prompt learners to reconstruct domain-specific knowledge so that it becomes active in adequate contexts, and cultivates the individual's ability to acquire new domain-specific knowledge to solve each problem. These activities should be added, and the utilization of domain-specific knowledge, views, and ways of thinking that help students to understand the properties of emerging technologies should be evaluated specifically.

We should also address ways that our virtual lesson games can be improved upon. Because our previous games were not based on a student model, teachers' actions were evaluated according to the frequency of explicit instruction of views and ways of thinking, the quantity of instructed knowledge, and the selection of instructional action. According to the introduction of a student model, instructional learning outcomes are reflected in a student model that enables one to simulate whether or not the student can utilize the learning outcomes in the context of his or her daily life. I hope that this simulation will persuade teachers to understand the need to change their lessons.

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Drawing on the Arts: Can Kinesthetic Tools Enhance Design Practice?

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ABSTRACT
The underlying pedagogy and classroom practice of creative design appears to be little understood, or even happenstance especially in the Learning Area of Technology in the New Zealand Curriculum. Classroom designing at best can reflect the ways of creative designer practitioners but only if the pedagogy is aware of a creative design approach. The research presented in this paper builds on a study into the practice of creative designers to reveal the events that occurred within their work. Identifying events that may translate to classroom design practice will go some way towards informing professional development, pedagogy and learning in creative design practice.

Prompted by Professor David Barlex at the 2012 PATT/CRIPT conference in London, this research looks to the Arts to establish whether kinesthetic tools of drama may indeed inform and enhance teaching and learning in design. This introductory paper presents some findings of a case study within a school to reveal details of a teacher's preparation, planning and approach to engage his students in an *initiation* stage of drama. It looks at the significant components of a drama teacher's pedagogy to enhance and inform the comparative *immersion* stage in creative design processing.

Repeated use of the word *creative* in this paper is deliberate. The descriptor is used to distinguish between what Scrivener (2000) notes as the more formulaic engineering problem–solving approach and the creative practice evident in graphic, media, architectural, spatial, product, fashion and digital design.

Keywords: Immersion, kinaesthetic, narrative, imaginative interplay, planned creative environments

BACKGROUND AND RATIONALE
Professional roles in national assessment in both Technology and Design and Visual Communication have provided the author with insights into the nature of creative design practice in New Zealand classrooms. Aspects of creative design practice are noted in a number of Learning Areas of the New Zealand Curriculum (Ministry of Education, 2007) and therefore need to be taught and learned. However, creative design practice is not fully recognised in its rightful place at the core of Design and Technology learning in New Zealand and at an international level. In an address to the House of Lords, Baroness Whittaker (2013) drew attention to the state of the design component in the British curriculum in comparison to innovative design practice, noting that "We have a truly world-class capability in design and it is highly export-facing. None of that will last if we impoverish the design curriculum in schools." A pedagogy that reflects that practice needs to be developed and mastered with a common understanding and approach across school communities.

The translation of key events within creative design practice to the classroom offers a valid starting point. Insights gained from a view into creative design practice were identified across a number of events. These events occurred at times within each process as dictated by the unique nature of the task and client needs. Some events within the designers' practice were common to all three stories, whereas others were specific to the designer, client requirements or the nature of the task. The research findings presented events found within each practice as broad groupings with no intent to indicate a specific stage, or hierarchy of event. Each designer was well aware of their own ways of working. An essential part of their practice was to constantly review and reflect on their approach as every design task dictated it's own direction towards resolution, with no two alike.
The Author (2010) noted that each designer "recognized and supported their own or the design team's way of working by creating emotionally and physically supportive work networks and environments to nurture their creative thought processes" (p. 255).

Identified events within the designers' creative practice include:

- *Framing the question*, to explore the intrinsic nature of the design project traditionally timed at the onset and throughout design processing.
- Deliberately planned emotional and physical creative and supportive working *environments.*
- The fostering of an *inquiry-based* approach.
- The engagement in and documentation of ongoing *internal and external dialogue.*
- Building an awareness of the *human interface with their environments*.
- Setting aside time to become *immersed in the theme* of the task in focus.
- Encouraging a *sense of play*, making *observations,* decision making,
- The cultivation of a *flexible approach* to accommodate *unexpected outcomes*.
- Employing *conceptual and prototype modeling* throughout the processing.

This paper looks at one event identified in the designers' practice: Time set aside to become fully informed, at one, or *immersed* with the theme or themes of a designing project. Drama employs a pedagogy that plans for and utilizes the stage of *immersion*. An alliance with this subject provides guidance to inform classroom-based idea generation. Time spent in setting the scene at a design *immersion* stage using kinaesthetic tools serves to deepen the experience of motivation, ideation and therefore student engagement and ownership, resulting in unique and creative outcomes.

THEORETICAL UNDERPINNINGS

The New Zealand Curriculum (Ministry of Education, 2007) requires that educators nurture young people to become "lifelong learners who are confident and creative, connected and actively involved" (p. 4). Students should also "be encouraged to value innovation, inquiry and curiosity" (p. 10). These attributes, often best instilled in early learning programmes, require modelling through all learning levels. Creative design practice informed by the Arts has the potential to fulfil this goal. The dramatic arts are defined in the New Zealand Curriculum as "the expression of ideas, feelings, and human experience through movement, sound, visual image and the realization of role" (p. 36). Such attributes are evident in successful creative practice in our communities. Tertiary institutions and potential employers also seek these qualities when our young are seeking further training or careers in creative practice.

O'Connor (2013) looks at creative approaches in our wider community to note that "our most successful scientists, artists, business owners and philosophers are set apart because they have retained their ability to play with ideas, to imagine new possibilities and empathetically engage with others" (p. 9). A collaborative approach plays a significant part in creative design practice where the wealth of differing contributions enriches idea generation. The Author (2010)

recounts a comment made by the director of a highly successful, creative design practice that a deliberate selection of different thinkers contributes to rich and innovative debate. Hatton (2001) observed that a collaborative approach "involves the participants negotiating the representation of role, narrative, and symbols with other individuals. Therefore meaning-making in drama is an inherently dialogic and socially constructed process… that… can be such a life changing, transformative experience for participants" (p. 28).
Gallagher (cited by Aitken Fraser and Price, 2007) characterises "the teacher as the person in the equation who creates spaces of possibility, who does not find solutions but nurtures the questions, while asking the learners to bring what they already know to bear on what they are learning" (p.12).

Amongst the many attempts to define creativity, Bruner (cited in Lewis, 2006) sees creativity as an "act that produces effective surprise" with further explanation that surprise within creative practice, "is the privilege only of prepared minds – minds with structured expectancies and interests" (p. 36). Bruner also points out that the creative act is a "silent process" that "requires its own set of questions" to affirm and drive its content and to examine its very nature (p. 35). Learning in Drama is familiar with the realm of silent processing through inquiry, imaginative interplay, uncertainty and exploration.

RESEARCH METHODOLOGY

The research project presented here utilised a case study approach that included interpretive, heuristic research using qualitative data obtained through observation, interviews and student evidence. Kleining & Witt (2000) explain the heuristic approach as involving intuitive questioning as a means of discovery and a flexible approach to the gathering of data.

The research was situated in a large decile 8 intermediate school in Auckland with 17 year 8 (11-12 year old) participants from the Dramatic Arts subject and their teacher. Three classroom observations of 2.5 hours duration per session were carried out in the planned learning space at the onset of a project where the students were being introduced to a new narrative. This initial stage was the preparatory *setting the scene* or *immersion* phase to encourage the students to own or commit to the unfolding narrative. An initial interview was held with the teacher to identify the teacher's pedagogy, and instigate the dialogue. An interview was held prior to each observed lesson to inform the researcher of the intended nature of that lesson. Annotated lesson plans were prepared by the teacher to establish Learning Intentions and the corresponding pedagogical approach. Three post-teaching interviews were held to reflect on expected and unexpected learning outcomes, guided by the lesson plan. The final interview was held after the classroom observations to reflect on the entire learning experience. The purpose of this interview was for the teacher to reflect on the effects of his pedagogy across the research period. The researcher worked to achieve an invisible presence within each designated lesson to become an accepted part of the group and cause minimal disruption to the flow of thought and participation. Class session observations were manually recorded as journal notes and sketches by the researcher. Documentation included faithful note making of the physical environment, nature, context and sequence of activities, and teacher/student interactions. Immediate capture of student reflection, and shifts in perception were collected by incremental mind mapping at the end of each observed session. The students' progressive ideas and reflections were recorded using different pen colours to signify the sequence of sessions and increase in pupil understanding and engagement at the initial, mid-way and last stage of the research at the end of each session. The mind mapping sequential capture of ideas was instigated by three prompt questions; *I saw, I thought* and *I loved*. A final interview was held at the end of the research period with self-selected students to capture their reflections on this stage of their creative process. The students had created a physical representation of their understandings of a sense of loss over the wartime separation of loved ones. They were working with a pattern where they cut away the negative space to leave a lace like frame. Some spoke of relating the frame to the feeling of being trapped in a cage. Others spoke of a caged bird when speaking of the sister locked in a room while her older brother went to war; they had experienced the emotions and lived the story. One mentioned that drama was a safe way to try out being someone else so that they could understand how it was to be that person and another said that they felt comfortable being able to speak and act in front of people. These were some results from the study. All findings were analysed through qualitative, thematic analysis.

FINDINGS

A creative pedagogical approach

This study was based on the observations of a teacher of Drama as he worked with his class to become 'at one' with a theme. Considered planning of the learning environment had taken place prior to each session. The learning experience was designed to encourage the students' imaginative, emotional and physical involvement as they identified with the plight of the displaced siblings in wartime England. C.Horne (personal communication, 31 October 2012) saw the "narrative as the thread that provides the structure and for vehicle" for creative practice. Defining the narrative is at the core of his planning and preparation.

The planned environment that the students entered with awe, had carefully positioned props in the theme of the narrative to take their attention. The role of the props was not formally introduced, but became apparent in the evolving narrative. Their part gradually materialized as focus shifted within the story. A large image with lace curtain blowing in the wind and flying birds on the wallpaper played a significant part in initial scene setting. The lace theme was used to pinpoint era. The nature of lace was further explored to deepen the experience of loss and gain where students used the negative space of the lace structure to physically create through stencil cutting the fabric that remained after aspects of loss were cut away. This activity also exemplified a dramatic condition of *tension* through contrast. Students worked individually and as a group to explore the key signifiers of space, image, text and relationships. Guided by the teacher, they observed in depth, to imagine and to ask questions of the evolving narrative. The 'teacher in role' was used to guide the story from the inside at significant moments. C.Horne (personal communication, 31 October, 2012) noted, "The drama allows students to imaginatively experience the story rather than just passively reading it or hearing it." He also noted that to think originally around each setting assists the students in making links to their own learned experience.

The observed sessions saw students quickly identify with the space, characters, situation and emotions within the narrative. A deliberate pedagogical strategy was employed to encourage sharing and refining of ideas to engender the whole group's ownership of the work. Within the collaborative approach, however, each student was required to and did commit to the work. On entering the space of the narrative, from the playground or other learning experiences, there was an obvious shift in each student—a sense almost of reverence to the narrative as it evolved.

Students discussed the characters' experiences to build understanding. Through role identification, the story became the students' story. The sense of ownership engendered within the drama was evident in their mind maps and discussions.
Even though the space was considered and prepared there was a sense of relaxed flexibility to encourage individual interpretation and response from students as the narrative unfolded.

Areas of commonality between the immersion and initiation stages of creative practice

A view into the practice of creative design identified times of *total immersion,* described as a total engagement with the theme of a design project by the designer. As Author (2010) recounted, all three designers in his study "concur that time needs to be set aside to deliberately remove oneself from life's day-to-day pressures, to become fully immersed in the design task. Times of immersion may be seen as either a passive absorption of influences, or an active, collaborative debate around a theme" (p. 256).

An *immersion* stage in design practice is seen to parallel the *initiation* stage in drama, both in nature and intent. C.Horne (personal communication, 31 October 2012) also saw the initiation stage as “an invitation to take part in something unknown, as an attempt to tap into their natural curiosity… I am encouraging a willingness to suspend disbelief.” At a point when the students were becoming part of the story, he also noted that they often ask, “Is this real?” This indicates that “the student is becoming more and more immersed in the narrative, they are ready to let go.” This stage then leads to a “slow building of belief.”

Both the drama and design domains are working within meaningful *contexts* and they have agreed upon codes of trust and acceptance as parameters for the work. *Risk taking* is encouraged, as it is here where innovation originates—when an idea emerges it is welcomed not blocked. The presence of *tension* is not just a sense of suspense but also a sense of heightened awareness and anticipation or anxiety and is common to both areas.

Collective wisdom through a collaborative approach enriches and broadens the experience in both creative design practice and drama. C. Horne (personal communication, November 13, 2012) noted that he was “trying to take the stress of daily life away to introduce another reality that students can step in and out of. It is play; multi-sensory, visual, auditory, kinaesthetic and tactile, engaged simultaneously to interest and intrigue.” These aims align with the commentary of practicing designers where they need to step aside from everyday life, away from business management and at times past work, to empty out and begin afresh within the theme of a new project.

CONCLUDING STATEMENT

The creative classroom practice requires students to become familiar with all related aspects and influences when engaged in a designing task. This research focus is in the design and management of creative learning environments that enhance students’ learning in Design/Technology. An initial research focus on the *setting the scene* stage to encourage learners to become fully *immersed* in a theme offers a way forward for creative design pedagogy. In particular, this paper outlines how drama pedagogy can influence students’ physical, emotional, sensory and cognitive engagement, particularly within the immersion phase of design teaching. To observe a well-considered drama initiation/introduction, where students become immersed in a theme as it happens, leaves little doubt that drama tools will enhance the depth of engagement, commitment and inquiry in students’ idea generation. An essential pedagogic consideration at the beginning of all creative design processing is to identify the salient theme or narrative that underlies the task. Allowing time at the onset of a design project to become immersed in the established theme encourages student ownership of the task and provides in-depth understanding. The drama space reflected the theme of the narrative so that students easily related to the learning experience.

Design classrooms could incorporate flexible displays that changed to suit each theme. A display created through; posters, digital imagery, fabric, colour, shapes, forms enhanced by relevant sounds or music will provide a creative learning classroom environment. The reading of a story excerpt relating to the theme will focus thinking (with more intensity than a video clip) as observed when early letters where read to drama students to help set the scene. The art of storytelling needs to return to enhance the establishment of creative design classrooms. As Morris (2013, April 1) suggests, “Once the arts are restored to a more central role in educational institutions, there could be a tremendous unleashing of creative energy in other disciplines…” It was evident that these students trained in drama techniques, displayed a heightened sense of awareness of the environment and social interactions within a theme. Their increased powers of observation developed through a time of immersion, assisted them to notice even subtle clues to inform their understandings. Further writing will provide an in-depth translation of where the Arts may enhance creative design and technological classroom practice.

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Etymology and Ethics: Terms for Sustainability in Textiles

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ABSTRACT
Sustainability is a core focus of the new ACARA (Australian Curriculum, Assessment and Reporting Authority) and is central to all subject areas within the technology sphere. Within the field of fashion and textiles research, however, the term 'sustainability' is so over-used that it has become almost ubiquitous (Brown, 2010; Black, 2009; Fletcher, 2008, Fraser & Farrer, 2011, Clark, 2008). Carefully considered, sustainability lends itself to multiple subtle applications, so it is timely that we consider how its terminology operates in relation to both technology and textiles.

By viewing the term 'sustainability' as an umbrella concept we can consider a range of sustainability sub-themes. These sub-themes can become important contextual markers, without which it may become difficult to continue using the existing terminology. For example, in Fashion and Textiles, we are concurrently, and often interchangeably, using a range of 'green wash' (Fraser & Farrer, 2012, p. 36) terms, including, but not limited to, slow-fashion, eco-fashion, eco-chic, eco-friendly textiles, eco-sewing, eco-design, up-cycling, re-cycling, green-textiles, green-fashion, ethical-fashion, sustainable-design, and organic textiles. In turn, 'sustainability' may be used to mean cultural, ecological or economical sustainability. Within the textiles and fashion industries it has been broadly applied to fibre, yarn and fabric production, fabric finishing, apparel (and other textile items) manufacturing processes, supply chain management systems, as well as the retail related aspects of branding, packaging and marketing. Clarification of a range of sub-themes for the use of 'sustainability' as a term within textiles and fashion will support learning and teaching in technology.

This paper will discuss how it might be possible to remedy the current disconnection brought about by an over-used term and consider effective sub-themes and applications for technology education. This is especially urgent from the perspective of textiles technology as the textiles industry is one of largest employers worldwide (Fraser and Farrer, 2012, p.24), and yet currently perhaps the least sustainable. The concept of sustainability within these industries is considered to be a paradox (Black, 2009; Clark, 2008) in relation to the pervasive development of 'fast-fashion'. This is of grave cultural, environmental and economic concern. Perhaps it is technology educators who can begin to expand the discussion around sustainable sub-themes, in support of the conversations that need to occur within fashion, textiles and technology. At Australian Catholic University theoretical, practical and philosophical sub-themes of sustainability are being integrated into all of the textiles units within the Bachelor of Teaching/Bachelor of Arts (Technology). This integration will be monitored through a research project that aims to measure increasing levels of student awareness and record an increased capacity to synthesise the complex terms of sustainability within Textiles and Fashion.

Keywords: Sustainability, Textiles, Fashion, Etymology, Ethics

INTRODUCTION

Use of the term sustainability must become more practicable within Technology education. Carefully considered, sustainability lends itself to multiple applications. This discussion of its etymology and several sustainability sub-themes aims to explore a range of relevant applications within Textile and Fashion design. It is important to clarify these sub-themes and their possible functions within Textiles and Design because of the way the field is perceived by society. The rhetorical titles used by Hazel Clark and Sandy Black clearly outline the current dichotomy: SLOW + FASHION-an Oxymoron-or a Promise for the Future…? (Clark, 2008) and Eco-Chic: The Fashion Paradox (Black, 2011).

ETYMOLOGY

Sustainability is an illusory, complex and yet vital term. Etymologically, it is linked to the word sustain and can be defined as: "support, uphold the course of, endure without failing, sustenance" (Hoad, 2012).

We understand etymology to be: "the history of a word or word element, including its origins and derivation", noting that "any shift in meaning that has occurred in the historical transmission of the word must also be explained" (Britannica, 2013). Within most pedagogical methods in technological education we would introduce a new or core topic of study with a definition, however in the case of sustainability the formal definitions remain very broad. As a field we need to continue to develop and apply our own definitions as the dialogue and research around textiles technology and its relationship to the broader question of sustainable practice in textiles and fashion emerges.

The term 'sustainability' has evolved from the science of ecology. The Oxford Dictionary of Ecology provides the following definition:

SUSTAINABILITY (SUSTAINABLE DEVELOPMENT)

Economic development that takes full account of the environmental consequences of economic activity and is based on the use of resources that can be replaced or renewed and therefore are not depleted. The concept was introduced in the late 1970s and was emphasized strongly in the World Conservation Strategy, published in 1980 by the IUCN in collaboration with the UN Environment Programme and the World Wildlife Fund (now the World Wide Fund for Nature). (Allaby, 2012).

Although it originally related to economic impacts upon ecology the term 'sustainability' is now applied across many fields. Within textiles and fashion we observe the need to define sustainability within the categories of fibre production; fibre, yarn and fabric production; apparel and non-apparel manufacture, design, supply chain management and waste disposal. Sustainability is used as a broad 'umbrella term' and thus requires careful definition in relation to specific subject areas like Textiles Technology. If this occurs, its application will become more meaningful and focused for students.

SUSTAINABILITY: AN OVERUSED TERM?

Sustainability has become a ubiquitous term (Brown, 2010; Black, 2009; Fletcher, 2008; Fraser & Farrer, 2012; Clark, 2008). Joan Farrer describes it thus: "at the last count and rising there were 70 different definitions of sustainability (Holmberg and Sandbrook, 1992; Pearce et al, 1989). What do 70+ definitions of the meaning of sustainability mean for practitioners in the fashion industry now?" (Farrer, 2011, p. 20). We need to be very clear about when, how and why 'sustainability' is used and what other sub-terms or field-specific terminology may be used to replace or expand upon the basic premise.

Expanding the terminology may assist students to apply the philosophical concepts of sustainability more effectively. Farrer opens her article with the question: “What is sustainability?” She continues,

The word sustainability has a plethora of meanings and is frequently misunderstood; unfortunately it has become synonymous and interchangeable with recycling and the environment, whereas the original rationale from the 1950s was to focus on social change to alleviate global poverty. The misrepresentation and cherry picking of values from the sustainable agenda, particularly over the last decade, by business, marketers, politicians and even by education, has led to the movement becoming hijacked for commercial purposes (Farrer, 2011, p. 20).

The need for a clarification of terms has been expressed by researchers within the field, including Farrer:

In many expert circles there is a struggle to find another word to replace sustainability, because its deeper meanings and associated philosophies have become worthless, vacuous brand development and ‘green-wash’ tools. One of the most cohesive descriptions given more than 20 years ago by Brundtland was that “… Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (Brundtland, 1987), (Farrer, 2011, p. 20)

Fraser and Farrer observe that this ambiguity or term misappropriation has led to general misunderstanding within the industry. They propose that consumers are becoming tired of “the cynical smokescreen of fair trade, ethical production and [the proliferation of] ‘green-wash’ [terms]” (Fraser & Farrer, 2012, p. 25). Farrer proposes a model of ‘Remediation’ that must consider three key factors: Planet, People, Profit.

The need for increased transparency of these sub-factors (planet; people; profit) (Farrer, 2011, p.20) and their complex degrees of inter-relationship is widely acknowledged within the industry:

Traceability in the supply chain is now becoming increasingly important to the consumer of clothing, in the same manner as seen in the food industry with the growth in the organic market. [Yet] how is the customer, buying clothes to know which is the best ecologically or ethically sound purchase? In order to become more ethical in their purchases and complete the desired virtuous circle, consumers need to be educated about the provenance of their clothing, in much the same way as food is now labeled with detailed contents, nutrition and origins. However, as with food – much eco-jargon has arisen when applied to fashion. The term ‘eco’ is a key culprit, together with ‘green’, ‘environmentally friendly’, ‘sustainable’, ‘bio’ and also ‘organic’. No internationally agreed standards exist for these terms yet, (Black, 2009, p. 240).

Within education we need to monitor the outcome of labeling initiatives and the push for a more uniform or ‘shades of green’ international eco-labeling system.

SUSTAINABILITY: MULTIFACETED DEFINITIONS
The term sustainability harbors multifaceted definitions and sub-themes that must be specified and applied to each field. There is a consensus among researchers that the term itself remains ‘elusive’: Lance Hosey suggests that: “for such a familiar term, sustainability remains [a] surprisingly ... inconsistent concept” (Hosey, 2012, p. 19). Kim Fraser and Joan Farrer describe the tenuous understanding of the term in relation to fashion and textiles thus: “fashion textile literature and theory relating to sustainability is often emotive, fragmented and vague” (Fraser & Farrer, 2012, p.25). Alison Gwilt and Timo Rissanen identify a sense of complexity and ambiguity around the term from the perspective of designers within the industry:

although there is an increasing universal awareness of environmentalism and ethical issues ... sustainable fashion can appear complex. Fashion designers and consumers are often confused by the language of sustainability and professional resources sometimes do not make it clear how people can connect with methods of best practice, creating barriers for engagement with sustainability (Gwilt and Rissanen, 2011, p. 13).

Gwilt and Rissanen's 'barriers for engagement' is key: these barriers are present in society as a whole (thus affecting technology students) and need to be analysed (Gwilt and Rissanen, 2011, p. 13).

SUSTAINABILITY: ETHICAL DESIGN PHILOSOPHY

Researchers have suggested that the majority of textile and fashion designers are unclear how to modify their approach to design, sourcing and manufacturing. Gwilt has suggested that some designers are focused on making changes to their approach but lack access to the appropriate knowledge and supply chain contacts which would allow them to do this effectively (Gwilt, 2011, pp. 59-73). This clearly needs to be addressed in textile and fashion design courses but also provides us with an example of why the theoretical issues and field-specific terminology of sustainability should be explored further in order to provide focused models for application across the educational sector (Gwilt, 2011, p. 64).

Perhaps one of the reasons why sustainability has been approached in a 'piece-meal' way is the need for it to be underpinned by an ethical philosophy (Gwilt, 2011, 67). This would involve a serious re-alignment of the current fashion and textiles design model (societal and educational). Gwilt mentions one recent textile and fashion education publication that includes a small appendix on 'ethics'; this currently considers aspects of copyright and ethical design practice in relation to copyright law – perhaps it should also include ethical practices related to sustainable design thinking (Gwilt, 2011, p. 67). A recent RMIT PhD thesis was also developed in response to this need for an ethical re-alignment of values and the overarching need to re-consider the 'value' (in terms of material, social, historical, cultural and personal value) of textiles in education and our communities:

The hypothesis proposes that there is a changing context of practice, and that empathy is integral to the holistic design for sustainability and social engagement response; recognising the transferable empathic skills within engaged design (Thomas, 2012).

This describes a shift towards recognition of the importance of ethics education around the issue of sustainability referred to by researchers including Fraser & Farrer (2012, pp. 28-30) and Fletcher (2008, pp. 41-73). In her book *Sustainable Fashion and Textiles: design journeys*, Kate Fletcher devotes an entire chapter to the concept of 'Ethically Made' Fashion and Textiles (Fletcher, 2008, pp. 41-73); Fraser and Farrer have referred to a new era where ethics will be vitally embedded into sustainable design thinking and philosophy (Fraser & Farrer, 2012, pp. 28-30). This research can richly inform our approach to integrating sustainable design philosophy into technological curricula and support a more meaningful engagement with graduate attributes like the recent inclusion of an 'ethically informed' list of attributes at Australian Catholic University including:

"Ethically informed and able to:

1. demonstrate respect for the dignity of each individual and for human diversity
2. recognise their responsibility to the common good, the environment and society
3. apply ethical perspectives in informed decision making".

In light of initiatives like this it is vital to consider how we might include ethics as a new fundamental concept in sustainability educational dialogue within technology.

THE 'SLOW-FASHION' PARADOX: THE 'VALUE' OF TEXTILES AND CONSUMER DISCONNECT

In textiles and fashion there is currently a sense of disconnection between the consumer and the purchased product. The phenomenon of 'fast-fashion' in particular is creating unprecedented levels of textile waste in the community. Gwilt and Rissannen describe how:

today the fashion industry relies on the fast and efficient manufacture of new seasonal trend-driven products… The continued cycle of buying, using and disposing of fashion clothing is based upon a system of production that has serious consequences for our society and the environment. The trend for fast fashion has generated an exponential rise in the scale of fashion garments that are often worn too little, washed too often and quickly become discarded, (Gwilt & Rissannen, p. 13).

Researchers are beginning to profile these waste patterns and predict that textile waste will soon need to be separated from regular household rubbish. Kate Fletcher writes: "the total amount of clothing and textile waste arising per year in the UK is approximately 2.35 million tonnes. This is equivalent to nearly 40kg per person per year" (2008, p. 98-99). She notes that this equates to 30 kilograms of landfill per person, per year (2008, p.98). She describes how legislative changes are being made in Europe in response this excessive waste: "most waste textiles are considered recyclable and fall under the European Union's Landfill Directive. Recently revised targets mean that all textiles will be banned from landfill by 2015 and will have to be collected separately from other rubbish" (Fletcher, 2008, p. 99). An alternative approach, the concept of 'Slow-Fashion' that has been proposed by a number of researchers (Fletcher, 2008, p. 173; Fletcher, 2010, pp. 259-266; Black, 2011, p.78) considers how:

It offers a changed set of power relations between fashion creators and consumers compared with growth fashion, based on the forging of relationships. It professes a heightened state of awareness of the design process and its impacts on resource flows, workers, communities and ecosystems. It prices garments higher than in the growth model to reflect true ecological and social costs and as a production model offers a radical alternative to high-volume standardised fashion (Fletcher, 2010, p. 264).

The fast-fashion phenomenon has devalued textiles as a commodity in contemporary western society. Ambivalence towards the value of textiles exists at the level of the domestic consumer and within the fashion industry. The consumer benefits from cheap clothing flooding the market and industry benefits from large profit margins and quick turn-around; this puts huge pressure on third-world nations manufacturing the goods in possibly unethical and inhumane working conditions and on the environment, where vast amounts of textile waste continue to accumulate.

SUSTAINABLE TEXTILES: APPLICATIONS FOR TECHNOLOGY EDUCATION

There are many areas within the sustainable textiles discussion that can be included in technology education programs. Farrer calls for a 'remediation' (Farrer, 2011); Fletcher asks us to focus on "sustainable by design: 'zero waste' design for textiles and fashion'' and other 'waste management strategies' (Fletcher, 2008); Gale and Kaur call for 'plain practicality' (Gale & Kaur, 2002); and Gwilt calls for a "relational design thinking or a more wholistic approach to design" (Gwilt, 2011). Other researchers remind us that the so-called fashion paradox may simply be another way of describing the ethical dilemma which seems to be at the heart of the most fundamental questions around sustainable practice within textiles.

Colin Gale and Jasbir Kaur outline the need for practical outcomes in order to improve the current status of ecology in textiles: "any understanding of the relationship between textiles and ecology just… alternate[s] between political analysis and plain practicality" (2002). Gwilt suggests a more wholistic approach to an industry based on three sustainable 'design-thinking' problem areas that offer potential guidelines for textile education practices:

(1) understand sustainable design strategies;
(2) link sustainable strategies with the fashion design and production process;
(3) apply life-cycle thinking to the fashion design brief (Gwilt, 2011, pp. 67-68).

Fletcher (2008, pp. 95-114) outlines two textile waste management strategies; her definitions could be applied both theoretically and practically sub-themes within Technology education:

Waste Management Strategies: (Fletcher, 2008, p. 99)

a) Design for recycling (DFR) and disassembly (DFD)
   Industrial Ecology (Fletcher, 2008, p. 108)
   Cradle-to-Cradle (Fletcher, 2008, p. 111)
   Zero Waste vision (Fletcher, 2008, p. 113)

b) Reuse, Re-cycling and Zero Waste (Fletcher, 2008, pp. 100-103)
   Re-use of goods (Fletcher, 2008, p. 100)
   Repair and reconditioning of goods (Fletcher, 2008, p. 101)
   Recycling of goods (Fletcher, 2008, p.103).

Technology education around sustainable practices in Textiles and Fashion would benefit if it reflected the goals of these researchers. It seems imperative that we use a multi-faceted approach when teaching sustainability, taking these theoretical and philosophical concepts into account:

- the domestic choice, use, care and disposal of textiles;
- a cradle-to-cradle design philosophy;
- the (global) demand for increased industry transparency in terms of (production, manufacture and supply-chain) and labeling;
- ethical concerns relating to the current unsustainable levels of demand and supply;
- awareness of the 'worth' of textiles in society as objects of material culture rather than as disposable fast-fashion fad items.

We need to consider how sustainability informs fundamental design philosophy (cradle-to-cradle); increase sustainable practices and labeling laws in production and manufacture; and consider less ecologically problematic ways to tackle textile waste in domestic sites such as individual homes and communities (Fraser & Farrer, 2012, p 31). Education is critical so students and textile consumers understand the resources - time, energy, effort and skills - that go into making yarn, fabric and apparel items and thus come to appreciate the value of textiles.

The need to consider change on a personal level is described by Fletcher: "something different to greater efficiency, also involving fundamental personal, social and institutional change" (Fletcher, 2008, p.xiii). Fraser and Farrer also describe this shift: "Now, however, economics and environment are being shadowed by the new Zeitgeist of ethics and empathy" (Fraser & Farrer, 2012, p. 32). If we can effect change on a personal or domestic level then we may see a ripple effect throughout industry and an increase in the demand for consumer education, 'traceability' and transparent, universal eco-labeling practices.

EDUCATION INITIATIVE: THE SUSTAINABILITY PROJECT

One of the challenges for textile technology educators is to integrate sustainability into an already complex and broad curriculum. At Australian Catholic University a more detailed integration of sustainability sub-themes is being introduced into the existing three major textile units, at first, second, and third year level. This call for a clarification and expansion of the term 'sustainability' into sub-themes and the introduction of an ethical design philosophy has emerged from that process. These units are being modified to include the theoretical, practical and philosophical sub-themes described above. As the students are exposed to a these sub-themes it is anticipated that their knowledge and capacity to incorporate aspects of sustainability into their own projects will improve incrementally. This study also aims to monitor any application of this knowledge in their 4th year units however the three major textiles units form the core of the research study.

Study Group: Bachelor Teaching/Bachelor of Arts (Technology) students
Location: Australian Catholic University (ACU)
Researcher: Dr Belinda von Mengersen

Rationale: To explore approaches for an integration of practical skills for domestic-level sustainability into the program alongside conceptual design, ethical and industry-based issues like supply-chain management and sourcing into all three key units.

Research aims:

1. Assess increasing levels of awareness (including complex concepts like ethics) of sustainability concepts within textiles technology (across the units)
2. Assess students on their capacity to list a variety of possible applications for sustainability within textiles projects
3. Assess students on their capacity to incorporate concepts of sustainability into their practical self-directed projects

Method: Integration of practical techniques that explore aspects of sustainability within the key textiles units as follows:
TECH108 Designing with Textiles (1st Year) – Foundations: Needlecraft (re-introduction of fundamental skills including weaving, knitting, spinning, felting, embroidery, hand-sewing and darning for re-use and repair)
TECH209 Textile Industries (2nd Year) – Eco-dyeing and printing (workshop, skills development)
TECH212 Textile Innovations (3rd Year) – Re-fabrication Project (project based on the sustainability concept of re-cycling).
The outcomes of this study will be measured through exam questions, design evaluation tasks and design projects.

Outcomes: The outcomes of this research remain speculative. As the project progresses it would be appropriate to expand this set of practical skills to enable students to effect change and consider alternatives within their own homes, future class-rooms and communities and begin to integrate some more complex integrated sustainable design (like 'cradle-to-cradle') thinking into the textiles units. It would be appropriate to consider textiles-specific ethical awareness or discussions within these units.

CONCLUSION

It seems vital in light of this research and the new ACARA curriculum focus to continue clarifying sub-themes that augment the term 'sustainability' within our already broad field of Textile Technology. These sub-themes need to address practical, theoretical and philosophical aspects of sustainability and attempt to integrate them into a wide range of learning and teaching activities.

GLOSSARY OF TERMS:
If space had allowed it would have been ideal to include a glossary of terms, instead please refer to detailed Glossary of Terms and Resource lists developed by both (Black, 2009, pp. 244-252) and (Brown, 2010, pp. 202-204) a note on 'Eco Labelling' (Black, 2009, p. 240) and 'The Labelling Jungle' (Black, 2009, p. 244). In the Kadolph, S. (2013) 1st ed. *Textiles Basics*, [Pearson] some basic tenants of sustainability are embedded throughout text.

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Activating Creative Forms of Reflective Writing for Sustainable Self-Directed Learning in the Lab/Workshop/Design-Studio

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ABSTRACT
Writing is a technology that re-structures thought - Walter Ong (1986)

Could 'creativity' be the key to more authentic reflective writing technology education? Could it provide sustainability by offering tools for self-directed learning?

This paper proposes that a practice of more *creative* reflective writing can help to sustain and support independent learning and teaching, through the use of a meaningful vocabulary and ongoing internal and external dialogue. Reflective writing practice is a strategy that could be used in more creative and ways to support the design development process within Technology Education.

The concept of creativity is undergoing a renaissance in Design and Visual Arts education. In this paper I identify some models of reflective writing practice that can be usefully applied in Technological learning within the lab, workshop, or design-studio setting. These models, which offer an alternative 'visual' and diagrammatical approach, provide the opportunity to document the design, development and cognition as it occurs, as well as the final reflective stages of learning.

Keywords: Evaluation, Creativity, Design, Reflective Writing, Learning Journals

INTRODUCTION
We do not write in order to be understood, we write in order to understand.
C. Day Lewis (1946)

Creative education researchers Orr and Blythman have proposed that the practice of writing "parallels the practice of making", and suggested that writing can operate effectively within the practice-theory loop (praxis) (2002). In this context, writing can support lab, workshop, or design-studio learning more effectively when: (a) it is being used regularly to build up skills and confidence; (b) it is linked to assessment tasks; and (c) when it is clearly linked to their personal endeavour (Francis, 2009, p.36).

This pedagogical method, which incorporates creative and diagrammatical models, highlights the connection between creative thinking and writing. In Technology it has the potential to assist students in developing reflective writing skills that support a sustainable self-directed primary and secondary reflective practice.

4. Creative reflective writing can be used to support research, design development and enrich production within the lab, workshop, or design-studio
5. Reflective writing can be used to encourage sustained critical awareness through self-assessment and provide a framework for independent self-directed learning

Creative, reflective writing models can enhance learning journals and other reflective writing practices. Potentially, they may support reflective writing practices within technology by offering more approachable, logical, and arguably less formal methods for *thinking* through writing. One of the crucial factors in Technology education, design is the capacity to identify problems. If we understand, as Sawyer suggests, "creativity involves both problem solving and problem finding" (Sawyer, 2006, p. 73), perhaps we can continue to diffuse the myth of the 'single big idea', and that reflection can only occur once the project has been completed. Such a realisation would enable a more considered and sustainable approach to the inclusion of reflective writing, in parallel with design thinking.

Reflective thinking and writing is a vital component of Design and Technology education. The use of creative reflective writing practices within learning journals can reinforce sustainable self-directed learning in Technology. Creative approaches can potentially be integrated throughout Sanders' design/make/evaluate model (2012). Within visual arts and design educators integrate a 'reflection-in-action' (Schon, 1991, p.191) model that encourages ongoing contemplation to occur throughout all stages of design. Francis describes this process:

Reflection while doing, and on how and what you are working on, helps the journey progress and encourages exploration of alternative routes that may be tried. Reflection after action, explaining (to self and others) through writing… and considering a range of perspectives and view-points are the key constituent to secondary reflection. This enables us to learn from the past and to develop skills and techniques that we can call on in the future (Francis, 2009, p. 36).

This process shifts the reflection from a final value judgment of the work to a more meaningful student-focused, ongoing documentation of the learning undertaken in any particular project. This student-centred approach can:

- offer the student a broader understanding of how learning undertaken in one project may be applied to another;
- shift the focus from assessment outcomes and justification of work already completed to an active documentation of insights or creative risks taken;
- support a link between theory and practice where creative, critical and reflective thinking skills are developed, and
- enrich the overall learning experience by allowing time for incremental reflection and thus metacognition.

The value of integrated reflective writing in this context may be best described in terms of its relationship to learning outcomes within Technology. While learning outcomes do vary subtly from institution to institution, there are many commonalities. An embedded practice of reflective evaluation can enrich many of these intellectual, professional and personal attributes such as:

- critical (and independent) thinking

- reflective thinking
- problem solving
- capability for independent, self-directed practice and managing own work
- capability for life-long learning
- capacity for initiative and innovation
- willingness and ability to analyse, synthesis and evaluate information
- demonstrated capacity for effective communication.

(These points are an amalgamation of the tertiary graduate attributes from Australian Catholic University, University of Technology, Sydney and University of New South Wales, Australia.)

As part of its proposal, this paper will introduce a set of approaches and terminologies currently being used within design and visual arts. It will describe two case studies undertaken within tertiary visual arts/design education. Such approaches speak directly to ambitious educational aims, and may be utilized to creatively enrich current reflective writing practices. The paper will also explore the role of creative, integrated, reflective practice models in supporting a more sustainable approach to self-directed learning.

CREATIVE REFLECTIVE WRITING TASKS

Creative exercises (Table 1) can encourage students to use a learning journal more consistently and find methods that suit their own learning. Many creative writing tasks can be adapted to field-specific design development within Technology. The following have been identified as useful strategies within The Studio Writing Research Project:

Table 1: Creative Reflective Writing Tasks

Task	**Reference/s**	**Summary of approach**
Use questions	(Moon, 2006, p.142; Johns, 1994)	"Questions help learners to get started in reflecting or to deepen their reflection." (Moon, 2006, p.142)
		Develop a set of program specific learning journal (or reflective) questions involving the writer (Johns, 1994, p.71-5)
Generate questions	(Moon, 2006, p. 142 citing Hahnemann, 1986)	"An intermediate stage between the use of pre-posed questions and unstructured writing is to ask learners to develop their own questions." (Moon, 2006, p.142)
		Pat Francis calls these Reflectionnaires (Francis, 2009, p.51).
Concept mapping or graphic representation of ideas	(Moon, 2006)	"A concept map encapsulates an idea and the themes radiate from the main idea and subdivide hierarchically," (Moon, 2006, p.143)
Writing lists	(Francis, 2009)	Lists are a "way of limbering up, and helping develop associations" (Francis, 2009, p. 105)
		Non-hierarchical lists including a Spiral (Francis, 2009, p. 96); the Plait (Francis, 2009, p. 97); the Daisy metaphor (Francis, 2009, p. 98-99);

		Vocabulary extension including Mnemonics (Francis, 2009, p.127); creating words (Francis, 2009, p. 130-131); repetition (Francis, 2009, p. 135); nouns and verbs (Francis, 2009, p. 138-139)
Free-flowing or stream-of-consciousness writing	(Moon, 2006 citing Elbow, 1973)	This process can be used as a less-formal warm-up (Moon, 2006, p. 143).
Take a sentence	(Moon, 2006 citing Hahnemann, 1986)	"Hahnemann (1986) asks her students to 'take one sentence…and write on its meaning'" (Moon, 2006, p. 144)
Draw or map a research process	(Moon, 2006) / Visualizing Research (Gray and Malins, 2004)	"Draw your project" (Moon, 2006, p. 151)
		"Undertaking a contextual review: mapping the terrain", visual models of mapping research (Gray & Malins, 2004, p. 48-64)
Draw an image	(Moon, 2006, p.150)	"Progoff uses the drawing of images to facilitate reflection or to summarise a session of reflection" (Moon, 2006, p. 150)
Write a poem	(Moon, 2006)/ create Textual ontology (Hall, 2012)	"The writing of poetry can enable the emotional content of a topic to be more freely expressed" (Moon, 2006, p.157).
		"A poetics of textual practice may…encourage student designers to put more meaning into their writing by making challenges to form," (Hall, 2012, p. 365-366)

RESEARCH PROJECT: THE STUDIO WRITING PROJECT
Stage 1: Integration of creative reflective writing focus within a studio based (face-to-face) undergraduate visual arts (textiles) class.

Study Group: 3rd year students Bachelor Fine Art (Textiles)
Location: College of Fine Arts (COFA), University of New South Wales (UNSW), Australia
Researcher: Dr Belinda von Mengersen
Context: This research project was developed in a Visual Arts context. The study group comprised 3rd year students developing self-directed projects.

Research Aims

- develop a set of skills to assist students with writing self-directed projects and framing creative-research questions
- increase reflective approach and awareness of incremental decision making
- assist students to explore the link between concept and process more effectively
- assist students to develop writing skills in support of professional practice

- explore creative reflective writing methods and approaches

Method

Part A – Mini-workshop series
A series of half-hour creative and reflective writing workshops were offered to the students. Students were introduced to a range of creative reflective writing methods (see table above – Creative Reflective Writing Tasks).
Part B – Questionnaire
At the end of the workshop series a questionnaire was conducted with participants.

Outcomes

83% of students said that the process of reflective writing 'always' supported their studio practice. 100% of students said that they would like to participate in more creative reflective writing workshops. They described that the creative reflective writing process assisted them thus:

- "writing helps me in all of these ways (practical material investigations; practical technical investigations; conceptually; writing artists statements and other supporting documents; reflective writing). It also provides an invaluable source of information, knowledge, analysis, personal thoughts and responses that create the foundation or future projects. Writing fundamentally helps to clarify and solidify the concepts that inform each project. This then expands to form artist and concept statements for projects and applications"
- "my creative and reflective writing revealed a lot about my concept, often describing it in ways I couldn't yet articulate"

The outcome of this project was very positive, students' work showed a significant improvement in depth of concept exploration and resolution.
Students developed more confidence in terms of aural, text-based and visual presentations.
Acknowledgement: The initial research for this project was supported by a Small Learning & Teaching research grant (2010) COFA, UNSW.

Stage 2: Development of a post-graduate elective subject with a creative reflective writing focus within a (fully-online) postgraduate cross-disciplinary art/design master class coursework program. The aim was to apply the research outcomes from Stage 1 to an entire subject.

Study Group: Cross-Disciplinary Art/Design Masters fully online Coursework Degree
Location: COFA.online, College of Fine Arts, University of New South Wales
Researcher: Dr Belinda von Mengersen

Method

Creative education research suggests that writing is one of the most effective tools for reflection. Orr, Dorey-Richmond and Richmond (2010) consider that "reflective practice is at the heart of creative education". Primary and secondary reflective writing skills cannot be assumed and should be fostered through regular reflective writing tasks.

This course, which was written for the Cross-Disciplinary Art/Design Masters Coursework program at COFA, UNSW, is a fully-online elective subject. It highlights the critical connection between creative thinking and writing. The subject, which included an expanded range of the creative reflective writing tasks (see table above) developed for the workshop (Stage 1), commenced in 2012 and is ongoing.

Initial outcomes: student feedback (2012)

Q.5 – The course was effective for developing my thinking skills (e.g. critical analysis, problem solving).
80% Strongly Agree / 10% Agree / 10% Moderately Agree
Q. 8. – I have learned a great deal in this course.
90% Strongly Agree / 0% Agree / 10% Moderately Agree

Note: It would be ideal to be able to identify a sustained self-directed learning impact via the creative reflective writing format. This aspect of the study remains an aspirational goal.

THE ROLE OF LEARNING JOURNALS

Learning Journals

Learning journals offer structure and creativity that can support both formative and summative reflection.

The aim of learning journals, as described by Francis is "to aid students in their own learning development" and to facilitate "individual professional practice" (Francis, 2009, p. 38). These journals "include brainstorming or mind-mapping, flowcharts, lists of intended explorations, links to bibliographies and breakdowns of research folders" (Francis, 2009, p. 39).

Moon shows how students learn from reflective writing and learning journals, in that such work:

- slows the pace of learning
- can increase the sense of ownership of learning
- acknowledges the role of emotion in learning
- gives learners an experience of dealing with ill-structured material of learning
- encourages metacognition (learning about one's own process of learning)
- enhances learning through the process of writing (Moon, 2006, pp. 26-35).

Learning journals encourage reflective development in a number of educational fields (Moon, 2006; Francis, 2009; Bolton, 2010). Moon identifies many uses for learning journals; for Technology educators, these could include:

- to record experience
- to facilitate learning from experience
- to support understanding and the representation of understanding
- to develop critical thinking or the development of a questioning attitude
- to encourage metacognition
- to increase active involvement in and ownership of learning
- to increase ability in reflection and thinking
- to enhance problem-solving skills
- as a means of assessment in formal education
- to enhance reflective practice
- for reasons of personal development and self-empowerment
- to enhance creativity
- to improve writing (Moon, 2006, pp. 44-51).

Learning journals can be enhanced when creative tools are offered to students to aid their approach to reflective tasks, whether those tasks are visual, or a combination of visual and textual, related to vocabulary extension or creative writing, or focused on ideas or problem development.

PRIMARY AND SECONDARY REFLECTION: LEARNING JOURNAL SUMMARIES

Learning journals may become more effective when their format allows for secondary reflection.

Learning journals focus on developing primary reflective skills through regular writing, but they can also include a process of secondary or second-order reflection (Moon, 2006, Francis, 2009) through to a summary document (Francis). This summary document (Francis, 2009, p. 219) allows students to go back into the material developed within the journal and synthesise the contents. The summary document guidelines should be written to assist students to focus on the design journey, major breakthroughs or risks, successful and unsuccessful outcomes, themes developed and research undertaken. This synthesis can then be used to write a concise summary statement in the traditional sense for summative assessment purposes, or to replace the evaluation.

LEARNING JOURNAL FORMATS

Learning journals require structure.
Moon considers that: "structure can help students to obtain greater benefit from the journal"; and that, in this context, 'structure' means "any imposed constraint on the way in which a journal is written" (Moon, 2006, p. 52). Structures applicable to Technology education include:

- double entry journals
- structure as exercises or activities
- structure in the form of questions
- the journal is used to accompany other learning (Moon, 2006, pp. 52-55).

Structure needs to be aligned to the project and program, but it can be enhanced by a creative, task-based approach that encourages students to use the learning journal regularly and in new ways.

THE ROLE OF CREATIVE PRACTICE MODELS

Creativity and Critical Thinking

Padget describes the relationship between creativity and critical thinking as 'symbyotic' noting how creativity, critical thinking and reflection actively cross reference in an engaged learning environment (Padget, 2013, pp. 2-3). This engagement may offer another approach to the reflective writing process (Padget, 2013, p.18).

In the context of Technology education reflective writing should provide evidence of critical thinking. Padget proposes that the following learning outcomes can be explored by integrating of creativity with learning and teaching pedagogical practice:

- "developing the term 'creativity', taking it from a narrow art and performance-based concept to an appreciation of the broader implications of creativity in the context of the learning and teaching experience;
- an appreciation of the close relationship that exists between creativity and critical thinking," (2013, p. 20).

Padget considers that some personal teaching philosophy can be re-framed, based on these tenets, in order to actively include more creative approaches where:

- "the learner is placed at the centre of the learning process
- methods are used that enable learners to make new connections, thereby gaining new understandings

- where the activity of teaching is not the transfer of knowledge, but the creation of possibilities for the construction of knowledge (Padget, 2013, p. 21 citing Freire, 1998).

Application of these creative models within Technology education remains speculative, although they are being considered for inclusion into various Technology units within the Bachelor of Technology / Bachelor of Arts (Technology) at Australian Catholic University. The aim of this implementation and subsequent research would consider how they may support more focused reflective writing and sustained self-direction, critical thinking and self-assessment skills throughout the Technology units within this course.

CONCLUSION

Creativity is integral to learning, teaching and evaluation. Recent research suggests that critical thinking can be enriched, independent thinking supported, and evaluation made more meaningful for students by the introduction of creative and reflective writing practices. This paper shows how reflective writing, learning journals and secondary reflection practices that are both formative and summative can be used to enhance Technology education pedagogy.

Note:
In 1996-97, the researcher participated in a writing-within-the-studio pilot program as a post-graduate student at Goldsmiths College, University of London working with Pamela Johnson (a program initiated by Professor Janis Jefferies). This concept was developed by others at Goldsmiths and became a research project called The 'Writing Pad' www.writing-pad.ac.uk/ initiative based at Goldsmiths College, University of London, UK. This then resulted in the development of The Journal of Writing in Creative Practice (Intellect, UK). The Writing PAD included an extensive list of international partner institutions. Other significant research has been published in The Journal of Art, Design and Communication in Higher Education (Intellect, UK) including the special guest edited 2-part edition (2004) 'Textual and Visual interfaces in art and design education', and a recent International Centre for Learning and Teaching in Art and Design, University of the Arts, London (CLTAD) conference events including (2010), 'Creative Partnerships: helping creative writing and visual practice students to make links between their creative processes and their personal, vocational and academic development.'

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Sustainability + Needlecraft = Textiles Technology: Could a Return to ‘Needlecraft’ Skills Enhance Sustainable Practice in Textiles?

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ABSTRACT

This paper proposes that a re-framing of Needlecraft in Textile Technology learning and teaching practice can enhance practical and theoretical aspects of sustainability. It introduces the concept of a fourth category of Needlecraft termed ‘Resourcefulness’ that incorporates both utilitarian and creative stitch practices. This discussion outlines historical and contemporary examples where these two forms have been effectively co-joined. Further, it describes two tertiary educational initiatives introducing new forms of Needlecraft into their curricula in response to the focus on sustainability and innovation within Technology education in Australia. Research suggests that the knowledge of Needlecraft that once resided in homes and schools has been almost entirely eroded within two generations (Fletcher, 2008, p.101). Perhaps this erosion might be partially redressed by re-framing aspects of Needlecraft that can enhance the integration of concepts and models for sustainable practice in Textile Technology.

Keywords: Sustainability, Textiles, Craft, Needlecraft

INTRODUCTION

What happened to Needlecraft?

The practice of this simple yet dynamic skill has been undervalued in recent Textile Technology (Textiles and Design; Design and Technology) curricula and within the domestic sphere (Fletcher, 2008, p.101). It is vital, however, that the Textile and Fashion industries embrace ethical and sustainable design philosophies across all areas, including fibre, yarn and fabric production, apparel and non-apparel manufacture, and marketing and supply chain management. Intrinsic to this shift is an unlikely candidate: the humble needle. As Textiles Technology educators, we need to reconsider needlecraft and its potential to provide essential learning, learning that may prove fundamental to more sustainable, ecological and ethical practice across the industry. The unassuming skill-set of Needlecraft, long fallen out of fashion, offers uniquely practical, creative and transformative capacities. If a student, even one majoring in textiles, does not know the meaning of such terms as ‘darning’, how can we hope to combat voracious textile consumerism or ask society to embrace ‘slow-fashion’?

NEEDLECRAFT TERMINOLOGY

In a recent publication Clayton (2008) lists 1001 Needlecraft terms, indicating the vast spectrum of stitch practices that sit under the banner of needlecraft.

We can broadly classify Needlecraft into 3 categories (Table 1):

Table 1 Three categories of Needlecraft

1. Structural	Including plain sewing, hand-construction techniques and couture dress-making
2. Decorative	Including embroidery and other stitching methods used for embellishment (this category could also include any other decorative structural or embellishment like fabric manipulation, knitting, crochet, canvas work, applique', patchwork, quilting etc.)
3. Repairable	Including darning, patching and mending (historically some darning was highly decorative as well as utilitarian, this can be seen through the elaborate darning sampler tradition, many superb examples are held in the Victoria and Albert Museum, London.

Traditionally these categories of needlecraft are taught separately in Textile Technology. Repair has become a maligned term as a result of its disconnection from more creative or design-based Needlecraft practices. Yet, perhaps it should be reconsidered in the context of Textile Technology with the rise of 'fast-fashion' and the subsequent increase in textile domestic waste.

Repair or utilitarian Needlecraft skills have been used in society most effectively during times of crisis including war, economic or resource instability, including examples such as the make-do-and-mend English government campaigns during World War 11 (Griffith, 2010), and the Wagga rugs made across Australia during the depression (excellent examples are housed in both the collection of the Powerhouse Museum, Sydney, Australia and Tumburumba Women's Hut, Tumburumba, New South Wales, Australia).

This paper proposes firstly that the category of repair could inform the development of sustainable practice in textiles and secondly that there needs to be a fourth category that intertwines aspects of decoration and repair termed 'Resourceful' Needlecraft (Table 1.1).

Table 1.1 Proposal for a fourth category of Needlecraft

4. Resourceful	Including co-joined aspects of decoration and repair.

SUSTAINABILITY: WHAT DOES THIS MEAN FOR TEXTILE TECHNOLOGY EDUCATION?

Many schools already employ projects based on recycled textiles, however there is much scope for extension and the introduction of other meaningful, practical tasks.

Reframing practical Needlecraft skills including embroidery, hand sewing and darning can provide an effective starting point. While recycling is an obvious and effective way to introduce students to the idea of sustainable practices in response to textile waste there are other approaches that may prove equally useful in the development of practical projects. Fletcher (2008) suggests that recycling is not always the best use of resources and that other approaches should be developed in parallel. Fletcher (2008), mentions three key strategies illustrating least to most resource intensive:

- Reuse (Fletcher, 2008, pp. 100-101)

- Repair and reconditioning (Fletcher, 2008, pp. 101-103)
- Recycling (Fletcher, 2008, pp. 103-105).

In this context it may be helpful to consider ‘repair’ as a key category and tool that can include practices of reuse, repair, repurposing and reconditioning, alongside recycling. I propose that Needlecraft skills are required in order to effectively carry out all of these applications.

DESIGN AND NEEDLECRAFT

It is generally understood that education moved away from traditional Needlecraft because of its domestic connotations. In some Australian schools, however, creative Needlework was developed with a visual arts and crafts focus:

The NSW art syllabus, which had been introduced in 1947, allowed for students to submit for their final work for the Intermediate Certificate and for the Leaving Certificate ‘one finely conceived and executed piece of Art–Craft work’. Included among the choice of techniques was ‘Needlecraft generally and embroidery, appliqué, cross stitch and crewelwork...’. It was in this context that students in some schools were introduced to the possibilities of stitching as a form of creative expression, (Wood, 2009, p. 781).

In the 1960s, Australian high schools offered three separate subjects that incorporated needlecraft skills: Needlework, Needlecraft and Garment Construction, and Visual Arts. From 1964-1967, both Needlework and Needlecraft and Garment Construction were taught. From 1967-1969, these subjects were effectively merged into Textiles and Design (Barlow, 2012, p. 34-36). Currently, depending on the institution, students can - potentially - study textiles. A brief glance at the titles of such courses reveals that, as ‘design’ became the key focus, the emphasis on domestic Needlecraft skills was eroded. This mirrors a societal attitude that - at best - has come to view such skills with ambivalence (Fletcher, 2008, p.101).

While embroidery in art and design flourished and became a successful creative craft in some Australian schools in the 1970s, it focussed on professional rather than practical domestic outcomes. This changing context, examined by Susan Wood, mirrors developments in the United Kingdom, especially the work of Constance Howard at Goldsmiths College, University of London, (Wood, 2009, p. 784). However, excluded from the formal education sector, traditional craft-based and less ‘design’ oriented practices like plain sewing and Needlecraft for repair or darning have been increasingly marginalised and undervalued. Textile work that is aesthetically driven has become more highly valued, while simpler skills - more closely related to the repair and reuse of textiles - have been neglected. The inevitable result is that most students are no longer exposed to them. Research suggests that, within two generations, this knowledge base has been almost entirely eroded (Fletcher, 2008, p. 101). Paradoxically, it may be within the sphere of technology, through the re-introduction of a fundamental Needlecraft skill base, that this attrition is most effectively redressed. Contemporary Australian embroiderer Mae Finlayson calls herself a ‘stitch imagineer’ in her staff profile (University of Tasmania, Australia), which indicates the capacity for creativity and innovation in Needlecraft practices that has long been known through examples like the ongoing influence of Constance Howard from Goldsmiths college in London (Hill, 2012). Perhaps we need to follow her lead by re-inventing the terms of Needlecraft for Textile Technology.

THE ‘VALUE’ OF TEXTILES: FAST AND SLOW FASHION

How should technology educators attempt to bridge the gap between ideology and reality, and what is the potential role of Needlecraft within education for sustainable textile practice?

Researchers Fraser and Farrer describe a ‘divide’ or ‘polarisation’ between high-end, made-to-measure fashion and cheap vertical or ‘fast’ fashion (2012, pp. 27-30). This fast fashion industry can produce a new range every six weeks. The scope and speed of such production results in an enormous amount of unsustainable waste (Farrer & Finn, 2009; Fletcher, 2008; Gwilt &

Rissanen, 2011) and equally unsustainable demands on the supply chain (Black, 2008). And what is the result of these fast, cheap textiles flooding the market? Inevitably, the status and inherent value of both product and process are undermined. Such profit-driven practice is clearly unsustainable.

To begin to address these concerns effectively, it seems necessary to develop strategies that support 'slow fashion' and allow sustainable practices to become more accessible through the re-introduction of Needlecraft skills. Black has described slow fashion includes "bespoke and longer life products, and new definitions of luxury and appreciation of craftsmanship" (Black, 2008, p. 78). In light of this Needlecraft just might provide a crucial link between design and ethics. For the necessary shift to occur, however, the corresponding skill-base of Needlecraft to support the concepts proposed by Fletcher of 're-use, recycling, repair and re-conditioning' (Fletcher, 2008, pp. 95-114) needs to be reframed within educational practice.

'RESOURCEFUL': COMBINING ASPECT OF DECORATION AND UTILITY

The author suggests that needlecraft becomes very interesting territory when both the utilitarian and decorative principles are combined.

HISTORICAL EXAMPLES

Historical examples that combine these principles include traditional Japanese Boro, and Sashiko (Paine, 2008) and Indian Kantha (Mason, 2009; Pain, 2008; Caldwell & Morrison, 1999) embroidery. Both techniques use running stitch to bond together layers of recycled fabrics (like quilting) to repair or existing or create new textile items. The Boro, Sashiko, and Kantha traditions affect repair or reuse and incorporate humble decorative elements within the one item using one basic stitch structure. In both cases the 'darning' or bonding stitches are visible rather than hidden as in the traditional western use of the technique. In Japan this 'visibility' and aesthetic appreciation for the used and worn is described as the Japanese Aesthetics of Imperfection and Insufficiency (Saito, 1997).

A CONTEMPORARY EXAMPLE

Designer Natalie Chanin takes the concept of patching, where one fabric is repurposed in order to repair another then uses running stitch to combine them. She incorporates a patterned element through the use of a stencil, uses a hand stitched (or beaded) applique' techniques where running stitch bonds one layer of fabric to the other. The running stitch operates in two ways, bonding both layers of cloth together (like quilting) and becoming a decorative element. Recycled cotton jersey t-shirts are used in this project, usually one as a base garment and a second for the decorative patches. Stains or signs of wear can be consciously covered using this method and the original base garment is transformed. Chanin has produced a stitch project book with many examples of this method (Chanin, 2008). This resource offers Textile Technology educators an example of how projects using the 'Resourceful' category of Needlecraft could be integrated into the curriculum.

The nature of these examples indicates that a fourth category of Needlecraft called 'Resourceful' could be introduced into the Textiles curriculum to enhance the practical application of the tenets of sustainability. The use of this term would signify a capacity for the principles of both utilitarian and decorative forms of needlecraft to meet and enrich each other in new and innovative ways. This approach, of combining both the utilitarian and decorative capacities of Needlecraft can offer Textile Technology educators another way to apply the vast tool kit presented by Needlecraft to the question of sustainable practice.

EDUCATIONAL INITIATIVES

Needlecraft skills are currently being reframed within two academic textile courses in Sydney, Australia in order to support the integration of sustainable concepts into the curriculum.

1. Julie Lantry from the Department of Fashion and Textiles University of Technology (UTS), Sydney, Australia has integrated a research project into the course called "Sustainable Journeys: Mediated Relationships between Australian Designers and Indian Heritage Textile Artisans" (Lantry, 2012), this project is linked with a Non-Government Organisation (NGO) called The Happy Hands Foundation, Delhi, India. Selected students undertake a three-week study tour and workshop series to initiate collaborative contemporary design projects between traditional textile Needlework artisans. Students learn traditional Chikankari and Sujani embroidery and are encouraged to apply these skills and increased knowledge of sustainable practice into their future projects.

2. Needlecraft skills that relate to the concept of 'Resourceful' (Table 1.1) are being introduced within the three core Textiles units for the Bachelor of Technology / Bachelor of Arts (Technology) at Australian Catholic University, Sydney (Table 2) to enhance the practical application of sustainability concepts.

Table 2 Introduction of 'Resourceful' Needlecraft skills into the BT/BA (Technology), ACU

First Year	Students are developing contemporary designs that use traditional Sashiko embroidery; alongside a range of fundamental Needlecraft skills including hand-made string from (recycled fabric), needle-weaving, needle-punch felting, knitting and crochet.
Second Year	Students are learning an increased range of hand-embroidery stitches and developing contemporary embroidery designs that can be applied to apparel or non-apparel items.
Third Year	Students are focussing on a re-fabrication project that incorporates hand-embroidery and fabric manipulation techniques and Needlecraft related to couture dressmaking.

It is anticipated that an increased focus on Needlecraft skills will improve:

a) Students' understanding of complex woven or knitted structures through a practical introduction to basic forms of these technologies
b) Students' limited needlecraft skills
c) Students' ability to apply Needlecraft skills for sustainable applications

Student skill development in the area of Needlecraft and their ability to synthesise sustainability concepts will be documented throughout the course.

THE NEEDLECRAFT PARADOX

Fletcher describes the considerable loss of practical Needlecraft skills in the home over two generations and yet at the same time there is a clear resurgence of interest in craft practices including Needlecraft within the community*.

This resurgence is most visible in evidence of 'craftivism', a form of activism that involves craft practices like the Knitting Nanna's (https://www.facebook.com/KnittingNannasAgainstGas) who protest against coal seam gas mining in Australia. It can also been seen in increase of craft-based techniques used within contemporary visual art practice in large scale works like Penelope (2011) by Tatiana Blass (where the process of making becomes a visible aspect of the work, Hemmings has described this as an 'archaeology of practice' that fascinates because of the art-going publics general lack of knowledge about such processes (Hemmings, 2010). Further, it can seen in the editorial focus of Hemmings, In the Loop: knitting now (2010), or the curatorial focus of McFadden, Pricked: extreme embroidery (2007). This publication and exhibition explore the capacity of Needlecraft to perform in an entirely different context, they also indicate a renewed community awareness of these craft-based practices.

This is further evidenced through the number of recent publications about Needlecraft (Gordon, Harding & Vance, 2012; Clayton, 2008 Chanin, 2008; Beaudry, 2006), and the community based 'craftivism' and 'Slow-Textiles' movements as described by Levine & Heimerl (2008) and Black (2008). Needlecraft in these contemporary forms is re-evaluating its capacity for subversion and narrative as outlined by Parker (1984) in her influential text, The Subversive Stitch.

DISCUSSION: A PROPOSAL FOR THE RE-EMERGENCE OF NEEDLECRAFT

I propose that within technology we need to consider a shift in our perspective in response to these examples and education initiatives, to consider that they may, through their use of Needlecraft provide an important starting point for the effective incorporation of meaningful sustainable practice in textiles education.

We should aim to enrich recycling-based textile projects, considering the potential to also teach about re-conditioning and re-pair and focus on the possible re-use or longevity of a garment. Here it has been suggested that simple Needlecraft skills for 'repair' and the new term 'resourceful' be refocussed within the curriculum in order to support this. Fletcher's reminder seems timely: that in such a short space of time, many members of the community have lost fine needlecraft skills involved in the careful repair and reconditioning or modification of garments. It is seems vital in our role as educators to change this: to offer a reminder of how historically valuable textiles and clothes were, and why and how they were reused and repaired. Perhaps this practical approach may also assist students in understanding more complex sustainable design methods like cradle-to-cradle, the complexities of design for recycling (DFR) (Fletcher, 2008, pp. 105-107), design for disassembly (DFD) (Fletcher, 2008, pp. 105-107), design for endurance, and design for future modification or re-purposing.

CONCLUSION

This paper shows how Textile Technology educators can effectually incorporate issues of sustainability into learning and teaching by reconsidering the potential of Needlecraft. It considers that the humble needle, arguably one of the first technologies (Schoesser, 2003) may continue to play a vital role as we look towards new approaches to creative sustainable thinking and innovative design development within fashion and textile technology. This discussion concludes that the introduction of a new fourth category of 'Resourceful' Needlecraft inspired by historical and contemporary models provides a practicable method with which to approach the re-evaluation of Needlecraft skills. This approach conjoins the utilitarian and decorative capabilities of Needlecraft and can offer Textile Technologists innovative ways to apply the questions of sustainable practice.

Note

* References for this point relating to community only refer to examples or publications from Australia, New Zealand, the United States of America and the United Kingdom. In other parts of the world Needlecraft is being used and applied in different way that lay beyond the scope of this paper. There are international examples of NGO's supporting the development of Needlecraft co-operatives in regional Indian communities using traditional techniques like Kantha; or the training Young Weavers education program in West Timor http://www.geniusmoon.com.au/campaign/cache/msgimport-Friends_of_YTP_newsletter_2_Sept_2011.pdf
These projects offer a broader international perspective.

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Assessment for Learning and Fostering Student Agency and Autonomy in Technology

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ABSTRACT

In this paper we focus on how assessment for learning (AFL) practices can provide opportunities for students to develop identities as capable and independent learners who are aware of and able to employ a variation of and/or something similar to the accountability systems for knowledge generation and legitimation that are used by technologists. Sadler (1989) argued that the indispensible conditions for improvement are that students move from being consumers to active participants in their own learning and assessment. Carr (2001) adds that learner agency of this kind involves students being ready, willing and able to monitor and progress their own learning. As autonomous and agentic learners, students are attuned to opportunities to learn, to making deeper sense of their own learning and knowing when and how to take strategic action to progress their learning. They have 'a nose for quality' and the inclination and means to pursue this (Claxton, 1995). Using examples derived from a three-year research project undertaken with 12 teachers in New Zealand Year 1-8 schools we illustrate how teachers fostered student learning and learning autonomy through patterns of participation that construed learning as a social practice and collective responsibility. We detail the ways the teachers sought to ensure students had access to a range of opportunities for feedback and supported student affiliation with technology. We conclude that the 'spirit' of AfL (Marshall & Drummond, 2006) is evoked when teachers have a pedagogical mindset that foregrounds the sharing of responsibility with students as the norm, and when they provide students with opportunities, and the means, to exercise responsibility for their learning and learning progress.

Keywords: assessment for learning, autonomy, agency

INTRODUCTION

In this paper we focus on how assessment for learning (AfL) practices provide opportunities for students to develop identities as capable and independent learners in technology. We consider how the classroom culture for learning provides opportunities for students to exercise agency and authority and how teachers can foster student learning and learning autonomy when patterns of participation construe learning as a social practice and shared responsibility. We detail the ways the teachers sought to ensure students had access to a range of opportunities for feedback and how they supported student affiliation with technology.

THE STUDY

The Classroom InSiTE (Classroom Interactions in Science and Technology Education) research project was undertaken in 12 New Zealand primary school classrooms over three years. The overall aim was to explore the nature of effective student-teacher interactions in science and technology as an aspect of AfL. Data were generated through classroom observations and included videotaping and audiotaping, and photographing interactions and artefacts produced (teacher planning, student work samples). Teacher pre and post lesson/unit interviews were conducted. Student interviews, both individual and group, were undertaken pre and post unit. Informal discussions during lessons with teachers and students were also undertaken. Several teacher-researcher meetings were audiotaped and any artefacts produced collected. Insights from AfL, science and technology ideas, pedagogical content knowledge, and student agency and autonomy were used to focus the data analysis. Data were triangulated through interviews, classroom observations, and student and teacher work. Unit cases were written and cross case analysis undertaken. Teachers and researchers worked in partnership undertaking joint analysis and writing.

KEY IDEAS

The indispensible conditions for improvement are that students move from being consumers to active participants in their own learning and assessment (Sadler, 1989). Carr (2001) concurs, explaining that learner agency involves students being ready, willing and able to monitor and progress their own learning. Students have what Claxton (1995) evocatively described as "a nose for quality" and the inclination and means to pursue it. The exercise of conceptual agency involves students expecting and being able to treat "*the concepts, methods, and information of the domain [or discipline] as resources that can be adapted, evaluated, questioned, and modified*" (Greeno, 2006, p. 539). In technology it "*is about enabling learners to have the confidence, competence and motivation to choose to be the person to take on the design and technology challenge and to* ***do effective and appropriate things*** *to address that challenge*" (Kimbell & Stables, 2008, p. 21 – bold in original). The 'spirit' of AfL can be linked with teachers and students engaging in learning as a shared responsibility where both teachers and students expect to learn. AfL practices, such as self- and peer-assessment, provide a means for students to reflect on and evaluate their developing expertise and understanding of the practices that are valued in the classroom community of which they are part. Jointly-defined learning goals and criteria for quality become tools that students can use to assess and develop their expertise as learners of technology. When students are positioned as both authoritative and accountable there is an entitlement, and expectation, that they will be able to move to access resources and have the authority to use, adapt, and combine these resources. In this paper we focus on how teachers supported student agency and resourcefulness and at the same time held students accountable to the norms of technology.

FINDINGS

(1) Patterns of participation for learning as a social and shared responsibility

Classroom routines and the patterns of participation that students and teachers develop together, shape and frame the extent to which learning is experienced as a social and shared responsibility.

Routines and frequently used task structures: Teachers deliberately set out to establish routines that supported learning as a social process. Lois and her Year 1 to 4 students worked on the technology topic of creating healthy snacks. In an early lesson she wove together several tasks to provide students with multiple opportunities to make and communicate meaning in around 30 minutes: a class discussion of what constituted a healthy snack, a group sort of healthy and unhealthy snacks, a class pooling of ideas where an anomaly was discussed, a revisit of the sorting task, and, a final class pooling of ideas. Lois used familiar classroom routines and task structures to advance the transition from one activity to the next and to help students remain focused on the learning goals of each task. Students were experienced in conducting sorts where a nominated leader acted as a coordinator, but everyone was expected to contribute with everyone's ideas being treated respectfully. In the class pooling of group ideas, students only contributed ideas not already given, a familiar routine to the class. Routines established the classroom as a learning environment in which students were expected, entitled and obligated to work together to support each other's learning (Gresalfi, et. al., 2008).

Recognising and crediting student ideas and suggestions: Teachers recorded student names beside the ideas they offered in group and class discussion, thus providing an enduring record of what was said and by whom. Displaying these records helped everyone build a picture of what was contributed and they were then revisited as a reference source. This technique positioned students as contributors of ideas that were worthy of collective consideration and helped establish a classroom culture that construed learning as a social process. Teachers also displayed student work as a way to accord value and credit students with having interesting and useful ideas. Free access to the displays expanded the time students had to think about the ideas and practices they were learning. Teachers also made floor books of student work. Photographs, text and diagrams helped students to 'see' their engagement with learning. Shared readings of the evolving book gave value to students' previous activities. These books were placed in the classroom library, a strong indication of the worth of student ideas.

Patterns associated with freedom to move and seek out support and resources: As part of a classroom culture for learning students need to be able to move freely around the classroom to access help, knowledge and resources for comparison, elaboration and inquiry (Roth, 1997; Windschitl, 2002). Gail's Year 3 and 4 students established together criteria for designing, making and testing a tong in their first two lessons. In the third lesson, Barry "invented" a spring to improve the functionality of the hinging mechanism in his tong. During this lesson, groups nominated representatives to visit Barry's group to explore his spring. They were very taken with Barry's idea and all adopted it, constructing a spring of some sort. However no students, including Barry, were able to securely attach their spring to the arms of their tong. By the end of the fourth lesson, no group retained a spring as part of their tong solution. This was a telling illustration of the conditions for conceptual agency. The idea of a spring emerged, was judged as valuable, diffused around the class, proved too difficult to operationalise, and so became redundant. Throughout this exploration it was essential that students could move about the classroom to source ideas and take them up in pursuit of understanding and/or task completion. Students also talked about joint responsibility for, and shared ownership of, learning. For example Mike (5 years) commented that: "*if you're stuck the teacher always helps you. Group work is good because the whole group got to make the food… When we are on the mat we can think about lots of things*". Shane (7 years) said: "*we got the jobs done faster and if you needed help doing a job and you can't do it by yourself you've got a buddy to do it with*".

(2) The distribution of authority and sources of knowledge and feedback

To be able to use what they learn beyond the moment and beyond the classroom students need to experience how different disciplines exercise authority over what counts as valued and legitimate knowledge. As well, the authority for developing and attributing worth to ideas needs to extend beyond the teacher.

Fading scaffolding to support agency and to share authority: Teachers designed task sequences where they gradually ceded authority to students. Jane scaffolded her Year 1 students through a kite design and make process. She began by guiding student observation of a simple commercial kite, pointing out the shape, reinforced corners, positioning of the braces, and flying string attachment. She modelled the making of an action plan and kite similar to the commercial one. Students emulated the same series of steps to produce a replica kite. Jane repeated this sequence twice more with different commercial kites on two different days. She was careful to replicate the technical language introduced in lesson one (bridle, flying string, braces, etc.) and used a similar sequence of steps in the action plan. Students followed her steps to also make these kites. Repetition served to increase the opportunities students had to make links between actions/ideas and particular words as well as to use the language. The use of the action plan encouraged students to "stand outside their practice" and helped them to develop a more robust self conscious awareness of what was involved (Kimbell & Stables, 2008, p.223). Finally, students created their own action plan to make their own kite having developed expertise and confidence. Jane was convinced that "*if these children had been given the task of making a kite* *without the scaffolding experiences, they would not have worked so confidently, creatively and successfully with designing their own kite*".

Creating opportunities to experience and understand how quality is judged: To help students develop a nose for quality teachers help students develop expectations for learning and the criteria for judging the quality of their work. In Grant's unit on creating outdoor signs for the school, students considered, for example, the fit between the structural size of a sign and its purpose, suitability of materials for outdoor use, and building skills for constructing a stable structure. The consensus factors they distilled from direct observational experiences formed the basis of their specifications, which were used to assess the form and function of their signs. Grant encouraged students to check designs, mock–ups and final products against the specifications. They identified successful elements and where they could make improvements throughout the entire process. For example, after making a mock–up of his sign and before making the real one, David (9 years old) commented: *"My colours stand out and the lettering is clear but I am going to put a black arrow at the end so my sign shows direction. If you look at my mock–up the direction doesn't show. I also need to think, is it [the sign] high enough?"* Self and peer assessment were based on the same specifications. As a penultimate assessment, the class assessed all the signs and decided which ones best met the specifications to fit particular locations in the school grounds, where they were placed. The class development and reflective use of specifications reduced the need for the students to rely on Grant's opinion alone.

Activating peers and others as sources of information and feedback: Students often sought advice from their peers. In Jane's Year 1 class for instance, several students helped out others by explaining, showing, modelling and sometimes taking over some stages of the kite–making process. Ben became the teacher for Joe who had arrived late in a lesson. This provided Ben with an opportunity to further familiarise, practise and embed skills and conceptual knowledge, and Joe with timely help and support. Working together was possible because of the freedom Jane allowed and her encouragement of students to share their expertise. It was also possible because Ben had sufficient confidence in his own knowledge and skills to offer support – he had tested out/flown his kite and knew that it worked. Students often validated their work through a testing process focused on the functional requirements of the product. This meant they could become sources of information and feedback.

Teachers also invited people with expertise as a strategy to lend credibility to tasks beyond the classroom. Grant involved a conservationist in his unit on kiwi and the design of traps for pests found in environments that kiwi inhabit with his Year 5 to 8 students. The conservationist discussed with the students how well their traps would work – the extent to which each trap met criteria particularised for the specified pest. Students valued this affirmation and critique, especially Gary who planned to use his group's trap to catch possums on his family farm. Additionally Gary had persuaded his father to help his group make a working trap that could deal with their possum problem, another example of activating others as a source of information.

Seeding the environment with material resources to support student agency: Teachers can seed the environment with artefacts to be used as sources of information and feedback. During the third lesson on kite making with Year 1 to 4 students Lois had made sequential posters for each step. As she demonstrated each step she referred to the relevant poster, the text and the diagrams. These posters were then displayed on the classroom wall. When groups subsequently made kites they sent delegates to read the posters to check next steps. This allowed for student independence and agency as the students did not need to consult Lois as the only source of authority to find out next steps. Leaving students free to decide when and how they accessed resources was a powerful demonstration that teachers trusted students to pursue learning goals independently of them.

(3) Fostering student affiliation with technology

Teacher AfL practices need to help students participate and find affiliation with the identity of an autonomous technology learner. AfL has a role to play in helping students recognise that their classroom technology learning has meaning for them and their lives out of school, and vice versa.

Attributing students with the identity of technologist: At times, teachers explicitly positioned their students as technologists to help students realise that what they were doing and learning was technology. The attribution of identity projected students into a relationship whereby the criteria for quality for a task were linked to the expected processes experts use to undertake and evaluate their work. For example, Ellie talked with her Year 3 and 4 students about being designers when designing a mask for their forthcoming school production. She led a class discussion to establish the specifications. She showed an architectural drawing of a house elevation, commenting: "*This is a design drawing of a house. Can you see the roof, the walls, the windows, the doors?"* Students nodded "*yes*". She said: *"The designer had to put all those things in his drawing. They were his specifications. You are going to be designers just like him. You need to show in your drawing that you have thought about all of the specifications we've decided... Can you do this?"* Students indicated they could and their subsequent designs addressed the specifications. By identifying the students as technologists (designers), Ellie provided the opportunity for them to engage with classroom learning through another lens. Mostly however, students were positioned as learners and doers of technology. The topic of study was identified as a technology topic, units introduced as technology units and reminders were given over the course of a unit to help students affiliate with technology, to continue to learn technology and to see themselves in technology.

Students talking about technology: Student commentary indicated that over time they formed clearer pictures of what technology was about. Their ideas often extended beyond the current activities and topics of the unit. Younger students indicated that they viewed technology as making things for people. Adam (Year 3) commented: "*It's about other people and how things would work for them and for me. It's about making*." Older student provided a more comprehensive view relating technology to designing and making particular artefacts and activities for specific groups of people. Tim (Year 8) said: *"It's something that helps us do something. For example, the whiteboard is like a pen and paper, but a development. Chairs help us sit instead of sitting on the ground. A cup is to drink water from easier. Glasses help us see better. Technology helps us do things and makes things better."* Student comments on what constituted technology were encouraging. It was seen as a discipline that could make a positive contribution to their own, and others', lives.

Attributing value to student out of school experiences: Teachers routinely invited students to contribute their out of school experiences and ideas in class. They positioned students as authoritative over matters where they had expertise to contribute. Simon commented that it was easy for him to make healthy snacks because he did "*heaps of cooking at home*". Lois indicated that because he could understand a recipe, he would be in a good position to help others. Gary (10 years) commented to Grant that he knew about traps and pests because "*they had lots of possums on their farm. They carry disease and are pests and we have to put out traps to catch them*". Grant thought he would be able to help other students with their trap designs. Students' out–of–school experiences and ideas were viewed as having value in the classroom.

CONCLUDING COMMENTS

Several AfL practices help make tasks meaningful to students and hold them to account for explaining and justifying their ideas. Authentic success criteria are a resource for strategically guiding student learning and for students to use in assessment. Teachers can design and fade scaffolding in a way that cedes authority and transfers responsibility to students so they can make independent evaluative decisions as their expertise develops. As part of setting up the possibility of students' longer–term engagement with a discipline, AfL practices need to support student affiliation with teacher goals for learning in a manner that also fosters student conceptual agency and motivates students to continue to learn technology, to see themselves in technology. Autonomy and agency are shaped and constrained by the nature of classrooms as social settings in which particular patterns of participation and responsibility have been established. Social aspects shape whose contributions are taken to be of merit and which actions and ideas influence what comes to count as valued and legitimate knowledge in a particular classroom. When students have opportunities to exercise autonomy and agency the teacher is not the sole authority in the classroom: teachers and students share responsibility for learning. The 'spirit' of AfL (Marshall & Drummond, 2006) is evoked when teachers have a pedagogical mindset that foregrounds the sharing of responsibility with students as the norm, and when they provide students with opportunities, and the means, to exercise responsibility for their learning and learning progress.

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Developing Education for Enterprise through a Technology Education Professional Development Programme

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ABSTRACT:
Outside facilitators involved in education research projects can play a key role in establishing goals, planning the research process, collecting data, and developing tools to assist with data analysis (Mitchell & Cubey, 2003). The research reported in this paper was underpinned by an interpretive-constructivist paradigm utilizing a Fourth Generation Evaluation methodology. The purpose of the research was to examine conflicting rationales for the implementation of technology education and Education for Enterprise, and to evaluate a professional development project. The professional development project was established to facilitate teachers' incorporation of Education for Enterprise and community partnerships within technology education.

Keywords: Technology Education, Professional Development, Education for Enterprise

INTRODUCTION
The Fourth Generation Evaluation research approach allowed the collection of substantive information about teachers' thinking and practice. The responsive evaluation methodology was designed to inform and develop that practice through the provision of professional development workshops, comprising data collection, analysis and reflection.

The project involved teachers from 16 schools clustered in three regions of New Zealand. Both primary school and secondary school teachers participated in three rounds of four workshops spanning a three-year period. Data was generated about the teachers' knowledge, thinking and practice through questionnaires, semi-structured interviews, classroom observations, and reflective journals. Observation transcripts were analysed, coded, discussed, and reflected on during reflection blocks at the beginning and end of each workshop.

Despite many education initiatives using enterprise as a theme there is still considerable conceptual confusion as to what Education for Enterprise actually involves (Gibb & Cotton, 1998). Enterprise education is often associated with a variety of concepts these include work related learning (Dwerryhouse, 2001), action-learning (Revans, 1991; Jones-Evans et al., 2000), experiential learning (Kolb, 1984) and entrepreneurial learning (Gibb, 1999; Rae, 2000).

Education for Enterprise in New Zealand has been defined in broad terms by a number of key stakeholders as:

… a teaching and learning process directed towards developing in young people those skills, competencies, understandings, and attributes which equip them to be innovative, and to identify, create, initiate, and successfully manage personal, community, business, and work opportunities, including working for themselves … (Ministry of Education, 2009, Para. 1)

The New Zealand Curriculum describes a clear vision of Education for Enterprise by setting the direction of pupil learning. Included in this vision is a desire to develop young people:

- who will be creative, energetic, and enterprising
- who will be confident, connected, actively involved, and lifelong learners.

(Ministry of Education, 2007, p. 8)

They should be confident and this is reflected by them being:

- enterprising and entrepreneurial.

(Ministry of Education, 2007, p. 8)

This enterprising theme is developed further in the New Zealand curriculum when discussing key competencies which are described as capabilities for living and lifelong learning. Under the Managing Self competency it is suggested that pupils who manage themselves are enterprising. When describing the learning area of technology we are informed that technology will make enterprising use of knowledge and skills.

DEVELOPING THE PROFESSIONAL DEVELOPMENT PROGRAMME

There have been many studies of school-based professional development, programs organised and delivered by external providers, at both the local (McLaughlin & Mitra, 2001; Smylie et al., 2001) and national levels (Corcoran et al., 1998; Garet et al., 2001) which have found that professional development programs can be disconnected from practice and fail to meet the needs of those involved. Often this has led to reluctance from teachers to be involved in professional development which includes the critique of their own or their peers practice.

This professional development Education for Enterprise project aimed to provide the participating schools with opportunities to develop professional learning communities. These would be comprised of school staff, the external facilitators who supported them, community mentors and a project researcher. Together this community would develop and reflect on their professional knowledge and practice of Education for Enterprise within technology education. According to Holly and McLoughlin (1989) professional development, can be viewed as a major factor in successful efforts to improve schools. The improvements here were to be identified by shifts in understanding and practice.

It was agreed by the facilitators and the researcher during the planning stages that the professional development program should include an opportunity for demonstrating evidence of success. According to Guskey (reported in Kreider and Bouffard, 2006) it is important for participants to develop a positive reaction to the professional development experience if shifts are expected as a result. The professional development programme was designed to create a reciprocal iterative process designed to identify and develop shift interventions.

To facilitate this there was some recognition of Waters et al., (2003), assertions that any shift requires action at both individual and school level and would involve second order change i.e., shifts in practice that require an examination of personal beliefs and a new way of working.

THE RESEARCH

The professional development undertaken in this project supported teachers in creating programmes that encouraged enterprising capabilities in students (O'Sullivan, 2011). Education facilitators worked in schools alongside teachers coaching, modelling and mentoring them to integrate enterprising concepts into technology education classroom programmes and aimed to increase teacher's knowledge, confidence and capability to do so.

The professional development project was at the centre of a three year Ministry of Education (MOE) contract. For the purposes of reporting the research four research phases were identified. Each phase consisted of a professional development workshop and commentaries from the education facilitators about the school facilitation and consultation visits carried out in schools to help them implement Education for Enterprise activities.

Responsive evaluation, as described by Guba and Lincoln (1989), is organised through claims, concerns and issues. This study utilised four basic methods for generating information and making decisions; facilitated group meetings and exercises, participant observation, individual interviewing, and focus group interviews. Techniques include the 'hermeneutic dialectic', in which stakeholder constructions are investigated, challenged and contrasted to help develop new meanings.

The project included sixteen schools; these were clustered in three regions. It was intended to adopt research methods that had been well established in responsive evaluation studies. This process begins with establishing early familiarity with the backgrounds of participating schools. The description of the schools was obtained from materials offered by the schools themselves.

The following tables give a brief overview of the schools originally involved in the Education for Enterprise project. The decile rating a school is allocated relates to the economic and social factors of the community surrounding it. It is determined by the Ministry of Education. There are ten deciles starting with decile one and moving through to decile ten. Schools in decile one have the highest proportion of students from lower socioeconomic backgrounds. Schools in decile ten have the highest proportion of students from high socioeconomic backgrounds. The three clusters were selected from positive responses and by proximity to each other and the facilitators.

Rural cluster comprises two significant river catchments with different makeups. One is open plain and was heavily settled by Europeans. The other is more Māori-dominated, remote and independent, and is still heavily forested. This region is one of the most important agricultural areas of New Zealand.

Table 1: Rural cluster schools

School	Number of pupils	Decile rating	Age of pupils	Education Facilitator
Rural C one	40	na	5-21	2
Rural C two	200	7	5-10	1
Rural C three	94	5	5-12	1
Rural C four	550	2	13-18	2
Rural C five	160	4	13-18	2
Rural C six	850	7	11-18	2
Rural C seven	166	1	5-12	1/2
Rural C eight	250	10	13-18	2

Coastal cluster surrounds a volcanic peak which is the dominant feature of the region. The region has an area of 7258 km² and a population of around 110,000. The region is very fertile, due to generous rainfall and the rich volcanic soil. Dairy farming is very popular, however there are also oil and gas deposits in the region, both on- and off-shore.

Table 2: Coastal cluster schools

School	Number of pupils	Decile rating	Age of pupils	Education Facilitator
Coastal C one	350	5	5-12	1
Coastal C two	200	9	5-10	1
Coastal C three	81	5	5-12	1
Coastal C four	240	8	5-12	1

City cluster is the most populous region of New Zealand, as well as being the most prosperous in economic terms. About 34% of New Zealand's population live in this region. One city dominates and it has the largest Polynesian population of any city in the world.

Table 3: City cluster schools

School	Number of pupils	Decile rating	Age of pupils	Education Facilitator
City C one	250	10	5-12	1
City C two	320	10	5-10	1
City C three	300	1	5-12	1
City C four	380	10	5-12	1

During the four phases of the research multiple intentions were adapted successfully in response to emerging claims, issues and concerns raised by workshop participants. Generally the purposes were:

1. To provide opportunity for participant professional development in technology education and education for Enterprise.
2. To develop understanding about the nature of technology education and its relationship to a connected curriculum.
3. To develop formative evaluation exercises.
4. To ensure credibility of research findings through clarification, feedback and discussion.
5. To inform summative evaluation meetings and discussions for milestone reports to the Ministry of Education.

To collect the baseline data for the project a simple questionnaire was utilized. The initial questions were formulated as a best fit with perceived intentions for the project at the time. It was intended to ascertain the participants' backgrounds and current dispositions towards technology education and Education for Enterprise.

- Firstly, demographic information was requested.
- Secondly, participants' experiences of previous professional development projects.
- Thirdly, participants' attitudes and experiences of working in community partnerships were included.
- Fourthly, dispositions towards enterprise education were sought.

Samples of the questionnaire data are summarized in tabular form below. The number of teacher participants attending workshop one was (N=32) the number of completed questionnaires was 32.

Demographics

(A full primary is a primary and intermediate school combined.)

Cluster Name	Number of returns	Number of schools	Primary	Full Primary	Intermediate	Secondary
Coastal	8	4	2	1	1	
City	10	4	3	1		
Rural	14	8	2	2		4

Question 12 - Number of years teaching experience:

Answer	1-5 years	5-10 years	10-15 years	15+ years
Response	3	6	6	17

Professional Development

Question 16 - Have you attended P.D. in the last five years?

Answer	Yes	No
Response	32	0

Question 17 - List P.D. attended
Answer ranged from 2-12 items per respondent.

Question 18 - Do you think the P.D. impacted on your teaching?

Answer	Yes	No	Unsure	Nil reply
Response	30	0	1	1

Question 19 – Feedback on P.D.

Answer	Positive	Negative	Unsure	Nil reply
Response	27	1	1	3

Community Partnerships

Question 20a - Are Community partnerships good for student learning?

Answer	Yes	No
Response	32	0

Question 22 - Are you aware of the community partnerships involving your school?

Answer	Yes	No
Response	30	2

Education for Enterprise

Question 26 - Do you consider yourself to be an enterprising teacher?

Answer	Yes	No	Unsure	No reply
Response	21	1	8	2

Question 28 - Do you consider Education for Enterprise to be important for New Zealand?

Answer	Yes	No	Unsure	No reply
Response	27	0	3	2

Some initial observations were fed back to the MOE as part of the project milestone report these included:

1. The project involved working with a very experienced group of participants.
2. The participants indicated they were active in personal professional development.
3. Generally the participants indicated a positive attitude towards professional development.
4. The participants seemed to believe that community partnerships are good for student learning.
5. Mostly the participants claimed to know about the community partnerships in their schools.
6. The majority of participants appeared to believe they were enterprising teachers; however, approximately 30% indicated they were unsure if they were or not.
7. The majority of participants seemed to believe that Education for Enterprise is important for New Zealand.

All four workshops were repeated in each of the three geographical and population clusters - coastal, rural and city. The workshops were conducted as a partnership between the 'local' experts (the teachers) and 'non-local' experts (the facilitators and researcher). The facilitators were involved heavily with planning sessions as well as being in the classroom whilst projects were being undertaken. The focus was on 'mutual aid' provided to improve teaching and learning of 'Enterprise for Education' through the learning area of technology.
The project phases were designed around the workshops, each of which was conducted in the same way with slight variations of the programme in response to evaluations from the previous workshops and discussions between the facilitators and the researcher. The workshops were either video or audio recorded. These recordings were transcribed and checked by participants for accuracy.

CLAIMS, ISSUES AND CONCERNS FROM PHASE ONE

Recorded and transcribed discussions revealed that the participants seemed to believe that the characteristics of Education for Enterprise and successful learning in technology were compatible, and that in many cases they were the same. Three schools listed "encouraging other staff to come on board because of the already tightly packed curriculum" as an issue related to an extra involvement with Education for Enterprise. The facilitators noted that as soon as teachers were given some practical ideas that fitted in with what they already had planned their outlook changed to become more positive.

Exchanges between the MOE and the project team led to a negotiated focus on community partnerships. This was to be achieved by the project team working with teachers to identify and develop more authentic links between classroom programmes and the wider community. It was at this point that notions of a 'connected curriculum' (O'Sullivan 2012) began to be incorporated more into the thinking behind this project. These changes and tweaks may be seen by some researchers to be disruptive or unnecessary, but in the fourth generation evaluation they are to be expected and welcomed. They reflect the underlying philosophy of this emergent type of methodology.

The connected curriculum focus centered on developing enterprising attributes, capabilities and competencies and technological skills that students can identify with. To achieve these additional aims the project team assisted teachers to find, observe and use models of best practice in the community. Strategies for mentor training were put in place so that they became aware of enterprise goals which would enhance the work they do with their students. The professional development programme was altered to ensure that parents and their communities were involved in the Education for Enterprise programme in the participant schools. This was to be facilitated by regular information newsletters, use of community members, as mentors and by organizing community sharing days and workshops for parents.

In Phase two the aims of the workshops became more focussed. They had two clear targets, to identify good practice in technology education and in Education for Enterprise.

CLAIMS, ISSUES AND CONCERNS FROM PHASE TWO

Participants were involved in gathering the data themselves by working in pairs with one interviewing the other. This activity was called 'The Daily Snoop'. They recorded their interviews via notes and reported back interesting findings to the whole group. There were 18 individual staff responses, the Education for Enterprise project team reviewed the responses and some trends were used to inform future facilitation. Two thirds (N=12) of respondents felt supported by the senior management teams of their schools. The project team had identified this as an important aspect and had tried to involve senior managers to actively engage with the Education for Enterprise project. Most of the respondents (N=14) suggested that by undertaking the negotiated activities children were showing enterprising attributes. The project team asked for commentary on school community partnerships and their value for student learning most (N=14) responded positively. When asked if the professional development programme had impacted on their teaching (N=15) indicated yes.

All the participants were very positive about their experience at the workshops. The only highlighted claims concern or issue was that in some schools it is difficult to get the same amount of commitment to Education for Enterprise from other staff not involved in the project.

For phase three of the research transcribed interviews were mapped against three focus areas from the original research questions. It was clear that the research had shifted from description and evaluation to responsive evaluation. A meeting followed between the project team and the MOE. Discussions centred on progress and the preliminary data reported via milestones. It focused on:

- teacher practice that supports the development of enterprising attributes, capabilities and competencies of students
- school-wide practices that support the development of enterprising attributes, capabilities and competencies of students
- the impact and influence that school community partnerships have on student learning.

CLAIMS ISSUES AND CONCERNS FROM PHASE THREE

The main focus of concerns was time and project management, for both the teachers and the pupils. The project team responded by delivering sessions at the workshops which targeted development in these areas.

There was growing evidence of school community partnerships that enhanced school curriculum learning. Students worked alongside: council experts, builders, Landcare scientists, marine biologists and a variety of small business people. In addition, sports and exercise specialists, environmental specialists, communication specialists, publishing and IT specialists, expert gardeners, catering and event planners supported Education for Enterprise initiatives in the schools.

In phase four of the research participating teachers and their principals were invited to attend the final workshops. The research had identified a need for senior school management to be involved if Education for Enterprise was to be sustained. To facilitate this, the project team had presentations arranged from teachers giving examples of their best practice. Participant feedback is a key feature of Fourth Generation Evaluation, be it descriptive or interpretive/hermeneutic. Lincoln and Guba (1985) suggest that participant feedback is the most crucial technique for establishing credibility because it allows for member checking.

This flowing highlights information generated from the fourth and final set of workshops, it also presents the findings of an analysis by the project team of 271 pages of transcribed video and audio recordings taken during the project. This analysis was undertaken to identify general responses/statements both negative and positive mapped to some of the research questions. It is a simple frequency table which shows the number of responses under each category. It is displayed like this to give the reader a synoptic viewpoint of the responses.

Research question.	**Recorded statements mapped to each research question.**	**Number of participant teacher statements mapped to each research question.**
3	Teacher practice positive	268
3	Teacher practice negative	37
4	School wide practice positive	85
4	School wide practice negative	51
5	Community link positive	104
5	Community link negative	34

Many experts in the field of evaluative professional development (Eraut, 2000; Hammerness, Darling-Hammond and Bransford, 2005; Timperley and Phillips, 2003) agree that unless teachers are assisted to develop their reflective skills to the point where they are able to critique and monitor their own behaviour in the classroom, routinized and unreflective practice will be unlikely to change. The amount of time a teacher had for a project was directly proportional to the amount of direction he/she would give. When time was short there was more direction and less student ownership of the learning process, the opportunity to improve enterprising capabilities, became compromised.

SUMMARY

By the end of the project period there had been a significant shift in the nature of activities undertaken by the participating teachers. Their growing understanding of Education for Enterprise and technology education was reflected in the outcomes developed from the units undertaken. The systematic experiences provided within the four phases of this evaluative research eventually proved to be effective in assisting the teachers to develop the requisite knowledge and reflective skills to bring about change in their practice. Involving the teachers in the process of generating data from within their own classroom settings was a powerful catalyst that facilitated a robust evaluation process and ultimately changes in their programme offerings.

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Sustaining Teacher Education: Does Where You Learn To Teach Make a Difference to the Teacher You Become?

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ABSTRACT

In England, as elsewhere, pre-service teacher education is subject to changing political directives. The last twenty years have seen an increase in government involvement, with government-defined criteria for student entry, course provision and exit competence Standards. Provision is regularly inspected to ensure 'compliance'.

School involvement in pre-service teacher education has also increased over the last twenty years with the introduction of school-based mentors, partnership with universities and now full responsibility for the recruitment and training of teachers.

Currently, there are several postgraduate programmes available in the UK for those wanting to become secondary school teachers, but two predominate. These are the university-based Postgraduate Certificate in Education (PGCE) and the school-based Graduate Teacher Programme (GTP), in which students are employed by schools as unqualified teachers whilst training 'on the job'. In 2012-13 85% of new teachers qualified through a PGCE programme and 15% through a school-based programme (DfE 2012).

This study investigated these two programmes with design and technology (D&T) student teachers, with the aim of finding out whether there are differences in the professional identities they form. The research is located within that relating to teachers' professional identity and explores an under-researched area, student teachers of design and technology. It also links to research in teacher preparation from a sociocultural perspective.

Government documents were examined and institutions providing PGCE and GTP courses were surveyed. This was followed by interviews and observations of student teachers as they progressed through their course, one group of PGCE students and one of GTP students.

The findings showed that the emerging professional identities of the two groups were similar and suggests that this is due to the macro-level context of learning to teach being more influential than the micro-level context. It also found that the two programmes attract different types of students and suggests that reducing the availability of choice would be detrimental to student teacher recruitment.

Keywords: pre-service teacher programmes; student teacher professional identity

INTRODUCTION

Teacher education in the UK, as in many other countries, has been subject to changing political directives. It has developed from the 'apprenticeship' model, through teacher training colleges to become a university-based degree course. Throughout this process teachers' academic qualifications, and their sense of professionalism, were raised (Whitty 2006). In England, this process is now being reversed. The government is reducing the role played by universities in teacher education and increasing the role of schools in the selection and training of new teachers (DfE 2011). This is occurring to a lesser extent in other countries too (Cochran-Smith et al 2008). As teacher educators we are concerned about the impact that this will have on the nature of the professional teacher emerging from such training.

This study investigated two contrasting teacher education programmes with D&T student teachers, with the aim of finding out whether the course taken impacted on their emerging professional identity. The research is located within that relating to teachers' professional identity and explores an under-researched area, student teachers of design and technology. It also links to research in teacher preparation from a sociocultural perspective.

CONTEXT

A review of the literature suggests that there is no agreed definition of teachers' professional identity, but it is agreed that it is not fixed, has sub-identities, involves both personal and contextual factors and agency, the individual's active involvement (Beijaard et al 2004). Most research focuses on qualified teachers, but Battey and Franke (2008, p.129) believe that 'The process of learning to teach is a social process of identity transformation' and MacGregor (2009, p.3) that how identity develops depends, to some extent, on 'the social and cultural constructs of others in specific contexts'. This suggests that the learning context is important in shaping student teachers' professional identity (Beauchamp and Thomas 2009, MacGregor 2009).

In this study, we use the definition of professional identity described by Lauriala and Kukkonen (2005). This has three aspects: the ought self, as represented in official documents, for example Qualified Teacher Status Standards; the ideal self, as promoted through teacher preparation programmes, and the actual self, the identity which the student teacher currently holds about him/herself.

In England, there are two main routes to become a secondary school teacher, the university-based PGCE and the school-based Graduate Teacher Programme, see Table 1.

Table 1: PGCE and GTP programmes in England

	PGCE programme	**GTP programme**
Who runs the course?	Higher education institution (usually a university)	The school and any agreed provider (local authority, consultant, university)
Who pays?	The student pays a course fee to the higher education institution (the government can provide a loan to cover this cost).	Free to the student, the government pay the school towards the cost of training & student salary. Non-funded places are available if schools are willing to pay the costs, these may charge the student a fee
How long is the course?	Usually full-time, one year	Usually full-time, one year
What are the entry requirements?	first degree in a relevant subject, plus school-level Mathematics and English qualifications	first degree in a relevant subject, plus school-level Mathematics and English qualifications

What is the teaching programme	12 weeks study in the university 24 weeks 'practicum' in 2 different schools	details vary from school to school some study in school or at a local university placement in one other school
Student payment	Student is not paid, some receive a training bursary if the meet the criteria	Student is employed and paid by the school
Course outcome	Qualified Teacher Status (QTS) and PGCE (an academic qualification at level 6 or level 7)	Qualified Teacher Status (QTS)

The main difference between the two routes is the student's orientation. PGCE students are university students and experience 'teaching practice' in school; GTP students are unqualified teachers undertaking additional study.

In 2012-13, 85% of new teachers qualified through a PGCE programme and 15% through a school-based programme (DfE 2012). In 2013-14 the figures are expected to be 78% and 22% (DfE 2013).

METHODOLOGY

This was a qualitative, small-scale study undertaken during the academic year 2012-13. In 2011-12 a survey of teacher education programmes for secondary school D&T revealed that they portrayed the 'ideal self' as technicist, with some elements of critical or reflective identity. Analysis of the Standards for Qualified Teacher Status (QTS) in England found that the 'ought self' professional identity portrayed was mainly 'technicist' (Owen-Jackson and Fasciato 2012).

This stage of the study was investigating the 'actual self', the professional identity held by the student teachers. It involved interviews, observations and questionnaires from two groups of D&T student teachers, a PGCE group and a GTP group. This was a convenience, or opportunity, sample but we believe that these groups are generally representative of larger cohorts.

Table 2: student teacher participants

PGCE

	Gender	Age	First degree	Experience
PG1	M	23	Childhood & Youth Studies	Chef/kitchen staff
PG2	F	26	Hospitality Management	Hotels, restaurants, bar experience
PG3	F	29	Design & Art Direction	Retail visual merchandising
PG4	F	24	Textile Design, Fashion & Interiors	Retail
PG5	M	42	Building Surveying	Construction industry & own business
PG6	F			

GTP

	Gender	Age	First degree	Experience
GT1	M	44	Product Design	RAF, local authority and cover supervisor
GT2	F	44	Textiles	Hosiery company, pub management, TA
GT3	F	49	Product Design	Architectural technician, TA, cover supervisor
GT4	M	31	Graphic Design	Graphic designer, marketing +

				children's football training, swimming teacher, summer camp
GT5	M	37	Interior Design	Interior design practice, own business, chef/catering (family business), DT technician
GT6	F	29	Illustration Design	Designer, cover supervisor, unqualified art teacher

All the students were interviewed at the beginning of their course using a semi-structured approach, observed teaching during the year and completed a questionnaire at the end of their preparation year.

FINDINGS AND DISCUSSION

Student backgrounds

The PGCE students were mostly younger students, only two had directly relevant degrees (PG2, PG4) and their previous experiences were limited. The GTP students, in contrast, were mostly older students, all had design-related degrees and relevant previous experience, with four having worked as cover supervisors in schools, one as a D&T technician and one with children outside of school.

All the PGCE students wanted to teach because they enjoyed their subject and wanted to share their knowledge/experience. Half also cited wanting to work with children (PG2, PG3, PG4). Reasons given by the GTP students mainly related to their own career development, one wanted a career change (GT4); two enjoyed TA/cover supervisor work (GT2, GT3) and three wanted a job that was creative (GT2, GT3, GT6). Only one referred to the subject (GT1), and two referred to wanting to work with pupils.

Sociocultural theory suggests that what learners bring to the learning situation is influential. These data show that the students were bringing different experiences, expectations and 'subject expert' identities to their course which would impact their developing professional teacher identities.

The contribution of the university and the school to their learning

The PGCE students noted that the university had developed their skills and knowledge, whilst the school practicum gave them experience of the day to day life of being a teacher, several agreed that this had been 'a baptism of fire' (PG1). All the PGCE students cited a school-based teacher as the person having had most influence on their development over the year.

For GTP students, the university experiences varied but all said that the university-based input diminished as the year progressed. Their school experiences also varied, one student (GT3) felt that she had been treated as a member of the team and that the school had taught her 'everything' and another had a 'good level of support' (GT4). Three, however, felt that the schools had provided only limited opportunities for learning. Unsurprisingly, all the GTP students cited a subject teacher as the person who had been most influential.

At the end of the year the students were asked to rank order aspects of teaching which had most/least importance for them at that time, see Appendix 1. One PGCE student and two GTP students were not available to complete this task.

Both groups identified as highly important relationships with pupils, planning lessons and managing lessons, which for new teachers is understandable. PGCE students also identified pupils' behaviour, but for GTP students this was considered of low importance. This is likely due to the longer classroom experience of GTP students providing them with greater confidence in dealing with pupils. GTP students did, however, rank developing teaching strategies as highly important, which belies their extended classroom experience. This may be due to their increased awareness of the range of teaching strategies or it may be that the PGCE students have had more opportunity, with the support and guidance of university staff, to try out more teaching strategies during their periods in school. Further work would be needed to investigate this anomaly.

PGCE students gave some importance to developing relationships with staff, managing resources and developing teaching strategies. As many of them will be moving to new, unknown, schools for their first teaching post these issues will be relevant. The GTP students gave some importance to assessment and monitoring, development of self and interactive teaching strategies. This reflects the fact that many, though not all, will continue to work in their training school and will be concerned with developing aspects of their work that they feel needs further improvement, and with developing their role within the school. Both groups gave some importance to continuing to develop their subject knowledge.

PGCE students gave little importance to assessment and monitoring and interactive teaching skills; whether this is because they feel confident in these aspects or because they have other concerns that they consider more important at the end of the year needs further investigation. They were less concerned with contextual knowledge of the school, which we would have expected to be higher as they move into new schools. The lack of importance given to this may be due to their not having this contextual knowledge, therefore not regarding it as important, or that they are not aware of the importance of contextual knowledge when planning and teaching.

GTP students also gave little importance to contextual knowledge, developing relationships with staff and managing resources. This is likely due to the fact that they are familiar with the context in which they work, have established collegial relationships and are familiar with managing the resources in their school.

This shows some differences in the developing professional identities of these student teachers. Whilst both groups are concerned about what happens in the classroom, citing elements of the technicist approach to teaching, PGCE students are more concerned than GTP students about establishing relationships with school staff. This likely due to the fact that PGCE students mostly go to ‘new’ schools for their first teaching post whilst GTP students mostly continue in their training school. GTP students, having spent longer in the school environment, are likely to feel more established as teachers.

Their views of themselves as teachers

The students were asked to give three words to describe themselves as a teacher at the start, mid-point and end of the course. No direction was given and students had an entirely free choice of words, they were not shown their earlier words at the later data collection points, see Table 3.

Table 3: student views of themselves as teachers

	Sept/Oct	**Feb/March**	**June/July**
PG1	Likeable Soft Informal	Confident Mature Organised	Approachable Fair Consistent
PG2	Unsure Inconsistent A sponge	Friendly Approachable Manager	Enthusiastic Friendly Firm
PG3	Developing	Confident Enthusiastic Committed	Enthusiastic Approachable Confident

PG4	Likeable Friendly Confident	Confident Organised Motivational	Caring Supportive Creative
PG5	Novice Gaff prone Eager	Strict Confident Understanding	Calm Fair Enthusiastic
PG6	Encouraging Empathetic	Confident Organised Enthusiastic	
GT1	Enthusiastic Nuturing Learning		Passionate Caring Inspiring
GT2	Unsure Run of the mill		
GT3	Exciting Motivating Respected	Kind Approachable Learning	Fair Encouraging Organised
GT4	Approachable Fair Knowledgeable	Fair Positive	Supportive Inspiring Organised
GT5	Willing Focused	Enthusiastic Involved Confident	Facilitator Positive Reflective
GT6	Approachable Passionate Eager	Motivating Resilient	Enthusiastic Resilient Supportive

There is no pattern discernible here, except that all students in both groups cited personal qualities rather than 'technical' ones. This supports other research, which found new teachers focused on the 'emotional and relational' aspects of their development rather than the cognitive (McNally 2006).

The students' emerging professional identities show little of the 'technicist' identity portrayed in the national Standards for Qualified Teacher Status in England. However, there is little reference in their responses to imaginative, creative teaching (Barker 2010), aspects which might be expected from D&T teachers. Only one student uses the word 'creative' (PG4) and only two the word 'inspiring' (GT1, GT4).

The students were then given a list of words, or asked to suggest their own word, for an analogy for teaching. Students in both groups chose words which indicated their view of the teacher as controlling the classroom – leader (GT3, PG4), expert (GT6, PG3), conductor (GT5, PG2) and ringmaster (PG5). One PGCE student (PG1) chose 'shepherd', one GTP student chose 'juggler' (GT4) and one chose 'actor' (GT1).

In each group the majority of responses indicated an emerging 'technicist/autonomous' identity, a teacher who is good at what they do and 'in charge' of her/his own classroom. This similarity could be the result of the students sharing the same social and cultural setting – English secondary school D&T departments. Although there will be idiosyncratic differences between departments they share an underlying social and cultural history and, in many respects, the role of the teacher is commonly understood. Our earlier research also showed that government documents and the teacher preparation courses also emphasised the 'technicist' identity and the students are likely to have absorbed this.

In both groups, however, there was a minority who showed different emerging identities. One PGCE student (PG1) suggested, through the word 'shepherd', a more vocational identity. Two GTP students' choice of words, juggler and actor, suggest an understanding of the complexity of teaching and suggest aspects of a 'critical/reflective' teacher identity.

CONCLUSION

The study set out to investigate whether university-based and school-based pre-service teacher programmes influenced the type of teacher the students become. It found that, despite their different experiences, the emerging professional identities of the student teachers were remarkably similar. As teacher educators, it was disappointing to find that the majority of these new teachers were adopting a 'technicist' identity, seeing themselves as able to perform as skilled technicians in the classroom. However, we understand that this is likely to be a pragmatic response to being judged against the Standards for Qualified Teacher Status and working in the 'performative' environment (Ball 2000) which now constitutes the English school system.

This finding suggests that the macro-level of the socio-cultural setting of teacher preparation is more important than the micro-setting. The shared social and cultural understanding of schools/education, and D&T within this, seem to have been more influential than individual relationships. The 'guided participation' (Rogoff 1990) involved not only the face to face relationship with the mentor but also the learning from their guided reading, their observations of different teachers and their discussions with peers.

Students seem to have located each individual learning experience within a bigger social and cultural context. Their emerging professional identities are located within this context rather than within specific university or school contexts. This supports the idea suggested by Boreham and Gray (2005) that student teachers' professional identities are not fully-formed on completion of their studies but develop during their specific work situations.

What the study did highlight, however, was big differences in each group's motivation for teaching and their reasons for choosing the course. The PGCE students, generally younger and less experienced, were motivated by enjoying the subject and wanting to work with children. The GTP students were generally older, more experienced, more focused on their career path and, with family responsibilities, mainly chose the GTP programme for financial reasons. This suggests that both programmes are needed to ensure accessibility into the teaching profession for diverse teacher candidates. Whether this choice will continue to be available, however, is not yet certain.

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APPENDIX 1 – ASPECTS OF TEACHING

Table 1 – aspects of teaching (1=most important, 14=lea

	PG1	PG 2	PG 3	PG 4	PG 5	**PG mean**	GT 3	GT 4	GT 5	GT 6	**GT mean**
Planning lessons	1	3	1	1	3	**1.8**	2	3	9	4	**4.5**
Interactive teaching skills	9	4	11	12	11	**9.4**	8	2	13	3	**6.5**
Managing lessons	5	6	2	6	2	**4.2**	9	5	1	7	**4.4**
Pupil behaviour management	7	5	3	3	1	**3.8**	11	9	8	9	**9.25**
Developing teaching strategies	6	10	9	5	10	**8**	10	6	3	2	**5.25**
Managing resources	2	7	10	4	9	**6.4**	12	10	11	10	**10.75**
Contextual knowledge – school, pupils	10	9	4	11	12	**9.2**	13	12	5	13	**10.75**
Development of self	12	11	12	7	8	**10**	7	11	7	1	**6.5**
Subject knowledge	11	8	5	8	7	**7.8**	6	4	4	8	**5.5**
Specific aspects of teaching the subject – please note these are below		13		13	13		5		12		
Assessment and monitoring	8	12	6	9	6	**8.2**	4	7	6	6	**5.75**
Relationships with staff	4	1	8	10	5	**5.6**	3	8	10	12	**8.25**
Relationships with pupils	3	2	7	2	4	**3.6**	1	1	2	5	**2.25**
Any other aspect – please note this is below		14		14	14					11	

Research Needs for Technology Education: Highlights of a Preliminary Analysis

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ABSTRACT
Two recent studies sought to determine the major issues needed to be researched in the school subject of technology education. Ritz and Martin (2012) undertook a Delphi study with an international panel of experts to answer this question while also undertaking a similar study (Martin & Ritz, 2012) with a U.S. panel of experts. The authors of this paper highlight the consensus opinions of both panels of experts to determine important research themes that technology education researchers might wish to further explore.

Keywords: Research Needs, Technology Education, Delphi Technique

INTRODUCTION
Researchers seek answers to the unknown for improving the present and future conditions of society. Technology education researchers continue to compile and report the findings of their research. Their findings are shared through journal manuscripts, conference presentations (such as PATT Conferences), research reports, and through press releases and interviews. Questions always arise, however, such as the following: (a) Are these studies providing the answers to move this school subject to a higher level of practice? (b) Are these studies contributing to the learning experiences of primary and secondary students?

Most technology education professionals take valuable ideas away from findings of new research and apply the ideas to classroom settings. It is part of the process that we follow as professionals to use research to inform our decision making process. The quantity of the work in technology education is impressive, since many universities have taken on increased roles in conducting research. What guides one to seek new information related to education, particularly technology education, and student learning? Their decisions are often guided by foci established by their universities or governmental agencies, their national governments in general, or by their own general interest resulting from individual practice or observations. It is nice for one to have the freedom to conduct research in order to develop a better understanding in the functions of our school subject. However, we are often influenced by what questions governments seek answers to and the funding they will provide to support formal and organized inquiry into finding answers to these questions. It is nice when these work hand-in-hand for researchers.

The authors of this study have been impressed with the research reports provided by the international community and the new interests of researchers and the guidance of government policies. We believe the research in technology education is healthy. But to better guide the research community, we sought to find if there is consensus of ideas on what needs to be further researched in order to make the school subject of technology education better and even more appealing. Thus, we undertook two studies to determine the topics that experts agreed needed to be researched for the betterment of technology education. With two studies completed (Martin & Ritz, 2012; Ritz & Martin, 2012), we now seek to highlight our findings by reporting a preliminary analysis of them from an international panel of experts and a U.S. panel of experts.

LITERATURE REVIEW

Studies have been undertaken to provide retrospective views of what technology education researchers have studied. Two of the more notable studies were undertaken by Zuga (1994) and Williams (2011).

Zuga examined U.S. research efforts from 1987 to 1993. This included reviewing 220 research papers, staff studies, periodical articles, theses and dissertation abstracts, yearbooks, and speeches. Dissertation abstracts accounted for 105 of the documents she reviewed. She categorized the research into studies on (a) curriculum status-42, (b) curriculum development-42, (c) curriculum change-27, (d) professional-39, (e) instruction-35, (f) effectiveness-22, and (g) attitudes-13. Fifty percent of the studies had curriculum topics as their focus. Zuga noted that little was researched on the topics of the nature of technology or the study of technology on student learning. However her studies showed where researchers had focused their studies during the late 20th century.

Williams (2011) reviewed 472 manuscripts published between 2006 and 2011, and he organized these manuscripts into categories (e.g., design, curriculum, technological literacy). His review included both journal and major conference manuscripts. He determined that 42 papers focused on design in technology education. Other significant topics researched during this five-year period included curriculum (34), technological literacy (34), and thinking (32). There were many other topics identified through his study that provided indicators where technology education research was directed. Williams was looking at the past to determine what research had been conducted and possibly suggest directions for the future.

These and other studies (de Vries, 2005; Petrina, 1998; Reed, 2010) reported in retrospect on what technology education professionals have contributed to our research base with limited attention to looking at the prospect or what might be researched to better position the technology education school subject. The intent of this research study and paper, therefore, is to highlight our findings by reporting a preliminary analysis of what the international community seeks to do for future research and compare it to what the U.S. community seeks to study. Other words, the authors report on the present with a view towards the future.

PROCEDURE

This study analyzes the findings of two Delphi studies completed in 2012 by the authors. These were 4-Round studies which sought to identify research topics researchers believed should be conducted for the betterment of K-12 technology education and also improve the teaching of this school subject. The international Delphi study on research needs for technology education employed a 32 member panel of experts. This study used a nomination process where two members of the international technology education community, who were elected into the International Technology and Engineering Educators Association Academy of Fellows, were asked to nominate two other researchers, from countries other than their own countries, who they felt could add to the research knowledge-base of a Delphi panel. The two prospective panel nominees were then asked to nominate two more panel members. This process continued (called daisy chaining) until all duplicate selections closed the nominations process. The panel formed itself into a group of 32 researchers representing 20 countries.

The U.S. panel was a purposeful selected group. Practicing technology education professionals who had been named recipients of the Council on Technology and Engineering Teacher Educators Teacher-of-the-Year Award were invited to participate. This panel was composed of 17 technology education teacher educators who agreed to participate in the study. This faculty represented 14 U.S. universities.

It should be noted that the construct of technology education has some variance in meaning around the world, and these world views should be noted when one reviews the findings and discussion found in this manuscript or others the authors have reported on these research studies (Marin & Ritz, 2012; Ritz & Martin, 2012). Technology education is viewed as general education for all students in some countries and regions, while it is more closely associated with vocational or pre-vocational education in others. Within this array of meanings, some focus on the study of using tools and making, some emphasize designing, while others focus on design and make for all students. Panel participants reflected on the research needs for technology education and their reflections would be influenced by their beliefs of what is meant by school-based technology education.

FINDINGS

The Delphi studies progressed for three months to enable the researchers to gain a high return rate for each of the four rounds. The return rates of each round for each study are listed in Table 1.

Table 1: ***Delphi Panel Return Rates Round***

Rounds	1	2	3	4
International	32 (100%)	31 (97%)	29 (93%)	31 (97%)
U.S.	17 (100%)	17 (100%)	17 (100%)	16 (94%)

Henceforth, the international study participants produced a list of 25 research needs for the study of technology education. The U.S. study participants produced a list of seven research needs. Table 2 lists the research needs identified by both the international and U.S. panels that are statistically significant. Table 3 lists the research needs to improve the teaching of technology education that are statistically significant. Detailed narrative descriptions of both the international and U.S. research needs for technology education can be found at http://media.wix.com/ugd/68f68f_0dc679faa3ed8c3d45bb6287cf851fb8.pdf?dn=Research%2BNeeds%2Bfor%2BTechnology%2BEducation%2BU.S.pdf

Table 2: Statistically Significant Research Needs for K-12 Technology Education

International Research Needs	**U.S. Research Needs**
Nature of designing, M = 3.68	Benefits of K-12 T.E., M = 4.24
Designing for secondary students, M = 3.62	Engineering content and curriculum, M = 4.18
Nature of technology, M = 3.90	Impact on academic achievement, M = 4.29
Technological conceptual knowledge, M = 4.07	Content for Tech. and Engr. Ed., M = 4.06
Value of technology education, M = 3.52	Shortage of critical research, M = 3.82
Value of student learning through T.E., M = 3.93	Student learning, M = 3.65
Learning that takes place through T.E., M = 4.17	
Abilities students develop through T.E., M = 4.28	
How do student learn in T. E., M = 4.07	
Shortage of research on the evaluation, M = 3.60	
Measuring higher order thinking skills, M = 3.83	

Knowledge and abilities learned in T.E., M = 3.66	
How students learn technology, M = 3.97	
Pedagogical content knowledge for T.E., M = 4.03	
Pupil's motivation towards technology, M = 3.62	
Assessment of technological performance, M = 3.97	
Sustainability and global citizenship, M = 4.10	

Mean is derived from a 5-point Likert-Scale

Table 3: Statistically Significant Research Needs for Technology Education Teaching

International Research Needs	U.S. Research Needs
Teachers conceptions of designing, M = 3.76	Cognitive science connections, M = 3.82
Epistemic beliefs of teachers, M = 4.14	
Program delivery, M = 3.82	
Meaning of T.E. by practicing teachers, M = 3.52	
Collaborative learning in T.E., M = 3.52	
How should design activities be taught, M = 3.90	
Understanding PCK, M = 3.88	
Assessment of practical work, M = 3.96	

Mean is derived from a 5-point Likert-Scale

DISCUSSION

What are the similarities and differences between the research needs identified by these two groups of panelists? For the research needs of K-12 technology education and teaching of this school subject, both groups were interested in conducting additional research on the content that should be delivered through technology education programs, what and how students learn in technology education, and the motivations/perceptions of students related to studying technology education. A further look into the panels' description of these research topics shows that both groups are interested in developing the technological literacy of learners and improving student learning through technology education. These research needs are summarized for purposes of analysis within the following themes.

Technological literacy content knowledge

For the international panel, members believed that research should be conducted to identify content that provides motivation for students to learn, and this content should be selected from the knowledge-base of technology which will transmit the most conceptually appropriate knowledge to learners. In addition the international panel believes research should be undertaken to better understand the epistemic knowledge of teachers related to the selection and delivery of this content, since teacher's beliefs affect what and how technology is taught. The U.S. panel was interested in the benefits to learners that the content and process of technological literacy contributed and what engineering content/processes needed to be blended into technology education programs at the K-12 levels. Both groups were interested in the content of technology education with the international panel citing five research needs and the U.S. panel identifying two research needs.

Student Learning

Both panels identified research needs for student learning. International panel members identified 10 needs, while the U.S. panel identified four needs. International panel members cited the value of student learning through technology education, comprehending the knowledge being transmitted to them, learning of key technological concepts, and evaluating technological literacy competencies learned. Related to this research need, international panel members sought to measure the higher-level learning occurring through the teaching of technology to learners. They were also interested in determining better ways to measure student performance in technology education, thus better understanding the knowledge students actually learn. In addition, the international panel sought to understand how students' best learned technology education content and processes. Another interest expressed was how collaborative learning aided students to learn technology.

U.S. panel members had fewer identified research needs related to student learning through technology education, but they did have the most interest in this area. They sought to determine if learning about technology contributed to a young person's development. They were also interested if technological content knowledge was transferable within technology and to other knowledge areas. Additionally, they sought to conduct research on how cognitive science contributes to the study of learners in technology education. Finally, U.S. researchers were interested in the development of student's critical thinking skills through the study of technology.

International researchers also express research needs in two other areas for technology education, K-12. These included research needs related to design and to the nature of technology. The U.S. panel members' research needs all fell into the above themes for K-12 learning.

Designing

Research needs related to design were cited four times by the international panel members. Their research needs included determining what knowledge and abilities that designing actually involves, criteria for evaluating novice designs, gaining conceptual knowledge through designing, and teacher trainee conceptions of design (do they understand the learning possibilities associated with teaching design). The international research community has shown much interest in design as needed research.

Nature of technology

This international research need sought to understand how the study of artifacts might help learners better understand the development of society. History is filled with artifacts that individuals and groups have created as they evolved. How do these artifacts relate to and contribute to societal development? It is strange that the U.S. did not include studies related to this theme within technology, since it is one of the International Technology and Engineering Educators Association content standards and it is often discussed as a basis for the study of technology.

In addition to the research needs for K-12 technology education, the panels were asked to identity major research needs related to the teaching of technology education. Three themes and a number of research needs resulted. The themes included improving student learning, sustainability/global citizenship, and student assessment.

Improving student learning

Both study groups contributed ideas for research needs related to teaching to improve student learning. The international panel cited two research needs related to pedagogical content knowledge – first, the identification of knowledge that supports teaching technology education and second, training of teachers who are armed with these instructional strategies. The U.S. panel sought research studies that will make connections between what is taught through technology and engineering education and student learning with the cognitive sciences. They believe that teachers need to understand how students learn, so they can make these connections during design-based instruction.

Sustainability/global citizenship

The international panel specifically identified this topic as a research need. It is questioned why the U.S. panel did not suggest research needs related to this form of teaching technology education as interest in this topic can be found in literature authored by U.S. researchers. With the U.S. focus to add engineering content and problem solving into the curriculum, it has been suggested that problem-based learning that focuses on solving major societal issues is a strategy for engaging learners.

Assessment

The international panel suggested that a major research need is to develop better assessments and techniques to understand how students learn technology. This research need appears to be absent from the U.S. study panel's suggestions, since standards-based learning assessments are currently removing time from the curriculum for open discovery types of learning experiences often cited as strategies for teaching a more enriching technology and engineering education curriculum.

SUMMARY

Identifying and conducting meaningful research can provide improved justification for the school subject of technology education. The researchers sought to develop a list of important research needs for both K-12 technology education and the improved teaching of this school subject that would provide direction to researchers both experienced and new to this school subject. The authors of this paper feel they accomplished this task. With two studies from two differing groups of experts, similar themes emerged in our analysis. Further research into topics focusing on technological content knowledge, student learning, designing, and improving student learning should assist this school subject as it progresses in school practice.

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Investigating the Self-Efficacy of Students Participating in VEX Robotics Competitions

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ABSTRACT
This paper outlines a proposed study to be completed for a dissertation in Technology and Engineering Education (TEE). The study will investigate the self-efficacy of middle and high school students participating in VEX Robotics Competitions (VRC). The VEX Robotics Competition is the largest and fastest growing competition for middle and high school students in the world (Innovation First International, 2013; Robinson & Stewardson, 2012; Robotics Education and Competition Foundation, 2010). VRCs offer students an opportunity to gain "real-world" "hands-on" experiences in science, technology, engineering, and mathematics (STEM) that are not normally offered in the classroom. This study measures the self-efficacy or confidence of students participating in VEX Robotics Competitions. The proposed approach that will be used in the dissertation research will be described. The study is planned to be conducted in three phases: 1) determining the outcomes obtained by students participating in VEX Robotics Competitions, 2) developing an instrument to measure self-efficacy of students related to the outcomes, and 3) determining the reliability of the instrument then reworking the instrument until an acceptable level is reached.

Keywords: VEX Robotics Competition. Science, Technology, Engineering, and Mathematics (STEM). Technology and Engineering Education (TEE). Self-efficacy.

INTRODUCTION
Robotics competitions have gained popularity since the 1980s. Today they are used to increase student interest in science, technology, engineering, and mathematics (STEM). Another factor influencing the development of robotics competitions is the belief that society needs to develop individuals capable of developing and maintaining the technologies that will be developed to continue to improve the quality of our lives. There are countless robotics competitions taking place around the world, including but in no way limited to VEX Robotics Competition (VRC), For Inspiration and Recognition of Science and Technology (FIRST) Robotics Competition, the National Robotics Challenge (NRC), and Boosting Engineering, Science, and Technology (BEST) competition. Countless resources including time, money, and energy are being consumed and used to produce and fund teams to compete in these robotics competitions. Depending on the competition, teams can spend hundreds of dollars or over US $50,000 annually for fees, materials, and other expenses. Teachers and mentors work hours beyond those required by their employers to ensure their teams will find success in their respective competitions. What are the outcomes of this time, money, and effort put forth by teachers and students?

PROPOSED RESEARCH PROBLEM

The problem for this research study is to develop an instrument to measure the self-efficacy of middle and high school students participating in VEX Robotics Competitions.

NEED FOR THIS STUDY

In a request for proposal by the Robotics Education and Competition Foundation (REC, 2011), it was stated that research needs to be conducted that brings “legitimacy to the idea that hands-on robotics activities, in concert with competition, motivates and inspires youth while building real-world skills that are transferable to college and career” (Item 6, Objectives). With thousands of students participating in various robotics competitions around the world, research needs to be conducted to investigate this “legitimacy.” As stated earlier many hours and funds are being used to support students participating in robotics competitions. Are the time, money, and effort being invested all worth it? Studies need to be performed that research the outcomes of robotics competitions to allow supporters to answer this question.

OUTCOMES OF ROBOTICS COMPETITIONS

Researchers have investigated outcomes of students participating in robotics competitions (Hendricks, Alemdar, & Ogletree, 2012; Kolberg & Orlev, 2001; McIntyre, 2002; Nourbakhsh, Crowley, Bhave, Hamner, Hsiu, Perez-Barguest, Richards, & Wilkinson, 2005; Nugent, Barker, Grandgenett, & Adamchuk, 2010; Robinson, 2005; Sklar, Johnson, & Lund, 2000). They have found that robotics competitions are thought of as hands on activities that allow students to gain real world experiences. Nugent et al. (2010) concluded “through hands-on experimentation, such technologies can help youth translate abstract mathematics and science concepts into concrete real-world applications” (p. 392). Other questions that are being explored include are more students pursuing STEM majors in college, are more students seeking STEM careers after participating in robotics competitions, and are students learning specific content knowledge from participation in robotics competitions? Only a few studies have explored these questions and others related to the outcomes of student participation in robotics competitions. Nourbakhsh et al. (2005) states that robotics competitions improve learning beyond normal concepts taught in the classroom, because through robotics competitions learning can “extend beyond the content of technical challenges and into broader scientific and social lessons” (p. 27). These broader social lessons such as team work and self-efficacy have been explored in depth by Williams et al. (2007) and Nugent et al. (2010). Only one study was found that has investigated the VEX Robotics Competition (Hendricks et al., 2012). This study explored students’ increased interest in STEM subjects after participation in robotics competitions. No complete studies were found that specifically explored student self-efficacy from participating in VEX Robotics. For this reason, this researcher sought to explore student self-efficacy from participating in VEX Robotics Competitions.

WHY VEX ROBOTICS

VEX Robotics is the largest and fastest growing competition for middle and high school students in the world (Innovation First International, 2013; Robinson & Stewardson, 2012; Robotics Education and Competition Foundation, 2010). Figure 1 shows the number of students competing in various robotics competitions during the past several seasons. During the 2012-2013 competition season there were over 7,300 teams competing in over 400 local competitions around the world. VRCs utilize a format that requires a team to align with another team and compete against two additional teams. This encourages teams to assist one another and to share design ideas and game strategy. VRCs are not just one team trying to complete a challenge the best; it is working with another team from around the world to beat two other teams. Teams competing head-to-head create a sporting event mentality that is exciting for students, teachers, and parents. The format that VEX Robotics uses for competitions and qualifying for the world tournament allows for a sports season like system. Teams can design and build their robot. Teams can then compete with that robot and determine what works well and what does not work well. The team then has time to make changes and improve their robot before competing in another tournament. A team can compete in as many tournaments that are available to them if they have resources available to support them.

The VEX Robotics Competition is relatively affordable for schools to compete. It only costs US $100 for a school to register its first VEX team. Each additional team a school would like to register is US $50. This lower cost is also due to the requirement to only use VEX components. This also creates a level playing field for all teams to compete, because one team cannot buy better equipment to outperform their opponents. Although all teams must use the same components, there is enough variety in the components that teams can still use their unique creative ideas to design their robot. These attributes have made the VEX Robotics Competition the largest and fastest growing competition and an ideal candidate for exploring student outcomes of participation in robotics competitions.

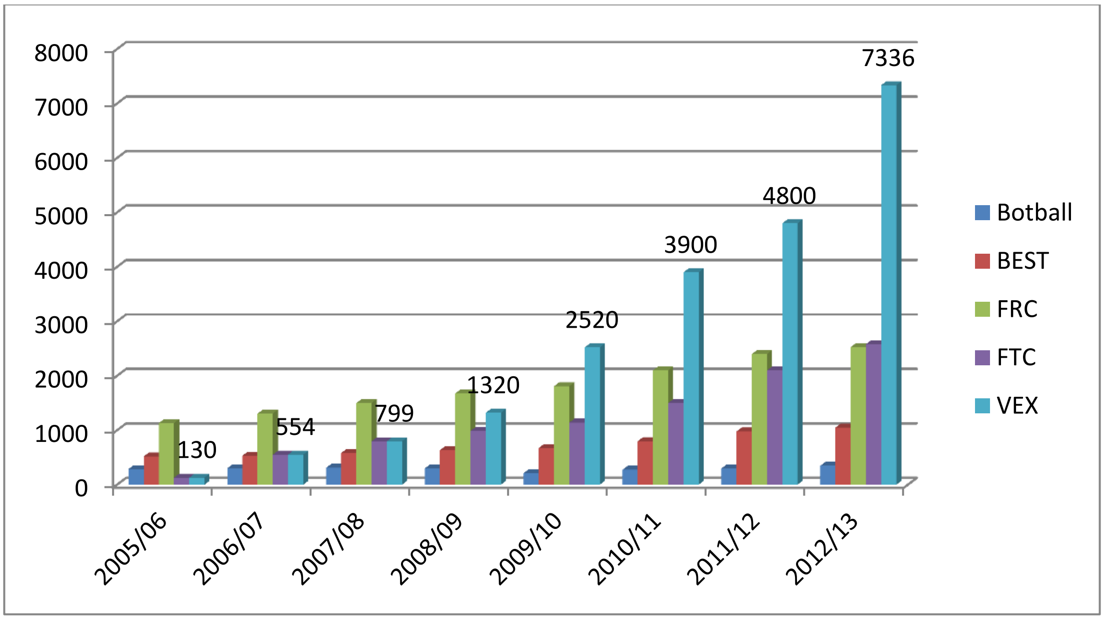

Figure 1: The number of teams competing in select competitions by year

Numbers shown are for the VEX Robotics Competition. BEST = Boosting Engineering, Science, and Technology; FRC = FIRST Robotics Challenge; FTC = FIRST Tech Challenge; VEX = VEX Robotics Competition. Adapted from "Longitudinal Growth of VEX Robotics Competitions in Utah and the Rocky Mountain Region," by T. P. Robinson, 2013, *Proceedings of the 19th Rocky Mountain NASA Space Grant Consortium 2013 Fellowship Symposium:* May 6, 2013, Salt Lake City, UT.

SELF-EFFICACY

"Self-efficacy is concerned with judgments about how well one can organize or execute courses of action required to deal with prospective situations containing many ambiguous, unpredictable, and often stressful elements" (Bandura & Schunk, 1981, p. 587). In other word, a person's self-efficacy measures how they think they will do when given a specific task to complete. A person's self-efficacy toward specific tasks helps determine what tasks that person might choose to pursue or to abandon. If a person feels confident toward a subject in school, they will most likely be interested in that subject, and, in turn, take more courses in that subject area and be more likely to pursue those areas as college majors and as potential careers (Betz & Hackett, 1981; Lent, Brown, & Larkin, 1986). Bandura (1982) states that "judgments of self-efficacy also determine how much effort people will expend and how long they will persist in the face of obstacles or adverse experiences" (p. 123). Lawanto, Santoso, and Liu (2012) summarize several research studies with the following statement; ". . . strong self-efficacy is more likely to stimulate the exertion of greater effort to overcome a challenge, while weak self-efficacy tends to reduce one's efforts or even cause a person to quit" (p. 154). A person's self-efficacy can play a major role in determining what activities he or she will pursue in high school, as well as what career or college path he or she may choose to follow after graduation.

Universities, industrial companies, and non-profit organizations are developing and supporting robotics competitions in a push to interest more students to pursue STEM classes in high school and STEM majors in college. Are these competitions increasing the self-efficacy of student participants? Research has been conducted to explore the self-efficacy of students in academia; however, there are no instruments or studies that specifically investigate the self-efficacy toward related outcomes of students that participate in robotics competitions. As a result, without such an instrument, no means to sufficiently measure the impact of VEX Robotics Competitions on student participants is available.

PROPOSED RESEARCH METHODOLOGY

This study is planned to be conducted in three phases: 1) determine the outcomes of students participating in VEX Robotics Competitions, 2) develop an instrument to measure the self-efficacy of students related to the determined outcomes, and 3) determine the reliability of the instrument and refine it until an acceptable level of significance is reached. Phase one has already been completed.

The first phase of this research was to determine the outcomes of students participating in VEX Robotics. A content (occupational) analysis was conducted with a group of experts. The experts were selected from the population of VEX coaches, mentors, and instructors. An expert was determined to be a coach, mentor, or instructor of a team who had qualified for the VEX Robotics World Championship in at least three of the past four seasons. After selection, each expert produced an initial list of outcomes. Each expert was asked to list all outcomes they saw students gain through participation. After all of the initial lists were received, a second committee compiled the lists of outcomes, combined repetitive outcomes, restated outcomes using performance terms, and organized the outcomes into five constructs based on the original lists of outcomes. The five constructs were 1) mechanical, 2) programming, 3) design, 4) teaming, and 5) professional traits. After the second committee compiled the list of outcomes, it was distributed to the original experts. The experts ranked the outcomes based on how critical each outcome was to team success using a five-point Likert scale. The results from the Likert scale ranks were compiled. All outcomes in each construct were rank ordered based on the average score received. For samples of outcomes in each construct see Table 1.

This list of outcomes will benefit VEX proponents in developing research instruments, developing curriculum, and assisting with fundraising. Specifically for this research study, the list of outcomes will be used to develop a self-efficacy instrument in phase two. A specific question will be developed for each outcome determined in phase one; doing this will help ensure the validity of the instrument. The instrument will ask students to rate their efficacy for each statement on a seven-point Likert scale. This seven-point scale will be similar to the scale used in the Motivated Strategies for Learning Questionnaire (MSLQ). The MSLQ has been used to measure the self-efficacy of students for over ten years, and it has been shown to have a high reliability coefficient (Pintrich, Smith, Garcia, & Mckeachie, 1993). It is assumed that most students will have some efficacy for each question asked. If the scale only allows students to distinguish their positive efficacy between agree and highly agree, it will be more difficult to make clear distinctions between overall efficacies of all participants. Using a seven-point scale will encourage students to more clearly distinguish their efficacy levels on each instrument item.

Table 1: Sample Outcomes for the Five Constructs of Participation in the VEX Robotics Competition

Constructs and Outcomes	Mean (0-4)
Mechanical	
Construct a structurally sound and stable robot – chassis, lift, end-effector	3.78
Construct various end-effectors (e.g., conveyor, scoop, rollers, gripper)	3.39
Programming	
Program conditional statements (e.g., if statements and while loops)	3.61
Draw the configuration (schematic) of the robot with input and output addresses	2.44
Design	
Design various end-effectors (e.g., conveyor, scoop, rollers, gripper)	3.72
Design a light structurally and kinematically sound and stable robot	3.50
Teaming	
Collaborate with other team members to accomplish tasks	3.82
Structure team to best use individual strengths and mitigate weaknesses	3.47
Professional Traits	
Demonstrate persistence and patience when faced with difficult tasks	3.88
Research solutions using electronic media (e.g., VEX Forum, YouTube, Facebook)	3.29

Note. The samples presented are the outcomes with the highest and middle mean score and in each construct.

Once the instrument is fully developed it will be distributed to small groups of students to determine its reliability. The reliability will be calculated using Cronbach's alpha coefficient. Gall, Gall, & Borg (2007) state that "Cronbach's alpha is a widely used method for computing test score reliability" (p. 202). It was determined that Cronbach's alpha would be used over more common Kuder-Richardson formulas because a Likert scale test is not dichotomous, developing right and wrong answers. When creating instruments it is ideal to reach a reliability level of .8 or higher. The instrument will be improved and revised until an acceptable level of reliability is reached. It is important for this instrument to be reliable to be used in future studies. It might be used in a longitudinal study to measure the self-efficacy of students who participate in in VEX Robotics over several years. To research the "legitimacy" of robotics competitions, a valid and reliable instrument is essential. Other tests such as a chi-squared test will be analyzed to see if initially there are differences between various groups of participants. These groups include males and females, various ethnic groups, various years of experience in VEX Robotics, and students that participate in formal and informal learning environments.

STUDY LIMITATIONS

It is inherent that there will be limitations to any study. This proposed study has the following limitations. The instrument is being developed specifically for VEX Robotics competitions; however, it will have the possibility of being adapted to other robotics competitions. Even though VEX Robotics Competitions are worldwide; the study will be limited to a sample of participants in the United States of America. The instrument will be limited to measuring only those outcomes identified by the expert committee, although the process used to determine the outcomes should have identified a majority of the outcomes. Every attempt will be made to ensure that generalizability of this study can reach its full potential.

CONCLUSION

This paper has outlined a proposed research study to explore the outcomes of student participation in robotics competitions each year. There are thousands of students competing in robotics competitions around the world. More research needs to be conducted to document the outcomes and benefits of these competitions. An important concept in academia is a student's self-efficacy towards their school subjects. The proposed research will explore students' self-efficacy towards the outcomes of the VEX Robotics Competition and can add to the knowledge gained through the study of technology and engineering education.

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Are We There Yet? Questioning Whether Sustainability is the Destination or Journey for Design & Technology Education

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ABSTRACT
Since the latter half of the twentieth-century, a groundswell of debate has contested the way we use and share the Earth's resources; and the impact this has upon the environment, and subsequently, life as we know it now and into the future. In sustainable development literature, debates are concerned about the limitations and inequitable distribution of natural resources; contamination and destruction of ecosystems; species extinction and subsequent decreasing biodiversity; and more recently, climatic consequences from atmospheric changes attributed largely to anthropogenic activities. Similarly, the sustainability of the school subject of Design and Technology has been a cause for concern in recent years. Yet history reveals that it was from the context of technology design, development and transfer that sustainability thinking emerged, suggesting synergies exist between the school subject and world beyond the school gate. This paper reviews the history of the paradigm shifts from technological progress to sustainable development, to analyse whether sustainability is the destination to which technology education ought to aspire, or the journey towards an as-yet-unknown destination. The aim is to reconcile sustainable development and technology education, in a way that is mutually beneficial to the sustainability of both.

Keywords: Sustainable development, Design & Technology education, paradigm, sustainability thinking

INTRODUCTION
Although the dynamic, evolving nature of Earth has long been recognised (Martin, 2011), it was only relatively recent that the fragile, finite, bigger picture of the 'blue planet' was introduced through images beamed to Earth from NASA spacecraft. The trajectory of scientific and technological developments that led to this vision have similarly been regarded responsible for raising the living standards of generations of people, particularly in Westernised, 'developed' nations. Concerns for equity continue where these improvements have largely failed to transfer to people living in 'less developed' nations (Williams, 2009; Selinger, 2009), compounded by increasing concerns that future generations may not experience similar opportunities from the Earth's resources. The "possible solution" (Ludwig, 1997, p.111) gaining momentum to address these social and environmental inequities, *sustainable development*, has been defined by the international community as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987). The historical background to the paradigm shift from progress to sustainable development sets the scene for *A Play on Sustainability*.

Although educators cannot be certain about what students will need to know in the future, the trajectory from the past to the present offers insights into mistakes to avoid in the future. The complexity and value of historical accounts of technology in culture and society have been recognised (Brennan, Feng, Hall & Petrina, 2007; Lee, 2011; Pannabecker, 2004). In a call for more constructivist, contextualised pedagogies, to support design and technological literacy, Pannabecker (2004) urged that learning about design and technological development situated in the socio-historical context of its emergence, would support student understanding of "how different groups interacted and contributed to the design and construction of technology, including conflicts, challenges, and failures" (p.74). The aim of the paper is therefore twofold, to trace the movement from technological progress through to sustainable development to understand what this means for the future of technology education, and to offer views from that journey that teachers can expand upon further in technology classrooms. A wealth of technology 'data' may be interpreted from literature when traversing across disciplinary borders, supplemented by resources on the internet and in multimedia formats.

While the narrative provides a convenient way of revealing this movement for the purpose of this paper, it can only be a simplistic and linear account that barely does justice to the complexity and richness of the topic. Similar to the way fields such as Science and Technology Studies (STS), philosophy, and sociology of technology inform understanding about technology in contemporary society; historical fields such as archaeology, anthropology, material culture and paleontology inform technological understanding about past societies for this paper. This account of the movement towards sustainable development aims to understand how the past informs the present, so that students have potential to emerge from schooling at the frontier of future debates and developments. As Martin asserts, "to fully understand a particular entity, one must look at the entity's whole existence, not just its "ontogeny" or individual development ... but also its "phylogeny" or evolutionary history and its interaction with other systems" (2011, p.630) .

The paper traces the history of the movement from progress through to sustainable development to propose what it means for the future of the movement and for technology education. The paradigm (Kuhn, 1970) is used to draw temporal and conceptual boundaries around consensus of attitudes towards technology, distinguished for the purpose of this paper as eras of 'progress', 'development, and 'sustainable development'. The paper summarises the movement, then concludes with implications for technology education.

LOOKING BACK: UNSUSTAINABLE PROGRESS

It has been estimated that the development of horticulture, followed by agriculture approximately ten thousand years ago (Flannery, 1994), afforded food security in a way that supported establishment of human settlements. Ensuing population growth required new forms of social and labour organization, which resulted in new ways of living freed from the need to source food; so that some had the opportunity to experiment creatively in activities such as pottery and metal production (Diamond, 2005). With energy harnessed from fire and domesticated animals, groups living in resource rich geographies and temperate climates tended to create and accumulate more innovations that were highly sought after goods. Diamond (2005) asserted that geographies were responsible for giving some cultural groups distinct advantages over others, which influenced such activities as trade and exchange, so that power imbalances both within and between these groups created the need for new mechanisms for dealing with conflict, defining boundaries, and forms of social control (Ferguson, 2011). In effect, the agricultural model developed to procure, preserve and distribute food, supported the growth of populations in sedentary societies, to the extent that human energy could be invested in creating new technologies which reinforced the value of land and ecology as 'resources'. At its most extreme, these values and technologies extended to defending and claiming new territories through warfare (Diamond, 2005).

Over millennia, various cultural groups adapted this model to their advantage in the process of building civilisations. The agricultural requirement of close proximity to water could be seen to influence the development of new ways of channelling water for irrigation and drainage (Mumford, p.58), thus improving farming and settlement systems. Building upon this, new means of deriving energy from the water-mill were developed between 150 B.C. and 50 A.D. (Finley, 1965, p.29), so that by the 18th century, water and steam were to converge with other innovations to supply energy for the Industrial Revolution. The factory model of mass production both led to reorganisation of new forms of human labour, or replaced human labour with mechanised processes. Increasing populations, more efficient production, and technologies of mobility, enabled some people to engage in exploration and others to engage in scientific discoveries Linked with technology and economic prosperity, scientific discoveries advanced knowledge in a way that was to influence Western worldviews into the 21st century. Electricity, fossil fuels and nuclear power inspired optimism for progress to secure a better world (WCED, 1987, p.6); so that with all people enjoying improved standards of living, technology was considered to be "one of several means of bringing about a perfect world" (Hall, 2009, p.58).

HAVE OUR AMBITIONS OUTWEIGHED OUR CAPABILITIES?

Early in the twentieth-century, there was much optimism that technological progress afforded by scientific advances, would transfer equitably around the world to improve the lives of all people. This attitude shifted towards one of pessimism over the course of the century, in recognition that equitable improvements had largely failed to transpire in poorer parts of the world (Williams, 2009; Selinger, 2009); and due to fear in the aftermath of attacks on Hiroshima and Nagasaki during World War II (Hall, 2009, p.58). By the 1960's, people were receptive to the idea that technological progress could equally have negative consequences, so that when literature released around this time resonated with these and growing awareness about resource depletion, pollution, species extinction, and peak oil; the international community recognised the paradigm of progress was losing support, and needed to be redefined accordingly. Two of the most influential pieces of literature were *Silent Spring* by Rachel Carson, which illuminated the human and environmental health problems associated with the use of agricultural chemicals; and *Limits to Growth*, a report by the Club of Rome, which used computer modelling to challenge the feasibility of unlimited growth (Du Pisani, 2006; Kanninen, 2013). By the latter part of the twentieth-century, the international community transformed the discourse for progress into one of development; absolving the concept of 'growth' that had been inherent to progress. With increasing awareness of the divide between the world's rich and poor, international efforts conceptually divided nations into "developed" and "developing" worlds, and increased aid to developing nations supported by Human Rights agreements; while turning to address environmental consequences of progress and development.

The paradigm for 'sustainable development' was constructed to address the two goals for conservation of ecological habitats, and equitable progress for human societies now and into the future; expressed by the triple bottom line of economic-social-environmental objectives (Dusek, 2009; Du Pisani, 2006). Since the Brundtland Report *Our Common Future* (WCED, 1987) defined these objectives, many nations experienced further rapid changes, uncertainty about global warming and concerns for 'peak oil', unemployment, the "structural adjustments" (Smillie, 2000, p.227) of globalisation, and much speculation about the role of science in genetic modifications (Dusek, 2009, p.133). As international agreements about how to achieve the goals of the movement have continued to be argued, recent attention has turned to concerns about the impact of anthropogenic activities, considered to be responsible for "fundamentally altering climate across the globe" (Elshof, 2006, p.20). Coupled with increasing human populations and demands for energy from all nations (Ludwig, 1997), it is evident that there will continue to be more development related consequences that scientists are only just starting to understand.

CONSEQUENCES AT THE CROSS-ROADS OF SUSTAINABLE DEVELOPMENT

The shift in attitudes that accompanied the shift from progress to development was concerned with social and environmental consequences of technological progress. In the historical review, similar consequences appeared which had further dimensions of positive and negative orientations. For instance, although the development of settlement may be considered positive, paleopathologists found that in the transition to agriculture, there were adverse consequences for human health. Their scientific analysis found evidence of increased infections, dental disease, and nutritional deficiencies in 19 out of 21 societies studied (Mummert, Esche, Robinson & Armelagos, 2011), explained by factors including social inequality, reliance on single crops deficient in essential nutrients, and population density supporting transmission of disease and infection (ibid.). While these consequences may be regarded as failures typical of any new technological endeavour in the early stages, the legacy of these consequences suggests they have only grown larger and more urgent, rather than been resolved.

Considerations for whether these consequences were 'positive' or 'negative' would depend on the subjectivity of the assessor. The same consequence may have been regarded as a problem for some, while for others; it would have presented new opportunities. Just as the health problems of early agricultural societies increased the pursuit of medical solutions, so the problems associated with progress and development have created new opportunities in the pursuit of sustainable technologies and industries. However as Daugherty (2003) reminded us, the invention of the automobile solved the problem of pollution from horse dung created by horse-drawn transportation, but within a century, automobiles became a leading source of air pollution. In effect, "[t]he pollution solution became the pollution problem" (Daugherty, 2003, p.36). Consequences may also be intentional or unintentional (ibid.), particularly with the "function creep" (Keirl, 2003, p.151) where technologies are not used in ways that were originally intended.

As such positive/negative and intended/unintended consequences represent the crossroads (Pauli, 2010, p.4) of development, where there are choices, or points of growth that set the journey towards new destinations. In addition to the cultural entanglements which contribute towards the cumulative nature of technological development, these cross-roads represent "the 'unknown' element of future challenges that students face" (Rockstroh, 2012, p.77). For sustainable development, consequences at the cross-roads suggest that what are currently regarded as sustainable technologies, may turn out to be very different. The success or failures of contemporary development will not be known until the technologies have stood the test of time. As Williams points out, "[i]n technology, it is not possible to predict what will work with certainty because of the manifold qualitative variable involved" (2010, p.6). The 'unknown' element, these variables, relate to the question *are we there yet*? The question is whether our technological ambitions have outweighed both the planet's capacity to resource these ambitions, and our own capacity to resolve their consequences, or are we facing a new crisis of 'peak intelligence'? With the prediction that human populations are expected to rise in the future, and the argument that sustainable development was "a contradiction in terms" (Du Pisani, 2006, p.94) between two "competing goals" (Ludwig, 1997, p.111) of social development and environmental conservation; the paradigm remains contested. Indeed, whether the paradigm is sustained, then whether or not it succeeds, will not be known until it has also stood the stood the test of time.

ARE WE THERE YET? GROWTH IN THE DISCOURSE OF DEVELOPMENT

The concept of 'progress' was traced back to early Christian philosophy, where it encapsulated "the gradual unfolding of a design present from the beginning of human history, and the concept of the eventual spiritual perfection of humankind in the next world" (Du Pisani, 2006, p.84). Du Pisani claimed that by the 13th century, progress came to represent the "cumulative advancement of culture" (ibid.), and had become synonymous with Western science and technology by the 20th century. As perceptions about science and technology shifted from utopian to dystopian, 'development' was conceived as a means to *distance* technology from 'progress'. Moreover, the discourse worked to distance the new paradigm from the utopian ideals of *growth* associated with progress, to counter models of zero-growth proposed following the *Limits to Growth* (Du Pisani, 2006, p.91). As an ideology, the contention remains that growth continues to influence policies and discourse through economic discourse. The tension between ‘development’ and ‘conservation’ (Ludwig, 1997) in sustainable development discourse, which Du Pisani refers to as “a compromise” that “was not fully embraced by either side in the debate about growth and conservation” (2006, p.94), suggests the paradigm may not have moved as far past the paradigm of progress as we are led to believe. Similar to the “belief in a future golden age” (Du Pisani, 2006, p.84) of the Christian promise in progress, perhaps sustainability remains a destination only for the faithful.

Appropriate solutions cannot be developed if they are responding to the wrong problem (Walker, 2006). It may not be possible to develop sustainable technical solutions, while human populations continue to escalate and economic growth continues unrestrained. In a recent book about the history of sustainability (Kanninen, 2013), also endorsed by the Club of Rome, the author asserted the need for a new paradigm, shifting from “global sustainability” with connotations of time to adjust activities, to “global *survivability*”, stressing the urgency with which he predicted humanity was faced. Amongst proposals for radical new forms of human organisation, institutions, technologies and practices, Kanninen (2013) considered the best hope was for “mobilization of younger generations ... as coming generations will be the victims of this crisis ... renewal coordinated: not through rules and regulations but through ideas and enthusiasm” (p.4).

LOOKING FORWARD: IMPLICATIONS FOR TECHNOLOGY EDUCATION

Increasingly it seems that society is as limited in its capacity to predict future consequences, as education is limited in its capacity to predict the needs of future generations. Despite this concern, a genuine grass-roots movement of support for sustainable development continues to gain momentum, an attitude towards technology that continues to be required for an authentic shift to eventuate. Leading author in the *Limits to Growth*, Meadows (1999) asserted that “leverage points” are “places within a complex system … where a small shift in one thing can produce big changes in everything” (p.1). The grass-roots movement offers many insights and ideas which may be adopted by individuals, and communities of practice (Lave & Wenger, 1991), and adapted for educational purposes. Pauli (2010, p.2) urges designers to emulate the “functionality embedded in the logic of ecosystems” to inspire new ways of problem solving. The idea of working *with* rather than *against* natural ecosystems is a key principle in Permaculture, which has transformed communities across the world. The focus of movements such as ‘Deep ecology’ can be seen as counter to “shallow ecology”, with a focus on technological fixes, but fails to challenge people to change their ways (Hay, 2010, p.164). While the leverage point suggests that technology education has the potential to inspire students to become leverage points for sustainable development, it also suggests that sustainable development might be the leverage point for increasing the value of technology education in the curriculum.

As educators engaging with our own ‘competing goals’ of synthesizing sustainability into content, while at the same time maintaining society’s expectations to prepare students to engage with the consequences of unsustainable development; the technology education community clearly has a role in shaping future debates and discourses. This review concurred with claims that technology education has the potential to develop students’ eco-design and environmental literacy (Elshof, 2005; Lowe, 2009; p.109; WCED, 1987, p.91), needs to “confront the *product paradigm*” (Elshof, 2006, p.21), employ alternative, cross-disciplinary and historical approaches (Pannabecker, 2004), and encourage creativity through development of technological literacy (Barlex, 2007). Our responsibility remains to pass on the baton of the best of our knowledge, in a way that encourages students to critically participate with, and creatively contribute towards their cultural heritage, now and into the future. To the best of the current generations’ knowledge, the grass-roots movement has helped develop an appreciation for using and developing sustainable materials, recycling, re-using, and reducing; however the problem remains that "few know how to make these economically viable" (Pauli, 2010, p.2). But through encouraging students to be creative and critical thinkers with an ethos for sustainability, a technology student with mathematical prowess may one day design a new economic theory to truly support a more sustainable future.

Returning to where the journey began, it appears that blue is the new green. The green movement of last century was an anthropocentric perspective. But in the 21st century, we now know we inhabit a blue planet, and need to consider the broader ecocentric perspective (Hay, 2010). Despite the challenges presented in this paper, the technology education community clearly has the potential to foster designerly thinking and technological literacy in ways that equitably respond to human needs now and into the future, and work towards sustaining the ecological resources and environments upon which such developments depend. But such a role will require a collective conscience to keep abreast of emerging knowledge, engage with scientific debates, and contribute towards thinking in a way that keeps the learning area relevant in the school curriculum. While ever technology education continues be a contested and "undervalued" (Williams, 2010, p.5) subject in the school curriculum, the challenge, but also the significance, and moreover the reward, of keeping pace with the paradigm of sustainable development, promises to be considerable.

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Disrupting Colonial Barriers to Inclusive Education for Indigenous and Multicultural Students

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ABSTRACT
It is well known that indigenous cultures have been sustained for thousands of years due to ways of being that were, and in some cases continue to be, very different to Western ways. With increasing urgency for new ways of thinking to support sustainable development, indigenous knowledges have been suggested to offer potential. In support of indigenous and critical respondents who reject such claims on grounds they continue the colonial agenda of appropriating indigenous resources, this paper argues for inclusive education to engage indigenous and multicultural students in Design and Technology education, so they may contribute towards sustainable designs, developments and discourses, on their own terms. Rather than romanticising indigenous worldviews and ways of being, or rendering indigenous knowledge subservient to a universal science, there is a need to value diversity in ways that support, rather than compromise, cultural identity. At a time when life as we know it is under threat from the consequences of unsustainable progress, and classrooms are becoming increasingly multicultural, sustainability asserts the need for inclusive pedagogies to encourage creative, diverse expressions of learners' identity.

Keywords: sustainability; cultural diversity; Indigenous Australians; learners' identity

INTRODUCTION: SUSTAINABLE DESIGN, DEVELOPMENT & DISCOURSE

Although the history of technological development may be read as the cumulative story of cultural responses to diverse ecologies from around the world; concerns the "developed" world enjoys these cumulative benefits at the expense of future populations and current "developing" worlds, have escalated. Emerging during an era when concerns about the fragile and finite (Kanninen, 2013) nature of ecological resources were highlighted, international efforts attempted to address social inequity in terms of environmental conservation; effectively shifting from *un*sustainable technological designs, developments and discourses, towards a "new morally defensible paradigm" (Du Pisani, 2006, p.94) for *sustainable development* (SD). With equitable socio-economic development and environmental conservation (Du Pisani, 2006) "the two competing goals" (Ludwig, 1997, p.111) of SD, debates continue about how, and indeed *if*, the social and environmental dimensions can be reconciled through this paradigm.

When considering inclusive education for multicultural technology students, equitable access to socio-economic development can be seen as a concern not only for people in 'developing' nations, but for people indigenous to 'developed' nations; many of whom suffer intergenerational "disadvantage and unequal access to the benefits of development as a legacy of colonization" (Gibbs, 2005, p.1365). This paper considers the "discourse of colonialism" (Thomas, 1991) in order to examine how this legacy might manifest in ways that present barriers to students from diverse cultural backgrounds. Drawing from my PhD research into learning and development in cross-cultural technology transfer and education, the paper foregrounds the value of sustaining cultural diversity to contribute towards inclusive pedagogies for Design and Technology (hereafter referred to as technology) education. For the purpose of this paper, indigenous and multicultural students will be considered representative of the non-Western, non-dominant minority classroom populations, for whom equity is of concern in the broader SD literature. This simplistic representation is only intended to stimulate further discussions for inclusive education, so that multicultural students may be empowered to engage with sustainable designs, development and discourse on their own terms. My intention is neither to speak for multicultural students or homogenise their diversity; but rather, to draw attention to the taken-for-granted Western worldview that predominates formal education and sustainability thinking.

IDENTIFYING BARRIERS TO INCLUSIVE MULTICULTURAL EDUCATION: COLONISATION

As human populations become more and more mobile, teachers are increasingly challenged to meet the needs of students from diverse cultural backgrounds (Oikonomidoy, 2011; van Eijck & Roth, 2011; Whitfield, Klug & Whitney, 2007). Led by UNESCO, international efforts to address these challenges promote 'inclusive education' as "an ongoing process aimed at offering quality education for all while respecting diversity and the different needs and abilities, characteristics and learning expectations of the students and communities" (UNESCO, 2008, cited in EADSNE, 2010, p. 11). While addressing the needs of all students presents a daunting prospect, the *Policy Guidelines on Inclusion in Education* (UNESCO, 2009, p.9), suggests the first task is to identify barriers to inclusive opportunities, followed by resources to overcome those barriers.

A transdisciplinary review of literature found that similar to the 'hidden curriculum', colonisation resides in Western society in ways that presents barriers to full participation of indigenous peoples (Moreton-Robinson, 2009; Kessaris, 2006; Gibbs, 2005; Hickling-Hudson & Ahlquist, 2003). In Western settler societies such as the USA, Canada, Australia and New Zealand, Moreton-Robinson (2009) insisted colonisation "has not ceased to exist" but "has only changed in form from that which our ancestors encountered" (p.11); through the simultaneous resistance and accommodation of imperial European authority (Hickling-Hudson & Ahlquist, 2003, p.1). For indigenous peoples, colonisation and colonial thinking are rendered visible through the often unconscious, everyday activities of the dominant majority society (Kessaris, 2006, p.347: Maffie, 2008); operating "discursively and materially" through institutions and popular culture where it is "built into and expressed through the "normal" functioning of the various social, political and cultural institutions of society" (Moreton-Robinson, 2009, p.11). Hickling-Hudson and Ahlquist (2003) asserted colonial thinking permeates through educational practices in ways that reify European culture "superior to all others", despite the "rhetoric concerning multicultural pedagogy" (p.1). In their case studies of schools in the USA and Australia, they found continued evidence of 'deculturalisation', or the use of education as a tool to destroy culture and replace it with a new one. Similarly in a study of science education (van Eijck & Roth, 2007), Eurocentric and culturally imperial approaches were recognised as barriers that "frustrate indigenous minorities" (p.929) from participation.

Drawing parallels between technological and scientific literacy, van Eijck and Claxton (2009) asserted these "presuppose that a particular *culturally* favoured way of knowing is considered a prerequisite for participating in society, namely, the way of knowing employed by scientists and rooted in a Eurocentric worldview" (p.223, emphasis in original). If the discourse of colonialism operates similarly in technology education, it may be apparent in academic discourse and policies that manifest through curriculum and pedagogies, enacted from teacher training down to the hidden curriculum of the classroom. Moreover, it may be evident in the taken-for-granted "mundane technologies" (Michael, 2000) of every-day technology classrooms and learning activities, and influence teachers' expectations for outcomes from design-and-make projects. If colonialism is a barrier to engaging indigenous students, it may similarly preclude multicultural students and others from diverse (i.e. low socio-economic) backgrounds from engaging in meaningful learning experiences and inhibit creative expressions of diversity in problem-solving and design activities.

IDENTIFYING CRITICAL AND CULTURAL RESOURCES TO OVERCOME BARRIERS

Critical traditions provide useful philosophical tools for interrogating discourses to challenge assumptions that serve to maintain the status quo (Petrina, 1998, p.39). In ecofeminism, Plumwood (2009) claimed that "failure to understand our ecological situation, being out of touch with what is happening to our ecological world and with ourselves as ecological beings" may be traced to early Christianity and Plato; from where humans emerged as "part of a radically separate order of reason, mind, or consciousness, set apart from the lower order" (p.118). The binary construction of human-nature relations was a dualism of superior-inferior proportions established to justify the domination by 'One' over subordinated 'Other', in ways that Plumwood contended, was to influence Western thinking through to the 21st century. Critical theorists trace domination and subordination through further dualisms (i.e. mind/body, reason/emotion, man/woman), revealing the way these themes permeate throughout Western literature and policy making to reify Western assumptions of superiority over 'Other' forms of existence (Sefa Dei, 2008, p.10). Of particular interest to SD discourse and multicultural education, Plumwood (2006, p.128) asserted these themes were adopted to legitimise 'colonisation' and colonial thinking, where they manifested in Western discourse as *anthropocentric* domination over nature, and *Eurocentric* domination over indigenous peoples.

While sustainability considerations suggests that anthropocentric domination may have influenced Western values towards the environment, the paper now turns to analyse Eurocentrism as a factor in the discourse of colonialism (Thomas, 1991). Numerous scholars (Aitken, 2009; Byrne, 1996; Grounds & Ross, 2010; McNiven, 2011) concur that when Europeans first settled in Australia, governments of the day co-opted anthropologists and archaeologists to justify the invasion (domination) and occupation (colonisation) of the continent through discourse. Anthropologists constructed the "discourse of alterity" to reify "us/them" distinctions and distance the coloniser from the 'Other' (Thomas, 1991, p.3), with key anthropological concerns focused on the point of cultural contact and economic forms of exchange; where for instance, they constructed the 'failure' of Indigenous Australians (Thomas, 1991, p.2), and the 'resistance' of Maori (van Meijl, 2011, p.136), to eagerly adopt the new technologies and consumption patterns of Western material culture. In this way, indigenous peoples were constructed as 'problematic' in that they were characterised as not only different, but inferior (Maffie, 2008) in their adherence to the 'past'. In this Western cultural construction, indigenous peoples were distanced from Western peoples by their resistance to technologies and values associated with progress; so that 'culture' became the point of difference, a property of the 'Other' which homogenised all those who associated with culture as pre-historic, primitive, and set in their static ways. Conversely, the culture of people who engaged with the technologies of Western progress were not problematised, or discussed in academic discourse, effectively, rendering their cultural nature invisible.

In contemporary discourses, anthropology has now turned its gaze to redress culture as a characteristic inherent to all humans (Mulcock, Pocock & Toussaint, 2005), with cultural-historical activity theory emerging as a field which seeks to understand human cognition and activity as cultural relationships with the world. Although culture originated in academic thinking to refer to the activity of 'cultivating' the land with tools, over time it was adopted by psychologists and human developmentalists to refer to "the tending of human children" (Cole, 1991, p.190), then applied to groups of people considered less "cultured" or "cultivated" (i.e. inferior) than people from the dominant (i.e. superior) society. Cole (1991) asserted "the core idea of culture as a process of helping things to grow was combined with a general theory for how to *promote* growth" (p.190, my emphasis). Through constructing culture as a characteristic inherent to indigenous people and a "curiosity" (Hart & Whatman, 1998) worthy of study (Byrne, 1996), anthropology and archaeology legitimised the "superiority of one group over another" (Grounds & Ross, 2010, p.56), to the extent that:

"It became conventional to envisage Aboriginal culture and technology as an example of the primitive Palaeolithic stage of human evolution and Aboriginal people as humans who had not progressed past this stage ... Aboriginal culture was static and unchanging ... relegated to the past and therefore did not pertain to the contemporary view of human progress; thus the civilising nature of colonial Britain was expounded and glorified, in effect legitimising the colonising act to the wider public for political gain" (ibid.)

In policy eras that followed, the impact of colonisation on Indigenous Australians, as for elsewhere in settler societies, "disrupted an entire value system, altered the power and status of groups within Indigenous societies and rendered them all subordinate to the coloniser" (Houston, 2007, p.46). In the 21st century, Indigenous Australians remain the most disadvantaged group in education (Fordham & Schwab, 2007; Glynn, Cowie, Otrel-Cass & Macfarlane, 2010; Wilson & Johnson, 2011). While small positive gains have been made, the legacy of colonisation manifesting through failed policies (Aitken, 2009, p.15) and intergenerational disadvantage cannot be overstated.

TOWARDS INCLUSIVE EDUCATION FOR MULTICULTURAL TECHNOLOGY STUDENTS

To address the first task of developing inclusive education (UNESCO, 2009), this paper identified barriers and possible resources to overcome those barriers to inform inclusive education for multicultural technology students. Following claims from indigenous writers, colonisation was analysed as a barrier to indigenous students, and potentially to students from diverse cultural backgrounds. Tracing the discourse of colonialism across multiple disciplinary borders revealed the way 'culture' and 'colonialism' had been culturally-historically constructed and implemented. Ecofeminism critically highlighted "dualisms" in discourse, where Plato's reason was used to distinguish between, then homogenise and distance; One, superior, dominant entity and Other, inferior, subordinate entity; justifying anthropocentric domination over ecologies, and Eurocentric domination over indigenous peoples. In the latter case, the paper examined the claim that colonisation legitimised European invasion, occupation and appropriation of Indigenous Australians and their 'resources'; problematising indigenous peoples to effectively increase Western superiority. The paper proposed that cultural-historical activity theory offers a possible resource to overcome barriers to inclusive education, through a framework that supports understanding of culture. Further, the theory has been foundational to constructivist and socio-cultural based pedagogies which recognise that "people construct knowledge through interaction with others in the socio-cultural environment" (Fox-Turnbull, 2007, p.67). The paper also identified critical approaches for their potential to reveal colonial assumptions "in the broader culture" (Kessaris, 2006, p.358) of Western settler societies. Colonisation was suggested to be covertly maintained by the people, artifacts and practices associated with designs, developments, and discourses, or the "technecologies" (Rockstroh, 2012) of Western material culture.

In technology education, these conceptual tools may be used to analyse and evaluate both existing and future educational topics and teaching resources for their inclusive potential. Critical pedagogies such as critical design (Barab, Dodge, Thomas, Jackson & Tuzun, 2007) urge educationalists to question their discourses, prevailing practices and structures, and to disrupt resources that work to exclude students. As design is a cultural practice laden with values, technological activities may contain many assumptions and biases such as those presented in this paper. However disrupting these resources does not mean to avoid those deemed inappropriate, but rather to *make explicit* that which was previously hidden; using those resources in ways “which empowers as it exposes” (Fine & Weis, 1998, cited in Barab et al., 2007), so that students develop critical conceptual tools for future encounters with similar resources. While this challenge appears enormous, the shift towards sustainability thinking demands such critical moves necessary to disrupt dominant designs, developments and discourses. Barab et.al. (2007) claim that when teachers have done so, unforseen benefits have emerged where they “envision their activities and understandings with new clarity and insight” (p.293).

TOWARDS INCLUSIVE EDUCATION FOR SUSTAINABLE DEVELOPMENT

To illustrate these critical moves in the context of sustainability thinking, the paper returns to debates that question whether SD will achieve its objectives. The debates relate to tensions between equitable socio-economic development and environmental conservation, where anthropocentric concerns are said to dominate over ecocentric concerns in SD discourse (Imran, Alam & Beaumont, 2011). Drawing anecdotally upon Australian popular culture pertaining to SD, the media appear preoccupied with the environmental dimension of SD, particularly how “climate change” might impact upon the Western quality of life. While ecocentric on the surface, the discourse tends to be couched in anthropocentric values associated with sustaining one dominant, Western way of being in the world; rather than values associated with sharing resources equitably. Problems pertaining to ‘developing’ worlds are typically portrayed as human rights issues, a distinct problem. From a critical perspective, Eurocentric agendas of “the West” (Ferguson, 2011), are promoted over equitable development for “the Rest” (ibid.), skewing the anthropocentric focus in favour of ‘One’ over ‘Other’ through an environmental lens.

Expanding this observation, a Google Scholar search found 529,000 articles for “‘sustainable development’ + conservation”, compared to 106,000 articles for “‘sustainable development’ + equity”, a trend that was replicated through further comparisons using terminology variations (Sept, 2013). Similarly, a study (Elshof, 2005) found “social justice and equity” were “considered less important” to technology teacher survey respondents, despite considering issues such as “human rights” one of the “most significant components” of SD from a personal perspectives (p.179). While not representative of different, broader, or more recent population samples; a critical analysis contends that social equity may be interpreted more as ‘additional’, rather than *inherent to* the story of Western diversity, and *critical to the success* of environmental solutions. Moreover, if the dominant global thinking that co-evolved with unsustainable development continues to silence minority voices, any imposed solutions can only be superficial (Anaya, 2004, p.58). If a criteria of SD success is the longevity, or sustainability of solutions, addressing the environmental dimension will require equitable representation from the full social dimension.

The final part of this attempt at UNESCO’s (2009) first task for developing inclusive technology education pedagogies, recommends the technology education community examine and disrupt assumptions and practices that work to exclude multicultural students. To briefly illustrate this need, two recent technology education articles highlight examples of exclusionary and inclusionary cultural discourses. The first article (Seemann, 2010) advocates the value of cultural diversity by drawing upon the ‘resources’ afforded by Indigenous Australians; from the potential of their lands to sustain urban lifestyles and economies with energy, food, minerals and fuel, through to their cultural knowledge for providing “fresh ideas” and “conceptual solutions” for innovations to “benefit the world” (p.560). Proposing the urgency of problems created by Western domination and development affords little time for “cordial” (p.559) conduct in appropriating these resources from some of the worlds’ most disadvantaged peoples, the literature suggests Seemann’s (2010) article encourages the technology education community to engage in two extreme forms of colonialism. The first form is a desire to “return to nature” (Rogoff, 2003), a “disillusionment with technology” (Dusek, 2009, p.132) referred to as ‘romanticism’ (Dusek, 2009; Ihde, 2000; Maffie, 2008; Petrina, Volk & Kim, 2004; Rogoff, 2003); and the second form of colonialism has been referred to as a modern version of piracy

(Lee, 2011; Maffie, 2008; Sefa Dei, 2008; Shiva, 1997). In contrast to this exclusionary discourse, an article by Lee (2011) appears to value and encourage greater understanding and respect for cultural diversity in technology education by foregrounding culture as inherent to *all* students and teachers. The article outlines a thoughtful range of historical, social, technological and environmental suggestions which have the potential to inform, guide and inspire technology teachers to develop culturally appropriate learning resources and experiences, that encourage students to "utilise the wisdom of other generations and cultures" (Lee, 2011, p.42) in design and technological activities.

CONCLUSION

This paper established that inclusive pedagogies for multicultural technology education need to recognise the culturedness of *all* students, who *learn by becoming* (Rockstroh, 2012, p.81) members of the culture with which they identify. As decolonisation "requires the imaginative creation of a new form of consciousness and way of life ... the coming together of two or more cultures as a result of colonialism and the production of new and different hybrid cultural identities" (Moalosi, Popovic & Hickling-Hudson, 2007, p.37), inclusive pedagogies which celebrate cultural entanglements (Rockstroh, 2012) suggests many possible unforseen innovations. By moving designs, developments and discourses beyond Eurocentric and anthropocentric thinking, Design and Technology education may work towards reconciling the social and environmental goals of SD, and establish itself in the movement. Moreover, fostering diverse cultural expression in problem-solving, design and technological activities has potential to support, rather than compromise learners' identities, encouraging students to engage in sustainable futures on their own terms – critically, creatively, and with confidence.

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Food Technology in D&T: What Do Teachers' and Pupils' in England Really Think?

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ABSTRACT
This paper presents the views and ideas for further developments of food technology of practicing teachers and pupils in secondary design and technology (D&T) in English schools. Prior research developed a modern conceptual curriculum framework for food technology, gathered stakeholders' views and analysed lower secondary school (11-14 years) schemes of work and upper secondary (14-16 years) external examination specifications against the framework (Rutland, 2009; 2010a; 2010b; 2011;Rutland, Owen-Jackson, 2012a; 2012b).

The paper focuses on pupils aged 11-14 years and aims to find out what teachers and pupils:
1. currently understand as the role/purpose of food technology
2. understand to be involved in 'designing' with food
3. consider to be the key aspects of food technology
4. think that pupils should learn when studying food technology
5. consider what needs to be further developed in the teaching and learning of food technology.

The findings noted that both teachers and pupils thought that food technology should be taught, that designing was important as designing and making with food helped pupils be creative, understand how to make 'healthier' foods and provided links with future careers. The development of practical skills and nutritional knowledge were key aspects of food technology, though there was little evidence of teaching the implications of eating highly processed foods and nutritional intake measures. The teachers considered that understanding what ingredients do and aspects of food technologies were important, for example preserving foods and emerging technologies but there was little evidence of these being taught to the majority of pupils before the 14-16 year age range. All pupils thought that learning to cook (a life skill) and knowledge of food/ingredients were important aspects of food technology.

It was concluded that there was a tension between pupils learning to 'cook' and food technology as a relevant and rigorous twenty first century curriculum area. Lack of curriculum time was cited as a key issue by teachers and pupils, reflecting local rather than national concerns. A key finding was a huge variation in access to food technology for pupils aged 11-14 years. Some schools had been given extra curriculum time for subject enhancement courses, though this was at the expense of offering examination courses to older pupils. The findings of this small scale research in England are indicative rather than definitive. A larger investigation with an

international dimension and the production a modern food technology teaching resources were recommended.

Keywords: food technology, teaching and learning; current practice; teachers and pupils.

INTRODUCTION

In recent years the key issues related to the teaching of food technology in England have focused on two perceptions a) the important contribution of food technology as an academic subject with intellectual rigour in a modern D&T curriculum and b) the importance of pupils learning to cook as a 'life skill' (Lawson, 2013). HMI have indicated, supported by the D&T Association, that schools face a considerable challenge modernising the D&T curriculum, including food technology (Ofsted, 2008, 2011).

A conceptual food technology framework was developed based on the views of a range of stakeholders (Rutland, 2009; 2010a; 2010b; 2011). It aims to create a modern curriculum that develops pupils' knowledge and understanding of issues related to everyday life enabling them to make informed and intelligent judgments (Elliott, 1998) within social, economic, aesthetic, technological, rational, moral, active and evolving contexts (Lawton, 1989; Guile, Young, 1999). The framework consists of a) designing and making food products b) underpinned by an understanding of the science of food and cooking and nutrition c) an exploration of both existing, new and emerging food technologies in d) the context of the sustainable development of food supplies locally, nationally and globally and e) an appreciation of the roles of consumers, the food industry and government agencies in influencing, monitoring, regulating and developing the food we eat. It was used to analyse examples of schemes of work for pupils aged 11-14 years and examination specifications for pupils aged 14-16 years (Rutland, Owen-Jackson, 2012a; 2012b).

The Department of Education (DfE) in England published for consultation a new draft D&T curriculum for pupils aged 5-16 years (DfE, February 2013). The response of the D&T community was summed up by Peter Luff (20.03.13) (Member of Parliament) in the 'Today's Commons debate in Parliament, the Design and Technology Curriculum'. He cited three themes, the narrowness of focus returning to the 1950's 'do it yourself' or DIY curriculum with a focus on basic craft and household maintenance'; secondly a lack of academic or technical, challenge or ambition and thirdly a reduction in value and popularity reinforcing the perception that applied subjects are less valuable. In relation~~ship~~ to food technology, there was no mention of designing and making with food and the underpinning knowledge, understanding and skills but there was a focus on pupils learning to 'cook'.

In the following months the D&T Association, the Royal Academy of Engineering and the wider D&T community developed a radically revised version. The changes between February and July are immense. The reference to repair and maintenance have gone, pupils continue to design and make using a range of materials such as textiles, construction materials and ingredients. However, there is a separate section called 'cooking and nutrition' where it states that as part of their work with food, all pupils will learn to cook and apply the principles of nutrition and healthy eating (DfE, July 2013).

These developments reinforce the need to clarify the nature, teaching and learning of food technology in schools. An article in D&T Practice (Rutland, January 2013) looked at developing a modern secondary food technology curriculum fit for purpose in the 21st Century and suggested that there was a need for a project to research, develop and trial teaching resources for pupils aged 11-14 years.

METHODOLOGY

The theoretical framework for the study is related to the purpose of education. There is a huge corpus on this and no definitive answer. Education is political and its purposes vary over time and according to the prevailing ideology. In England, the current view appears to be that education should serve the economic and social needs of society by preparing children to be workers and active citizens. Within this context, we were considering whether the food technology curriculum should be developed as an academic contribution to pupils' general education or as a practical life skill.

The conceptual framework for food technology developed in an earlier phase of the research presented a view of food technology as an academic discipline developing pupils' knowledge and higher-order thinking skills through relevant and appropriate practical work. This view contrasts with that presented in the national curriculum for England (DfE 2013). In this phase of research, therefore, we gathered the views of teachers and pupils on food technology currently taught in schools and their views for future developments.

Questionnaires collected data from fifteen teachers in a range of state, private, mixed and single sex school of 780 – 2000 pupils from the north, midlands and south of England. Some of the teachers had responded to the D&T Practice article (Rutland, January 2013). Data was also collected from a total of 202 pupils aged 11-14 years.

The teachers and the pupils' completed a different but similar questionnaire based on the same issues. The teachers were also asked to look at a list of topics based on the conceptual framework for food technology and respond to the questions. Responses by pupils were from across the age range and were voluntary.

FINDINGS AND ANALYSIS

Fifteen of the teacher questionnaires were returned, but three were not fully completed. The three teacher's views were analysed but not their response to the aspects of the food technology in the conceptual framework. There were responses from 62 Year 7 pupils, 38 Year 8 and 102 Year 9 pupils.

Background and curriculum time

The teacher questionnaires revealed huge variations in the accessibility for pupils to food technology in the school curriculum. In Years 7 and 8 this varied from to 2.5 hours to 69 hours and most were around 15-18 hours. In Year 9 it varied from a 2.5 hours minimum to a 114 hours maximum, with the balance evenly divided between those schools retaining national curriculum D&T teaching for Year 9 and those starting food technology examination work in Year 9.

1. Reasons for teaching food technology: All the teachers agreed that food technology should be studied by all pupils, although one teacher commented that it should not be called food technology. The majority reason given for this (64% of responses) was that it is a 'life skill', five cited because it teaches about 'nutrition or healthy eating', three cited 'to tackle obesity' and only one cited because it develops creativity, independence and team work skills.

Similarly, the overwhelming majority of pupils (87%) agreed that all pupils should study food technology, mainly because it teaches 'how to cook' or as a life skill, particularly in Year 7. In Year 9 there were also references to learning about 'nutrition and healthy eating'. Year 7 and Year 9 pupils also thought that it was 'fun'. The small number who thought that it should be optional stated that it was not enjoyed by all pupils, or they were not good at it.

2. Designing and making: In the teachers' views, based on the conceptual framework section (Appendix C), the majority indicated that design strategies were important. The strategies of product evaluation, sensory analysis, nutritional analysis and modifying recipes were more highly supported with only 'image boards' being considered 'not important' by all teachers. A variety of design strategies were taught, particularly with Years 8, 9, 10 and 11 with only user trips and image boards being less popular.

A smaller majority (57%) of teachers agreed that pupils should ‘design and make’ with food, mainly because it helped them to be creative with food, understand food and utilise their knowledge and skills. Those who disagreed (29%), did so because they thought that there should be more emphasis on developing pupils’ practical skills. Two teachers were ambivalent, seeing that ‘designing’ with food encouraged pupils to be creative but believing that the focus should be on developing knowledge and skills.

The majority of pupils (91%) agreed that they should be taught to ‘design and make’ with food, mainly because it helps develop creativity. Year 9 pupils also said that it helped them to learn how to make food healthier. Other reasons cited were to do with links with jobs/careers and, across all year groups, a small number mentioned that it helped developed skills such as independence; organisation and making them feel proud of what they made. The small number who thought that they should not ‘design and make’ thought that the focus should be on learning to ‘cook’ rather than the design work.

Content of food technology courses

There was high agreement by the teachers and pupils that the development of practical skills and nutrition are key aspects of food technology (71% and 64%). This was reflected where all the aspects of ‘combining food materials’ and ‘cooking food’ were considered important and taught by the majority of teachers to all year groups. Similarly, most teachers considered ‘guidelines of a healthy diet’ and ‘properties of food’ taught across the year groups to be important. Aspects of ‘nutrition’ were also considered important by teachers and whilst there was evidence for basic nutritional knowledge and the nutritional content of foods being taught, there was less evidence for the teaching of nutritional intake measures and the implications of eating highly processed food. Other key aspects mentioned were health and safety (57%), understanding ingredients and the effect of cooking on ingredients (43%), designing/developing ideas (21%), understanding food labelling and the social, moral, environmental dimensions of food (14%) and one teacher (7%) citing each of developing knowledge for food choice, sensory analysis, food source/seasonality, wise food shopping and pupils having fun.

Interestingly, the responses in the conceptual framework section (Appendix C) show that teachers give importance to ‘understanding what ingredients can do’ but there was little evidence of this being taught to the majority of pupils until they were 14 years old. The responses from teachers showed that they considered aspects of ‘food technologies’ to be important, particularly ‘ways of preserving food’ and ‘emerging food technologies’ but again there was little evidence of these aspects being taught to the younger age range. The picture is similar for ‘the context of sustainable development of food supplies’ and ‘roles of the consumer, food industry and government agencies’.

Pupils gave a variety of responses as to the knowledge needed to design and make, but none mentioned design strategies and only one pupil mentioned ‘research skills’. The majority, across all year groups, cited knowledge of food or ingredients (39%); many cited knowing how to cook or use equipment (26%). In year 7 13 pupils (21% of year 7) mentioned ‘health and safety’ which is often a focus of Year 7 teaching and in Year 9 there were several mentions of ‘target market’ and healthy eating, again likely to be a reflection of the focus of the teaching. All pupils regarded learning how to cook as an important feature of food technology, with some mentioning specific skills that they had learnt, for example ‘rubbing in and chopping’. In Year 7, 17 pupils (27%) pupils mentioned ‘fun’ rather than health and safety. In Year 9, there were mentions of designing and making, healthy eating and nutrition.

When the teachers were asked what they thought pupils learnt in food technology there was a wider variety of responses:

- Practical skills (57%)
- Understanding food/ingredients and Time management/organisation (36%)
- Nutrition, Food safety and hygiene, Team work, Independence (29%)
- Healthy eating and Planning (21%)
- Creativity (14%)
- Food labelling, Social/cultural aspects of food, Problem solving, Designing, Research skills, Social skills (7%)

What is missing in food technology and future developments?

Teachers were then asked what was missing from food technology and responses varied. Several mentioned skills (29%) and nutrition/healthy eating (21%), but there were single mentions of idiosyncratic views such as 'creativity with leftover food', 'links with farming', 'the enjoyment/appreciation of food' and the contribution of food technology to pupils' literacy and numeracy. However, the biggest number of responses (36%) referred to a lack of curriculum time, with two mentions of funding and one of technician support.

Pupils were also asked what was missing from food technology and 80 of the 202 reported 'nothing'. However, like the teachers, pupils also highlighted lack of 'time' and many also said they wanted more variety in what they cooked (15%) and more choice over what to cook (11%).

Finally, teachers were asked how their food technology curriculum would develop and improve over the next academic year and, again, responses varied considerably and were reflections of local concerns rather than any national or subject foci. Responses included:

- Focusing more on skills, one teacher mentioned introducing sugar craft
- Introducing more social, moral, cultural and environmental issues
- More outdoor growing space

Whilst one teacher said they would be integrating more with Science, Technology, Engineering and mathematics (STEM), one said that there would be less designing and one that they would move their focus away from technology. However, pupils thought that food technology could be improved with more practical work (17%), more curriculum time (16%), particularly in year 7, recipes which are more interesting, complex or challenging (13%) and more choice over what they cooked (11%), particularly in Year 9.

DISCUSSION.

It is acknowledged that the findings are indicative rather than definitive as they are based on a small scale research project in England. However, we believe that the sample was sufficiently representative to provide validity.

It is of interest that not all schools, whether private or state funded, followed the national curriculum for pupils aged 11-14 years. One state funded, selective grammar where historically General Certificate of Education (GCSE) Food Technology had been offered had decided to run food as an enrichment subject for girls aged 13-18 years. The Year 9 course was an optional, very popular food enrichment course of 34 lessons integrating theory, demonstrations and practical work to encourage skill and creative use of ingredients to emphasis healthy eating. This led to a course, for pupils aged 16-18 years, focusing on 'creative cooking' as a life skill. However, senior management in the school would not allow the department to offer examination courses for pupils aged 14-18 years, which the teachers felt was a lost opportunity.

Another teacher in a mixed, private school with considerable experience in higher education and the food industry, had set up a food department where her brief had been to make it 'fun' and prepare the pupils to live away from home. It was an interesting, very practically based curriculum where science and industrial aspects were integrated and the inclusion of extra, optional sessions such as a sugar confectionary course. The teacher wanted to start examination courses for older pupils but this was not currently possible. The majority of the schools ran food technology courses for pupils aged 11-14 years and one of the state funded comprehensive schools taught a food technology curriculum for pupils 11-14 years followed by food technology examinations for pupils aged 16 and 18 years. The teacher was a moderator for external examinations board for pupils aged 18 years and was keen on the career opportunities it offered to her pupils in the food industry.

Examination courses traditionally have been taught to pupils aged 14-16 years and there was a wide range offered in the schools, some starting in Year 9, included GCSE Food technology, Hospitality and Catering, Home Economics and non examination in-house Food Enhancement courses. This has implications for pupils aged 11-14 years, the focus of this research, as a key issue concerns the range and breadth that can be included. What should young people know and understand about food that will enable them to choose and use food wisely and what are the influences both inside and outside school that will inform this knowledge? How will young people develop an understanding of the implications of current concerns such a health, consumer understanding and awareness, food production and world food availability? How will they take responsibility for the way they choose and use food and become pro-active in developing a critical discourse concerning food in our society? (Rutland, Barlex, 2009).

The findings indicate that the majority of teachers and pupils regard the purpose of food technology as developing a ‘life skill’ rather than contributing to pupils’ general education. Although, there was some acknowledgement of the academic learning it develops this was not the focus for teachers or pupils. Yet, the conceptual framework of food technology developed during this ongoing research incorporates breadth and depth. It includes the need for pupils to understand underlying scientific concepts about combining food materials and designing and making with food. It requires a capability to carryout product development making conceptual, technical, aesthetic and constructional and marketing design decisions. Pupils will understand, and be able to take into account, the properties of food and understand the ‘how and why’ of the ways ingredients interact in preparation and cooking. They will learn about the nutritional properties of foods and the potential impact of eating highly processed foods, how food is grown, where it comes from and how to sustain food sources nationally and internationally. Finally, as future informed consumers they will learn about the role of the food industry and government agencies. This sees food technology as contributing to pupils’ general academic development, not simply as developing their ability to cook.

Currently, in England there is a substantial lobby for children to be taught to cook in schools. The government sees it as a way of dealing with society’s obesity health problem. This was very apparent in the draft D&T National Curriculum when first published (DfE, February 2013) with the only mention of food as ‘cooking’. In the latest curriculum document (DfE, July 2013) ‘ingredients’ are included in designing and making with a separate section on ’cooking and nutrition’ and healthy eating. It can be argued that if schools base their food technology curriculum for the years 11-14 on the conceptual framework, then pupils would automatically be taught about nutrition and how to cook and would, we believe, provide them with a much richer educational experience.

However, there are issues of curriculum time, teacher availability, the physical resources to teach all aspects of food technology together with developing a high level of ‘cooking skills’, that impact on the range and quality of the food technology curriculum taught. It will be very interesting to see how schools deal with this. D&T curriculum time for pupils aged at 11-14 years is not large and has to cover all specialist areas in schools, and food technology teachers will need to make decisions. Will they opt for just teaching pupils to ‘cook nutritious meals’ or will they want to give their pupils a broader, rigorous and more intellectually demanding curriculum that develops them personally, intellectually and provides potential routes into interesting future careers? As noted in this research, teachers considered aspects of the food technology conceptual framework to be important, yet there was little evidence of them being taught until pupils reached 14-16 years. Schools and teachers will need to establish what should be taught to their pupils, think flexibly and creatively making use of all resources.

RECOMMENDATIONS

We believe it is important that work is undertaken to encourage teachers and pupils to see the valuable contribution that food technology can make to pupils’ general education. Whilst the development of practical skills is important these need to be set within a broader and more rigorous learning context.

Having identified a modern food technology curriculum fit for the 21st Century in England, the next step is to develop teaching resources for pupils aged 11-14 years to clarify the nature of food technology and structure the teaching and learning that should take place. A project has been developed although funding has not yet been secured. Further research gathering data from a larger population and exploring other nations' concepts of food technology would extend and enrich this research and development.

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Education for Sustainable Development in Compulsory School Technology Education: A Problem Inventory

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ABSTRACT

Awareness of sustainability issues is increasingly demanded in society. Education for Sustainable Development (ESD) is a requirement stated in the Swedish curriculum. Findings (Schools Inspectorate, 2012) indicate considerable variations in how teachers in Sweden work with value related issues. It is also found that schools/teachers commonly lack a holistic approach and a common stance in this assignment. Reportedly ESD seems dependent on the personal interests and abilities of individual teachers (ibid.). In order to develop teaching about sustainable development within the Technology subject we need knowledge about how ESD is carried out today (content and work methods). We also need to know how the concept of sustainability is interpreted by concerned key actors in schools (teachers and principals). During the spring of 2013 a pilot study focusing technology teachers' work with sustainable development within their technology classes is being performed. Based on interviews (teachers and principals) we analyze what are perceived to be the main difficulties associated with the integration of sustainability into technology education. Findings confirm previous research stating that knowledge about sustainability is vague among teachers. Most teachers and principals in the study are primarily (in some cases only) aware of the environmental/ecological aspect of sustainability. The study also points to a discrepancy between perceived and actual need for improving teachers' competence in ESD. Since ESD is not well defined, fully understood and established among those responsible for the actual teaching there is an evident risk of ESD being treated as 'one further requirement' rather than as the asset it actually represents to technology education. It is suggested is that the planning, organization and implementation of future ESD efforts must be coordinated carefully with all concerned parties in advance and be supported more substantially than previous efforts. The idea that the subject matter technology should be given the overall responsibility for ESD in schools is also promoted.

Keywords: Education for Sustainable Development (ESD), Technology Education, Compulsory School, Teachers, Principals

INTRODUCTION

In the current compulsory school curriculum introduced in Sweden in 2011 (Skolverket/National Agency of Education, 2011) sustainable development is highlighted in the

Fundamental values and tasks statement (ibid p. 9). These fundamental values should be reflected in all syllabuses. Sustainable development is accordingly mentioned directly or indirectly in most subject syllabuses. In the Technology syllabus (ibid p. 254) sustainable development is e.g. mentioned in the section describing the aim of the subject:

… teaching should give pupils the preconditions to develop confidence in their own ability to assess technical solutions and relate these to questions concerning aesthetics, ethics, gender roles, the economy and sustainable development (ibid p. 254)

A recent study (Skolinspektionen/Schools Inspectorate, 2012) shows considerable variations in how teachers in general work with education about value related issues. Findings indicate that schools/ teachers commonly lack a holistic approach and a common stance in this assignment. This is, according to the report, reflected in how teachers design their teaching which mainly seems dependent on the personal interests and abilities of the individual teachers (c.f. Pavlova, 2009, 2012; Pitt & Lubben, 2009). In order to develop ESD within the Technology subject, in line with the visions of the curricula (e.g. ibid p. 254), we need to know how ESD is carried out today (content and work methods).

The pilot study presented here is part of a research project that aims at increasing our knowledge and understanding about how future technology education (school) and engineering education (university) should be designed in order to secure the inclusion of the various dimensions of sustainability presented in the so called Bruntland-report (WCED, 1987), as effectively as possible.

Based on interviews with teachers and principals in compulsory schools with a technology profile we explore how compulsory teachers/schools work with ESD from the following questions: (1) How is the concept of sustainability interpreted/defined (2) How is sustainability taught (learning objectives, teaching methods, pedagogical strategies/tools)?,and (3) What resources (e.g. training efforts, material/tools, etc.) are (according to the informants) required in order to strengthen ESD in general and in technology education in particular.

BACKGROUND

The concept of sustainability

In the Brundtland Report (WCED, 1987) it is stated that development in society need to meet ecological as well as economic and social demands. Today, there is broad consensus that in order to achieve ecological sustainability societies must develop in such a way that the regenerative capacity of biological systems is maintained over time. However, there is significantly less agreement on what it means for development to be ecologically, socially and economically sustainable (Vallance *et al*., 2011). From the literature it is clear that at present there is no single agreed-on definition of sustainability (neither the concept ‘itself’ nor as regards to the three dimensions of sustainability mentioned in the Bruntland Report).

Sustainability in compulsory school education

The present curriculum was introduced in 2011.It contains three parts (Fundamental values and tasks of the school, Overall goals and guidelines for education and Syllabuses for all school subjects). In the fundamental values and tasks section, the concept of sustainability is mentioned only once. On the other hand the importance of a sustainable approach is highlighted already in the first paragraph;

Each and every one working in the school should also encourage respect for the intrinsic value of each person and the environment we all share (Skolverket/National Agency of Education, 2011, p.11).

Four perspectives are to be highlighted in all educational (historical, environmental, international and ethical). Regarding the environmental perspective it is stated that;

Teaching should illuminate how the functions of society and our ways of living and working can best be adapted to create sustainable development (ibid. p. 12).

In total sixteen (16) overall goals are presented in the curriculum. Three (3) of these goals include sustainability or/and a sustainable approach. The most obvious one reads:

The school is responsible for ensuring that each pupil on completing compulsory school has obtained knowledge about the prerequisites for a good environment and sustainable development (ibid. p. 16).

Sustainable development is explicitly written out as an important part in in eight (8) syllabuses (home and consumer studies, biology, physics, chemistry, geography, social studies, crafts and technology). In e.g. the Technology syllabus (ibid p. 254) sustainable development is mentioned in the section describing the aim of the subject:

… teaching should give pupils the preconditions to develop confidence in their own ability to assess technical solutions and relate these to questions concerning aesthetics, ethics, gender roles, the economy and sustainable development (ibid p. 254).

RELATED RESEARCH

In a study of Canadian (Ontario) schools, Elshof (2005) set out to identify which facets of sustainable development technology teachers deem to be the most significant, from a personal, collegial and student interest perspective. It was found that there is a great need for professional development of teachers, to break up traditional disciplinary boundaries and to create new discursive spaces.

According to Pavlova (2009) the current co-existence of environmental education (EE) and education for sustainable development (ESD) has created a concern regarding overlap and duplication of goals and programs in EE and ESD. This lack of clarity is pointed out as a contributing factor to the inefficiencies in achieving goals and development in educational initiatives/activities. Pavlova (ibid.) also argues that emphases on the social dimension of design for ESD need to be strengthened in order to align technology education with global developments. In line with this McGarr (2010) argues that the integration of ESD needs to move beyond awareness rising, particularly in relation to raising awareness of environmental issues.

The challenge ahead lies in exploring ways in which a much more critical dimension can be added, one which challenges both teachers' and students' beliefs and perceptions about technology, and in doing so, illuminates a range of issues pertinent to ESD (McGarr 2010, p 330).

Across disciplines, there are great challenges regarding how to integrate ESD in the curriculum. Different stakeholders are competing for priority in influencing curriculum design (Layton 1994). This combined with the continuous changes in the political landscape is making the development of ESD in schools a sometimes difficult balancing act.

THEORETICAL CONSIDERATIONS AND METHODS USED

This is primarily a descriptive study however; the question of how to explain and understand the findings is, to some extent, also addressed. The starting point of our study is the requirement that sustainability should be included in education. In order to understand how different actors respond to this requirement, the intermediate process, i.e., the question of how education about sustainability dimensions is organized planned and implemented needs to be addressed. In this study, the Frame factor theory thinking model (FFTT) is used as a tool for understanding the informants' different ways of responding to the listed requirements. FFTT was introduced by Dahllöf (1967, 1999) in the 1960s and was initially referred to as Frame factor theory thinking by Gustafsson (1994). FFTT provides a model for thinking about education not as an effect of interventions, but as opportunities within established limits. According to Dahllöf, guidance towards a certain goal or outcome requires different conditions, i.e. control of what comes out of training.

The aim of this pilot study is to, in a small scale, try-out tentative interview questions and methods/tools of analysis. Data collection and analysis is therefore limited to statements from four teachers and three principals. The selection of schools is based on the fact that these schools have participated in a technology education school development program called the Boost for Technology Initiative (www.tekniklyftet.se).

Semi-structured interviews with principals and teachers were conducted in June and July 2013. All interviews lasted 25-35 minutes and followed the same interview template consisting of questions sorted into five focus areas: the interviewee's background, the concept of social sustainability, learning objectives, curriculum integration and opportunities/ difficulties. At the time of the interviews, the teachers (three women and one man) had been teaching for between 6-25 years. The principals (all women) had been principals for 4-21 years. None of the informants were currently or had been involved in work/research directly related to sustainable development. Collected data has been transcribed, systemized and analyzed through repeated readings of statements.

RESULTS

Below a selection of our first results are presented. It should be noted that these results are based on statements from a very limited number of respondents.

Both principals and teachers have been actively involved in the integration of sustainable development in their classes/schools (teachers directly as they are responsible for the actual teaching and principals indirectly by being originators/promoters and facilitators of time and resources). Most of them say that they feel fairly comfortable discussing sustainability issues in school education. Examples of their thoughts and views are accounted for below.

The concept of sustainability (Q1)

The challenge to define the concept of sustainable development is met with considerable confidence by the informants. The concept is perceived as familiar but, at the same time elusive. Several of the teachers directly associate to their own teaching practice. The link to the environmental aspects is strikingly frequent in informants' responses.

When we work with it in the school it mainly concerns environmental issues…about recycling … That's the very theme we worked with!

Only one of the informants is familiar with the fact that the concept of sustainable development has been divided into three different dimensions.

My understanding of the concept is that I as a citizen should feel confident that everyone in the community takes their decisions based on the three keynotes, ecological, economic, and social sustainability - to ensure that everyone is safe.

When presented to, and asked about social and economic sustainability the notions in most cases are vague. Some informants indicate that it is the first time they have encountered these dimensions in relation to sustainability in general and in relation to school education in particular. This is in particular true in the case of economic sustainability.

It is really difficult to work with it when you do not know what it is.

Both principals and teachers are well aware of the requirements stated in the curricula (National Agency of Education, 2011) regarding the integration of sustainability dimensions into compulsory school education. Their knowledge about how ESD is projected in the different syllabuses is generally more general and unspecific. There are some examples of statements in the data (answers that could be described as cautious) showing traces of guilt of not being fully updated (being ignorant and untutored) about the different aspects of the sustainability concept.

How is sustainability taught in the selected schools/classes? (Q2)

Sustainability (as understood by the informants) is integrated in the education in various degrees. Environmental aspects are in particular highlighted (pollution, recycling of packaging, and energy issues). The importance of linking education to students' needs and questions is emphasized. Most informants do recognise social dimensions as being implied in their teaching and therefore dealt with (in various degree) within their school/classes. Social dimensions are however explicitly specified as a learning objective by only one teacher and one principal (however under another heading). Issues concerning economic sustainability are not specifically addressed by the teachers.

According to the informants, ESD should be included in all school subjects. When asked in what subject matters sustainability ESD could/should be taught the informants mention Geography, the Natural Sciences, the Social Sciences, Craft, Food Technology and Technology. Reportedly ESD education is, commonly performed in the form of projects, thematic work, study visits or by inviting experts (preferably active in the vicinity of the school).

Statements expressing that sustainability issues (ESD) have been addressed prior to the introduction of this concept in the curricula are found in the data.

Actually, we have always worked with this, but we didn't call it Sustainable Development.

What resources are required in order to support ESD? (Q3)

Most of the informants are fairly content with how they work with ESD. Resources available as well as content knowledge and pedagogical competence among the teachers is not seen as a problem by two of the three principals. Several teachers seem to agree:

You learn when you work with it … and we can search on the internet

However some do request opportunities for betterment (preferably shorter courses during 1-3 days). Guidelines, good examples and most of all a precise definition to relate to are other requests mentioned. The policy documents are, according to the informants, perceived to be helpful although no one exemplifies how they have used these documents in their teaching (except to 'tick off' elements to be included).

DISCUSSION AND CONCLUSIONS

The aim of this pilot study has been to explore how sustainability is perceived, interpreted and taught in Swedish Technology education. The analysis is based on documentary studies and interviews with teachers and principals. Earlier research has shown that ESD in schools is still fragmented and rather unsatisfactory. This study, although based on a small sample, confirms that knowledge about sustainability in technology education is vague and that teachers and principals mainly are aware of the environmental/ecological aspect of sustainability. The study also points to a discrepancy between perceived and (as we understand it) actual need for improving teachers' competence in ESD. In line with earlier research our results show that the social aspects, and to an even greater extend, the economic aspects of ESD, are less familiar and therefore in general not dealt with. We do need to move beyond this limited approach to sustainability and prepare pupils and students for all aspects of technology in society. The suggested basis for this is the foundation of integrated critical thinking at all educational levels and more focus laid on aspect of sustainability relevant to young student's needs and wants. We have also investigated which kind of resources that are needed in order to enhance awareness and increase knowledge about all aspects of sustainability. Although demands for ESD competence development are raised by the informants these demands are very moderate (occasional lectures and/or training days). There may be reason for us to consider why the complexity of the field is not fully reflected in the demands presented by the informants. Looking at this from a Frame factor theory thinking perspective (FFTT) (Dahllöf, 1967, 1999), our findings appear logical and understandable. Decisions and directives concerning sustainability education in school has been taken at the organizational level with few opportunities for principals and teachers to influence the what, when and why's of ESD. The problem is not ESD itself. All informants fully share the visions and goals stated on the executive level. The problem rather lies in the implementation process. When/if the aims and goals of ESD is not well defined, fully understood and established among those responsible for the actual teaching there is an evident risk of ESD being treated as 'one further requirement' rather than as the asset it actually represents to technology education. Our suggested conclusion is that the planning, organization and implementation of ESD should be anchored and coordinated with all concerned parties. Findings indicate that the inclusion of school level actors (principals and teachers) in this process would increase the possibility of adapting EDS to the conditions of compulsory school education. In order to further secure the quality and quantity of ESD in compulsory school we suggest that that the overall responsibility for ESD should be laid upon one designated subject matter. Our understanding is that Technology is a school subject well suited for this assignment.

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Rethinking Design Thinking in Technology Education

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ABSTRACT
Design thinking has a central focus on creative, innovative, empathetic activity orientated towards process, problem resolution and products for ill-defined contexts, through application of a particular form of thinking. Little attention however has been given to the cognitive flaws that are inherently a feature of the decision-making aspects of design thinking in an educational setting. As a consequence designing is often presented within Technology Education as an idealistic rational activity that brings about conscious planned change in the made world.

This paper represents the first stage of an embryonic research project examining the existence, identification of and reflection upon cognitive limitations and heuristic flaws of those engaged in design thinking processes as part of a Technology education experience. As such the paper provides a discussion, overview and rationale for the use of Metacognitive Debiasing and Reflection Tools in Design Thinking (MDRTDT) activities as part of an educational experience that will be used in the research study.

Keywords: Design Thinking, Cognitive Limitation, Heuristics, Technology Education

INTRODUCTION

Design within Technology Education (Technology Education is used as a term within this paper which encompasses Design and Technology) is often discussed with ever increasing diversity and association in relation to 'problem-solving', 'the iterative process', 'creativity', 'imagination', 'critical thinking', 'critical evaluation', ' critical reflection,' 'learning through doing', and so on. Most recently this diversity is embodied with the redrafted National Curriculum in England: Framework Document (2013) with the overarching statement for Design and Technology stating that:

Using creativity and imagination, pupils design and make products that solve real and relevant problems within a variety of contexts, considering their own and others' needs, wants and values. (DfE, p.192)

Within such discussions design is framed as something positive and a force for good, based upon an assumption that design represents a rational activity that brings about conscious planned change in the made world. My starting position is that 'Design' as a 'process' (or more correctly a series of processes) and activity is central to being human; we are all natural designers and we all engage in the processes of designing. In making this point it is important to make the distinction that we are not all born vocationally orientated and professionally equipped as designers. It means that we are genetically predisposed (in a similar way to Chomsky's concept of language acquisition) to problem identification and resolution whilst innately ambitious to improve our natural habitat and environment. Culturally and educationally we are further shaped and distorted in our thinking towards thinking of design in often less intuitive ways. However given that design is a naturally occurring human activity means that we therefore need to consider what does it mean to be human as being human involves a whole series of values, beliefs and ethics, which may not be consistent for all of humanity. Equally as design shapes the human world again we need to consider what this may mean in what is a rapidly changing world and how our 'needs, wants and values' when applied to changing the world, notionally for the better (whatever this might actually mean), may ultimately distort the carefully balanced sustainable and ecological systems we exist within. Current rhetoric however presents the image of the designer as a force for good that designing, as an activity is a positively framed activity, whilst problems are to be solved often using simplistic constructs of creativity and imagination.

This paper will therefore examine and aim to rethink the term 'design thinking' which carries with it association of a special form of rationalist, creative, imaginative, systematic and immersive thinking that designers do, framed within a forward and positive projecting context. In addition the paper aims to rethink design thinking as an educational activity in an education environment as well as challenging rational notions of design thinking within a context of design focussed 'Technology education' experiences.

DESIGN THINKING

Technology education has evolved to operate within a cultural/ problem solving continuum with a pervasive rationale for the subject occupying different positions focussing upon the creative and/or the technical and the aesthetic and/or the functional. Within such a continuum 'design thinking' is represented as the means to resolution based upon creative, empathetic, rational and designerly (Cross, 2006) processes.

Within a broader vocational context design thinking is acknowledged with the field of design and acts of designing through the use of design processes and methodologies to generate innovative ideas and creative responses (Brown, 2009; Cross, 2011; Martin, 2009) such us using mind mapping, brainstorming and iterative processes. Most recently the ability of designers to engage in design thinking has been considered as a special form of thinking (Lockwood, 2009; Moggridge, 2010; Norman, 2013; Verganti, 2009) and whilst there is no uniform definition of design thinking Moggridge (2010) suggests it is a harnessing of the 'power of intuition' and a 'process' to create 'solutions' to problems. Norman (2013) in a U-turn on the existence of design thinking, after initially advocating it was myth, suggests that designers have developed a variety of techniques that avoid them being 'captured by too facile a solution' and that such approaches would represent 'design thinking'. Verganti (2009) also sees design thinking as something unique in relation to multidisciplinary interpretation and not merely about aesthetics but about semiotics and interpreters developing a design discourse. In doing so Verganti rejects the prevailing dogmas of styling, user-centred design and intuitive creative endeavour. More pertinently design thinking is increasingly considered as a participatory co-creation activity requiring engagement with problem owners, with specific domain understanding, that require a particular form of thinking related to employment and application of specific process skills.

From this limited exploration of design thinking it is firstly acknowledged that there is no robust universally agreed definition of design thinking (Rogers, 2013) but the strongest common denominator embraces the centrality of the user and empathy to the human condition (Rogers, 2013, p.434). Secondly that the nature of defining design thinking is transient and emergent whilst predominantly focused on processes in design. In acknowledging this I want to explore some of the emerging definitions within an educational rather than vocational and business context and consider what is the potential value, nature and orientation of design thinking in an educational setting. In doing so I also want to position this in a wider educational context by provocatively suggesting that the location for the development of design thinking may or may not be part of a broader 'Technology Education' experience. The reason for suggesting this is that there is an inherent danger that Technology educators consider they have a monopoly on the development and nurturing of design thinking. My suggestion is that they don't and it is only by recognizing that they don't that a more informed rationale for the existence and operation of design thinking in Technology education may emerge.

In examining design thinking in an educational context a clear starting point would be to examine the design processes, which are commonly associated with Technology Education and which are seen to represent design thinking in action. However given that the issues that surround the development, application and misuse of the notional 'design process' are well documented (particularly in relation to how 'processes' have been distorted by assessment practices and how creativity is often marginalised within limited models of designing) the focus of this paper will be elsewhere. Therefore whilst acknowledging the limitations associated with 'design processes' I want to focus on exploring a different aspect of designing in relation to the cognitive limitations that we each have in a design thinking context. The starting point for this exploration is to challenge the notion that whilst engaged in 'design thinking' there is a perceived rationalist, creative, imaginative, positive projecting, cognitive coherence associated with designing which I suggest is far from justifiable. As humans, there are significant 'cognitive flaws' that we each carry which I believe an awareness of constitutes a significant, yet currently unacknowledged, learning opportunity.

Previously, having identified that design thinking should not be considered the preserve of Technology education, when the context of Technology education contains a significant design element with a rationale to 'improve the quality of life' then I believe that Technology education does provide a unique opportunity to explore cognitive limitations in an attempt to better understand design thinking in multiple contexts. Such an opportunity is gained by engaging in a process of metacognitive intervention through cognitive debiasing, which identifies cognitive limitations and heuristic flaws, embedded as part of a broader interpretation of design thinking.

COGNITIVE LIMITATIONS AND HEURISTIC FLAWS

In previous writing (Spendlove, 2007a; Spendlove, 2007b; Spendlove, 2008) I have explored how our emotions and sub conscious processing plays a central part in our decision-making and how concepts of narcissm and altruism (Spendlove, 2010) also influence our thinking. I have also acknowledged that underlying assumptions relating to social, political, theological, psychological, philosophical, pedagogical and cultural values all interact with decisions we each make. Ultimately our cognitive state is slow, messy, error-prone and unreliable, the product of 3 billion years of trial-and-error evolution that has led us to have cognitive limitations that lead to weak memories, unreliable decision making and to believe the improbable or impossible.

In addition our language is neither optimally constructed nor straightforward. We have problems with probabilities as illustrated by the 'conjunction fallacy' (see 'Linda Probability' question), which involves involuntary and unconscious cuing (Tversky and Kahneman, 1983) when making what appears to be straightforward decisions. Equally approximately 85% of the time analytical decisions that we think we are making have already been 'primed' by the unconscious mind whilst at the same time we are innately looking for patterns that may not exist. Such extreme 'apophenia' is recognized as the inclination to make spontaneous perception of connections and meaningfulness of unrelated phenomena (Carol, 2003). Relativity, imprinting, anchoring and arbitrary coherence are all further examples of cognitive limitations that add to our consistently illogical processing, particularly when reasoning under various degrees of uncertainty which is the position that any designing must operate in.

An unfortunate consequence of such cognitive limitations is an overriding antidote of avoiding engagement with these limitations through over reliance upon 'intuition', 'gut feeling' and simple 'rules of thumb' often resulting in heuristic flaws. Indeed we are often steered by such feelings however what we feel about something informs us what we think and not the other way around (Damasio, 2006) as such intuition or deliberate practice is when we operate 'quasi-automatically and with reasonable proficiency' (Pigliucci, 2012) and is an instinctive sense that something is right, a heuristic shortcut, but which is prone to errors when engaged in decision making particularly when operating under a cognitive load. A further way of overcoming our limitations is through the adoption of purely optimist strategies. Optimism bias is a key survival strategy as we mentally project forward and identify our future needs. However again this is prone to error which Sharot (2012) cites as the 'superiority illusion' in that we tend to think we are better than we are. Sharot give an example of a survey of driving where 93 per cent of respondents indicated they were above average in driving ability, which would be statistically impossible.

Returning back to subconscious processing, image recall experiments have consistently shown our ability to subconsciously store and access information that go way beyond that which we would try to process in normal ways. Such image based sub-processing offers interesting questions about how designers recall and manipulate images in the mind and the extent to which this is a conscious process and the authenticity of design ideas. What we see or recall is also equally unreliable as in the Müller-Lyer illusion, a familiar optical illusion, in which we know that the two lines are the same length but we process through our visual system as something different. This is just one of a range of examples which show that our emotional and cognitive operations are limited and unreliable and guide us to make decisions which may not always lead to the 'best' solution.

Whilst identifying many limitations exist in relation to our ability to make design decisions in the interest of others there is also the alternative side of this discussion, which relates to the exploitation by designers of the limitations of cognitive processing in others. Kahneman (2011) identifies a 'focusing illusion' where we misjudge the potential impact of certain circumstances. As such designers and marketing specialists exploit consumer demand by offering a better future using a combination of focusing illusion and visual illusions whilst thriving on an optimism bias, manipulating consumer emotions and thriving on the many cognitive limitations identified above.

It would therefore appear that any form of education claiming to develop 'design thinking' and capability in design should involve an insight into the limitations of designerly thought and the inherent cognitive limitations and heuristic traps. However an equally important dimension has to be a strong ethical and sustainable dimension, which relates to the exploitation of cognitive limitations and emotional manipulation of others. A sad reality is that designers as well as helping others also exploit others through the shaping of a future world that may not be achievable or desirable. As such a paradox exists that recognises that significant negative impact on the natural world comes from some of the most creative individuals.

Recognising such cognitive flaws can be considered as central to 'agency' as in the intentional ability to exercise some control over one's thinking and subsequent existence. As indicated by Bandura (2001, p.1) agency is achieved through "intentionality and forethought, self-regulation by self-reactive influence, and self- reflectiveness about one's capabilities", and such qualities, I would argue, are essential in any designerly process particularly in a context of decision making when dealing with uncertainty.

In identifying recognition of cognitive limitations and misuse of heuristics as an integral feature of agency and design thinking within a Technology education context, a case is being made for the rethinking of design thinking. As such this paper represents the first part of an embryonic research project looking at the existence, identification and reflection upon cognitive limitations and heuristic flaws of those engaged in design thinking as part of a Technology education experience.

IDENTIFICATION, REFLECTION AND CONCLUSION

Within the context of design thinking as part of Technology education I have identified the existence of a series cognitive limitations which I believe through a metacognitive approach of debiasing (Fischoff, 1982) and reflection provides a unique opportunity to both expose such constraints and most significantly to offer the opportunity learn from such limitations in order to improve future decision making. In choosing these areas to focus upon I am acknowledging that the areas I have chosen represent a relatively small number of the extensive list of cognitive limitations identified in a vast range of literature. The areas chosen were however selected through a extended process of abductive reasoning (whilst acknowledging the potential cognitive flaws in this process) as having specific relevance within Technology education when dealing with uncertainty and a summary of each are provided (Appendix one) in the form of an inventory of design thinking cognitive flaws. Each limitation identified represents a cognitive bias that can distort design thinking, which as part of this research project I will be looking to develop a range of metacognitive debiasing and reflection tools which will form part of a reconsidered design thinking strategy.

The paper has sought to outline a rationale for reconsidering such limitations of design thinking approaches within Technology education by drawing upon existing literature and applying to a Technology educational context. The second stage of this research aims to use the identified inventory of design thinking cognitive flaws with the aim of engaging learners in metacognitive process using a series of debiasing and reflection tools as part of an enhanced design thinking strategy. Through participating in such a process it is anticipated that learners will engage in a more rigorous design thinking approach that will have relevance within and beyond their Technology education activities.

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APPENDIX

Table 1: Inventory of Design Thinking Cognitive Flaws

Cognitive flaw	Definition
Anchoring	The establishment of an initial judgment (called the anchor) from a simple feature and then adjusting the estimate, to form a final judgment. Adjustment to the initial judgement, however, is usually constrained and conservative, as a consequence the final judgment is biased towards the original anchor judgement (Tversky and Kahneman, 1974)
Affect Heuristic	A positive (like) or negative (dislike) evaluative feeling toward an external stimulus (e.g. some hazard) that allows us to ‘‘lubricate reason’’ allowing us to be led astray or manipulated—inadvertently or intentionally— silently and invisibly (Slovic, 2007)
Apohenia	The broad term applied for identifying or perceiving patterns in often random or meaningless data – where such patterns are neither present nor intended (Carol, 2003)
Attentional Bias	The tendency to selectively attend to personally relevant information over neutral information (Mathews and MacLeod, 2005).
Availability Heursitic	A person is said to employ the availability heuristic whenever he estimates frequency or probability by the ease with which instances or associations could be brought to mind (Tversky and Kahneman,1973).
Confirmation Bias	Seeking information that is consistent with one’s own views and discounting disconfirming information (Griffiths 1994).
Focussing illusion	Bias that occurs when concentrating on just a single good, presented in a single response framework, is liable to inflate respondents’ perceptions of the importance of that good and hence raise their desire for that activity/good (Schkade and Kahneman, 1998).
Optimistic Bias	The often mistaken belief that the chances of experiencing a negative event are lower (or a positive event higher) than that of one’s peers (Weinstein, 1980).

Social and Cultural Relevance in Approaches to Developing Designerly Well-Being: The Potential and Challenges when Learners Call the Shots on Design Projects

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ABSTRACT
This paper builds on a position paper presented previously that outlined the concept of designerly well-being and, through reviewing critiques of Design and Technology (D&T) curriculum activities, proposed approaches that would support the concept. This paper describes a pilot study that explored designerly well-being in a situation where learners undertook design challenges in contexts that they saw as having socio-cultural relevance to their own lives. The pilot study explored how teachers structured a D&T 'enrichment day' based around the design contexts that 14 year olds express interests in. The interests were identified through a survey based on one used to identify topics of social and cultural relevance for learning in mathematics (the ROSME project). Having identified the interest areas, the teachers planned and enacted the enrichment activity with a cohort of 46 learners. Based on learner evaluation questionnaires and a teacher evaluation interview, the study illustrates how positively the learners responded to taking on 'big design' challenges in future-facing scenarios. The study also indicates challenges faced by teachers in planning and managing such activities and the transformative impact the day had on the teachers' views of approaches to D&T project work.

Keywords: Designerly well-being; design challenges; socio-cultural relevance; emotional response to designing

CONTEXT
This paper takes as its starting point a position paper presented at PATT26 in 2012 that explored the idea of developing designerly well-being as the basis for the development of a Design and Technology (D&T) curriculum. The position paper made explicit the belief, "that society is a better place when young people have experienced design and technological learning - that the designerly well-being of the individual makes for the designerly well-being of society." In addition, the concept of designerly well-being was characterised as the "satisfaction, pride, confidence and competence of being able to engage designerly thinking and action with criticality and capability" (Stables, 2012, p.426). The paper drew on review documents that, collectively, suggested that where D&T was successful, learners were engaged in relevant contexts and ambitious 'Big Design' challenges – those with social and cultural relevance that would make a difference to people's lives. This new paper presents the findings of a pilot study that explored the impact on learning and teaching when design project briefs are derived from

socio-cultural issues that the learners have identified as being of interest to them. The pilot study draws, in part, on previous research into socially and culturally relevant mathematics education - the multi-country ROSME project (Relevance of School Mathematics Education, Julie and Holtman, 2008) and more specifically a single country study undertaken in Malawi (Kazima, 2013). These studies explore the idea that learning is more effective when learners find the context of their learning relevant to their own lives. Kazima highlights the extent to which educational policies increasingly include the need to bring relevance into the curriculum, while rarely is the student voice heard when learning activities are being designed. Well-intentioned teachers spend considerable time planning activities that they think will be relevant to learners. But how often are the learners consulted?

In conjunction with issues of relevance, the pilot also explored the development of agency, criticality, pride in achievements and confidence, drawing on the concept of capability in the context of D&T (Kimbell & Stables, 2008; Stables, 2012, 2013) and more broadly through the ideas of others such as Sen (1992) and Nussbaum (2000). In focusing on the designerly well-being of humans (rather than professional designers) the research had in mind the democratizing of the process of designing as a counter to the disenfranchisement of the general public, as described by Shannon (1990).

Allowing learners to take on challenges that they see as relevant, potentially creates the conditions for well-being expressed by Princen (2010) when he states that
"Humans are at their best when

1. they are faced with a genuine challenge;
2. they are creative and productive;
3. they find meaning in their own problem-solving and impacts larger than themselves;
4. they help themselves and help others;
5. they self-organize and self-govern;" (Princen, 2010, p.175)

THE PILOT STUDY

The pilot explored the impact on learners of undertaking team-based, socio-cultural, 'Big Design' challenges through D&T. It also explored the impact on teachers' planning and evaluating such D&T activities and how this impacted their future thinking related to implementing D&T learning and teaching. An undertaking of this nature presents both opportunities and challenges and the pilot school was chosen as one that would be open to these and to the inevitable exploratory approach that was taken. While it might have been more realistic to explore the approach within regular, timetabled D&T lessons, for pragmatic reasons the main design activity of the pilot was conducted as a one-day enrichment activity. The school involved was a small, independent school. To maintain some consistency with the Malawi Maths survey, the learner group focused was Year 9 (14 year olds). The whole year group (46 learners) were involved. The structure of the pilot was:

- Survey learners to establish priority interests for D&T projects;
- Feedback survey results to teachers to enable planning;
- Observe the enrichment day;
- Evaluatory post activity questionnaire with learners;
- De-briefing interview with teachers.

Initial questionnaire

The pilot utlised a customized version of the ROSME survey – a Likert-style questionnaire with a 4-point response scale ('not at all interested' to 'very interested'). Table 1 shows a sample of questions.

Table 1: Comparison of questions from maths and d&t surveys

Things I'd like to learn about in Mathematics	Things I'd like to learn about in Design & Technology	Category (from Kazima's analysis)
Mathematics involved in making computer games, cell phone games & TV games	D&T involved in designing computer games, mobile phone games and Apps	Modern technology
Mathematics linked to weaving baskets & mats such as *mikeka*	D&T involved in producing hand-crafted products	ethnomathematics
Mathematics involved in studying issues of climate change & the environment	D&T involved in addressing issues of climate change and the environment	environment
Mathematics involved for deciding the number of cattle, goats or sheep to graze in a field of a certain size	D&T that help farmers get the best productivity from their farms	agriculture
Mathematics used in making airplanes & rockets	D&T for designing transportation systems for the future	technology

The learners completed the survey during a D&T lesson. They were informed about the nature of the research, the parallel survey in maths teaching in Malawi, and that the results would form the basis of design projects on the enrichment day.

Planning

The survey results were fed back to the teachers who held three planning meetings to prepare. The researcher was present at two of these and all were recorded. The researcher also introduced strategies from previous research that might be helpful. It was made clear that the teachers were free to accept, adapt or reject these. The first presented the concept of generality and specificity within any contextual setting (described as three levels - broad *context*, *referenced* focus and *specific* brief (Kimbell et al. 1991; Kimbell et al. 1996) and the value of learners understanding the general and specific. The second was choreographing the activities to support an iteration of action and reflection (Kimbell et al, 2004). The third was the sustainable design strategy of creating future scenarios, and then 'back-casting' from these to bring designing into a future context with a sense of reality. (See, e.g. Quist and Jaco, 2006) They were also provided with the original position paper (Stables, 2012).

The enrichment day

Following the planning sessions, learners were grouped by their responses to the initial survey. Teachers presented an overarching context of 'empathy' and, within this, two areas of reference – 'lifestyle' and 'future systems' that covered the areas learners had shown most interest in. Each group was given an A2 image board to spark ideas and a briefing sheet that raised questions about future living (Figure 1). Each group's aim was to develop a scenario and brief and design a prototype to address these. The groups worked with one of three teachers in a base room and had access to studio and workshop facilities. The teachers facilitated the learners as needs arose. During the day groups presented their developing ideas to others in their base room. At the end of the day each base room voted for the best idea in their room and the three resulting groups went 'head-to-head', presenting to the whole year group who then voted for the best overall idea from the day.

Figure 1: Image boards for the overarching themes.

Using emoticons to capture personal feelings

Understanding designerly well-being includes understanding the emotions an individual experiences when designing. As an initial exploration in this territory, the learners were asked, periodically, to reflect on how they were feeling, to capture this by circling one or more ‘emoticons’ and explaining why. The exemplar section of the emoticon capture sheet is shown in Figure 2.

Team Number	First name	Date
Time	Circle the emotions you feel about the project at each stage	Briefly, say why
e.g. 9.30	 happy confused angry back-off motoring relieved success	Confused – the project looks like a big challenge Relieved – we have all day and a good team

Figure 2: emoticons to record emotions whilst designing

The evaluation questionnaire

At the end of the enrichment day each learner completed an evaluation questionnaire, structured into five sections. The first four sections contained Likert-style response statements (strongly agree to strongly disagree) about the challenge set, the structure of the day, their team’s project and their own contribution. The fifth section asked them to list three things that were better than ‘normal’ D&T and three things that were worse.

The debriefing interview with teachers.

The de-briefing teacher interview was undertaken collectively, taped and transcribed. It was structured around the teachers’ expectations for the day, their overall reactions, the learning that took place, the challenges of planning and managing the day and the anticipated impact on future projects.

FINDINGS

The Survey of interests

The learners responded enthusiastically to the initial survey. Certain areas showed up as being very popular, the highest being "design transportation systems of the future" with other quite diverse areas also being highlighted, from "designing computer games and mobile phone Apps" to "design that could help achieve world peace" and "designing that helps people have a healthy lifestyle". There were some noticeable gender differences – boys being keen to "design equipment for sports competitions and events" and girls to engage in "designing involved in the clothing and accessories industry". A set of illustratively distinctive responses (based on mean average) is shown in Chart 1.

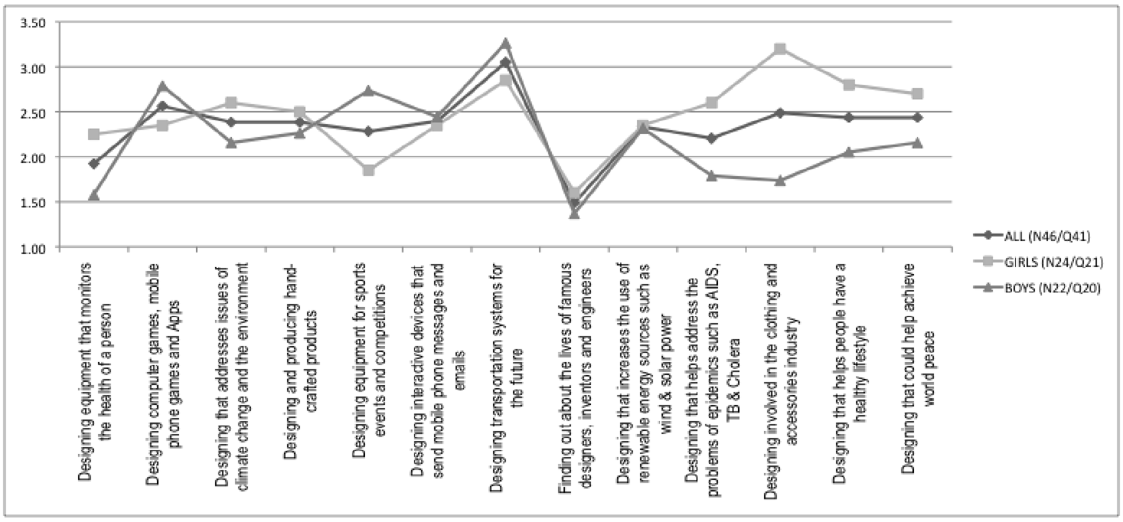

Chart 1: Survey of interests

However, the averages hide the varied number of areas ranked highly by different learners, some ranking up to nine topics as 'very interested', some ranking only one topic. With some learners a trend could be seen, e.g. being "very interested" in designing for health, the environment and world peace, or "very interested" in designing for sports events, computer games and apps and transportation systems.

Teacher's reaction to the survey and subsequent planning

The teachers were intrigued by the results of the survey. They recognized the complexity of creating groups based on learners' interests and saw the idea of working from a broad context, through more defined references as a way of managing this. Throughout the planning sessions certain topics dominated their discussions: the practicalities of organizing groups, facilities etc; meaningful ways to contextualise and resource learners' projects; structuring the day; and managing learner expectations. The latter was a major pre-occupation as several learners had already expressed fixed ideas of what they wanted to design and make on the day and a small group who were characterized as learners disinterested in anything other than 'making' had prioritized a very limited range of interests.

Teachers were using their existing model of D&T lessons to try to envisage a whole day's activity, anticipating the morning broadly focused on designing and the afternoon on making. However, they were keen to give the learners as much space as possible and to be flexible as learners' ideas emerged. In the event, the preparation undertaken and this latter attitude enabled the learners to progress effectively through the day, having established clear scenarios and briefs such as:

- Group A: in the future, new technologies may result in people becoming less healthy and more isolated - resulting in the design of a website for bringing communities together for social sporting activities;

- Group B: Army dogs used in bomb disposal are often killed in action because of inadequate protection, leaving their soldier companions distraught - resulting in designing comfortable, flexible, protective armour for bomb disposal dogs;

- Group C: In the future young people will be less pressurized to follow fashion and more able to develop their own personal style - resulting in creating ways of using augmented reality to see how well an item of clothing suits an individual;

- Group D. In the future geo-energy could be used more to reduce climate change, - resulting in concept development of ideas such as launching millions of tiny mirrors into space to reflect sunlight and creating artificial trees that suck carbon out of the air and store it underground.

The Evaluation Questionnaire

The learners were very positive about the enrichment day. Of particular interest is the highest rated statement "Letting the pupils chose the design topics works well". It is also notable how proud learners were of their achievements, how they achieved more than expected and how they felt that the learners were the ones making the decisions.

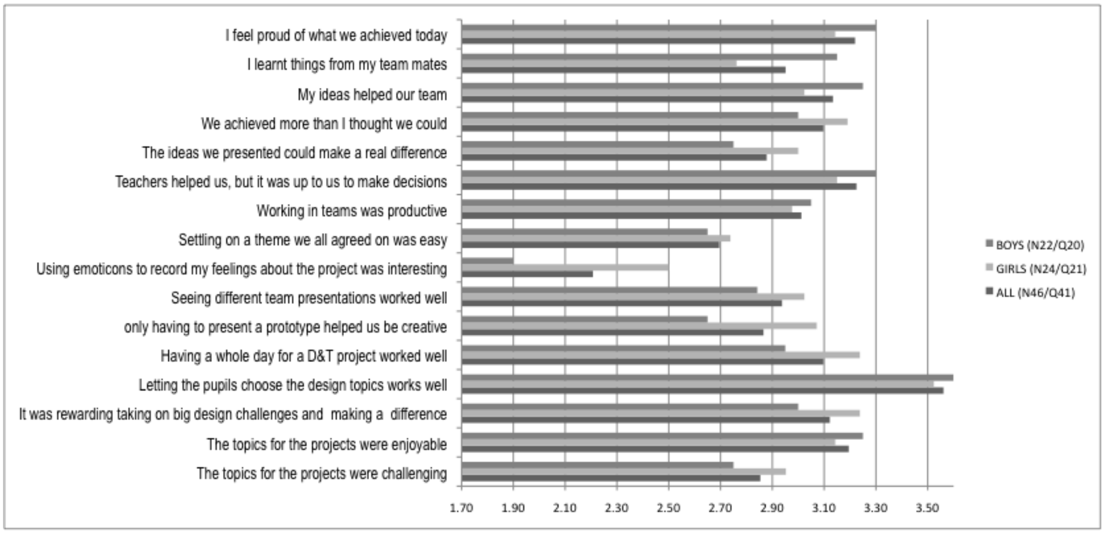

Chart 2: Learners' evaluation of the enrichment day

Within the results there were some gender differences. For example boys felt more proud of their achievements and felt they had learnt from their team-mates, while girls felt the reward of take on big design challenges and felt that their ideas could make a real difference. The biggest gender difference was in relation to the emoticons, which will be returned to later.

Looking at group reactions opened up further subtleties. The four projects above illustrate these, for example a lack of consensus about the sense of reward and the difference their ideas could make, in contrast to considerable consensus about the value of learners choosing the projects and the pride felt in achievements.

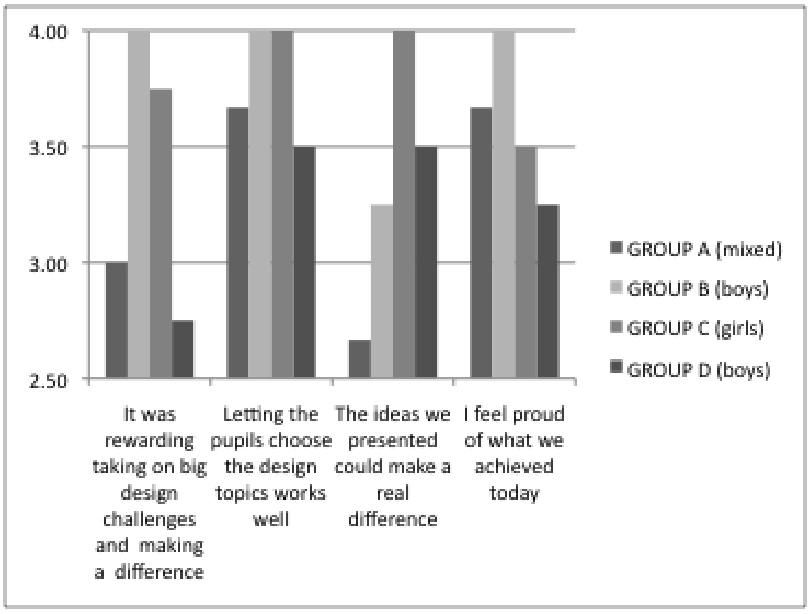

Chart 3: Group effect on the challenge

The Emoticons

The use of the emoticons in the pilot was its most speculative aspect. Whilst there is a growing body of research in the use of pictorial capturing of emotions in relation to user-centred design (see e.g. Desmet et al., 2012; Laurans & Desmet, 2012) there has been less focus on pictorial capture of emotion whilst designing. In overall terms, the emoticons received the least positive response in the evaluation. But there was a gender split, girls being far more positive than boys. Chart 4 illustrates further subtleties, for example that Group A, a mixed gender group, is the most positive. However, the value of using the emoticons does not appear to be related to learners expressing overall pride in their achievements, as can be seen by Group D.

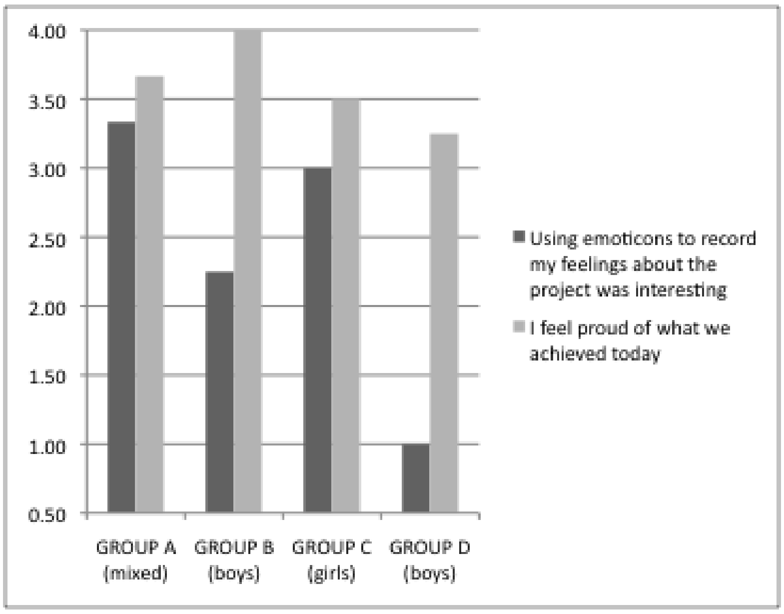

Chart 4: variations in responses to the emoticons, illustrated by groups

The detail of how different learners approached the use of emoticons shows distinct variations. Table 2 shows examples from the illustrative groups. While some simply indicated the project's progress, others expressed more complex thoughts, including mixed emotions, for example

Learner 4 in group C who is happy with the group but confused by what they are supposed to do. She hints later at some conflict in her group "2 girls taken the idea – what do other 2 do …?!). Learner 5 in Group B illustrates the shift in emotions across the project – from his early Confused/Back Off "Don't know what we are doing, bad mood" to his Happy, Relieved " Our project went well, its over" at the end, followed by a self-initiated comment added after the winner was announced.

Table 2: illustrations of the variety in use of emoticons

	After introduction	Before break	Mid morning	Before lunch	Mid afternoon	End	After voting (learner initiated)
GROUP B Learner 5 (boy) (emoticon score = 2)	**Confused, Back Off**: *Don't know what we are doing, bad mood.*	**Back Off**: *Bad mood.*	**Happy, Motoring, Relieved**: *Good mood, going well, good idea.*	**Happy, Motoring, Relieved, Success:** *Everyone good.*	No comment	**Happy, Relieved**: *Our project went well, its over.*	**Happy, Relieved, Success:** *We won.*
GROUP C Learner 4 (girl) (emoticon score 4)	**Confused**: *Not very sure how it's going to go. Or exactly what to do.* **Happy**: *I like the topic our group has.*	**Happy**: *Getting good ideas and thoughts.* **Relieved**: *Getting somewhere - designing what we are making.*	**Happy**: *Doing well starting designs.*	**Happy**: *Designing on computer.* **Motoring**: *Moving forward.* **Confused**: *2 girls taken the idea - what do other 2 do ...?!*	**Happy**: *Going really well, finished a lot.* **Motoring**: *Done a lot - moving forward fast.*	**Happy, Motoring 'half Success'**: *Really complete - only to present.*	
GROUP D Learner 1 (boy) (emoticon score = 1)	**Motoring**: *Ready to start!*	**Motoring**: *Continuing.*	**Motoring**: *We've gotten the ball rolling.*	**Back Off**: *Project building is slowing down.*	No comment	No comment	

The Teacher's reaction to enrichment day.

Teacher reactions expressed in the de-briefing interview were quite stark - their overall response summed up by their phrase "shell shocked". They made clear that, in advance, they had major anxieties – about learner engagement, learners sustaining interest, being disappointed in the

topics. The extent to which their anxieties were groundless amazed them, no more so than in the case of the group of 'maker' learners they had been most worried about.
"I have known some of them since they were in year three. They have always wanted to just make things and the fact that they really had these deep conversations and developed an emotional attachment to the project really surprised me."

The teachers were surprised by the seriousness and level of debate that was evident, and the way the teams dealt with challenges. Several comments related to the learners' growing recognition that they were being asked to act in a mature way, and that they saw this as a positive challenge. As one teacher put it
"They came in expecting Design and Technology the subject. That is what they experienced normally. They didn't get Design and Technology, they got life."

The teachers were surprised at how comfortable 14 year olds were with dealing with abstract ideas and how, at times, they felt they were working with older students. They were unequivocal about how much learning had taken place: learners learning about themselves; how to work in groups; how to communicate; and how to learn independently.

In terms of the future, the teachers were clear that the day had caused them to question their current approach. The extended time the enrichment day provided was seen as an opportunity that could be used to kickstart to a project.
"I don't know how we'd fit this in, but … it might be nice to have a whole day as a lead into the project. … I'm brainstorming here, you could almost start a project with a whole day and then work on it in term so that you've got three projects a year."

WHERE NEXT FOR DESIGNERLY WELL-BEING?

Whilst small-scale, this pilot provided insights into how giving learners the opportunities and support to take on 'Big Design' challenges allows for the development of confidence and the sense of achievement and pride that illustrate aspects of the concept of designerly well-being. The ways that the learners responded to the day illustrates Princen's description of "humans at their best". The initial position paper made a point about the paradox of 'exciting stuff' being what happens outside of regular lessons. This enrichment day could be seen as further illustrating this point - the learning that took place certainly fits with Resnick's characterization of 'out of school learning' as involving "socially shared cognition", "contextualised reasoning" and "situation specific competence," (Resnick 1987, p.15). But having experienced the enrichment day, the teachers saw beyond this 'one-off' event to a way of integrating the approach into an entirely fresh manner of approaching D&T projects. How they develop this, and how the approach might be received in other schools must be seen as next steps in developing a more practice-based view of designerly well-being. Gaining insights into the impact on learners, beyond a one-day experience, must also be a future concern. Much still needs to be explored, including ways of understanding the emotional responses generated by the act of designing and the potential of developing the use of emoticons in this. All of this will be explored further as the project progresses.

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Engineering by Design™: Preparing STEM Teachers for the 21st Century

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ABSTRACT
Preliminary findings from a study on the implementation of an integrative Science, Technology, Engineering, and Mathematics (STEM) education professional development (PD) program, *Engineering byDesign™* (EbD™) and the supporting theoretical framework regarding integrative STEM teacher preparation will be reported. Through a series of surveys completed by EbD™ PD participants, data were gathered to determine effective strategies used in integrative STEM PD, teacher perceptions for using an integrative STEM approach, and the concerns of technology and engineering teachers in their preparation for teaching major mathematics and science concepts needed for studying engineering in technology education.

Keywords: Professional Development, Teacher Preparation, STEM, Technology, Engineering

INTRODUCTION
The focus on STEM education in some countries seems to have evolved from the idea that a country's economic prosperity is based on the success at which they prepare and motivate students to participate in STEM careers, thus providing a knowledge-base to further develop their economy (Report to the President, 2010). Technology and engineering education has become a vital component of STEM education and can potentially offer students opportunities to experience the real-world application of knowledge from these school subjects by working to solve societal problems. From the perspective of improving the delivery of technological and engineering literacy and the creation of robust learning activities through integrative STEM knowledge and activities, the International Technology and Engineering Educators Association (ITEEA) has staked its claim in STEM education (ITEEA, 2012).

Currently, technology education in some locations is in the midst of an integrative STEM educational movement, as made evident in 2009 when the International Technology Education Association added "Engineering" to its title. With this change came added motivation by several countries to include engineering education in their K-12 programs (Fantz & Katsioloudis, 2011). Furthermore, pedagogical perspectives have highlighted the idea that engineering creates the link that ties mathematics and science together (Katehi, Pearson, & Feder, 2009). These connections have led to the purposeful combination of engineering design, scientific inquiry, and mathematical computation in the context of real-life technological problem solving (Sanders, 2009). An understanding of such processes has many implications for the improved teaching and learning through STEM education. However, to teach engineering effectively, technology education teachers need content, concepts, and pedagogy related to an integrative STEM approach (Fantz & Katsioloudis, 2011). Additionally, the absence of a sound educational rationale for this combination of subjects can inhibit its development (Williams, 2011).

Although ITEEA has embraced the idea of an integrative STEM approach, it is important to analyze the preparation, perceptions, and concerns of teachers involved in teaching complex STEM concepts and skills.

ENGINEERING BYDESIGN™

EbD™ is a standards-based program designed by ITEEA, as an integrative K-12 STEM solution for schools; its focus is on achieving technological and engineering literacy for all students. It is a comprehensive approach to education that aims to meet the needs of students, teachers, and administrators by providing an organized learning community, educational materials, and in-service training for continued PD. However as President Obama's Council of Advisors on Science and Technology (2010) reported, schools all too often employ educators who lack the necessary skills for effectively designing and teaching the integrative topics found within STEM. Additionally, the amount of teachers who know their subject matter well and are passionate enough to inspire students is even fewer. These issues can be attributed to the lack of adequate support, including appropriate PD, as well as interesting and intriguing curricula that teachers receive. As a result, many of their students conclude early on in their education that STEM subjects are unwelcoming, leaving them ill prepared to meet the challenges they will face throughout the 21st century.

With the National Science Board's (2007) recommendations for the creation of more highly qualified STEM educators, *EbD™* works to provide a community of continued PD to help increase the effectiveness of its integrative STEM curriculum. This PD is designed to help create national consistency of curriculum implementation among teachers planning to or already implementing the *EbD™* integrative STEM curriculum. In addition, it gives teachers the hands-on experience of completing student lessons and activities, as well as practiced methods for enabling them in the classroom which also offers opportunities to study current issues related to integrative STEM education.

STEM TEACHER PREPARATION, CONCERNS, AND PROFESSIONAL DEVELOPMENT

Research has begun to show that the integrative and applied nature of engineering can enhance student achievement in various subject areas (Baker, 2005; Silk, Schunn, & Cary, 2009). However, incorporating engineering into technology education can require a greater depth of knowledge in science and mathematics. It is the incorporation of engineering that may have led to technology education being responsible for teaching integrative STEM in some locations. In order to effectively teach integrative STEM, teachers need to be taught pedagogy, content, and concepts related to the application of mathematics and science to engineer solutions of real-world problems (Nadelson, Seifert, Moll, & Coats, 2012). Nevertheless, the addition of STEM responsibilities requires changes in pre-service and in-service teacher training. Some researchers claim that technology education preparation programs may not provide enough content to prepare teachers to teach engineering, let alone the application of mathematics and science concepts (McAlister, 2005). Several technology education teacher preparation programs in the U.S. responded to these changes by adding engineering to their program's name. However, a change in a programs name does not necessarily mean that the program incorporated engineering content, as well as the mathematics and science concepts needed to practice engineering design. Fantz and Katsioloudus (2011) conducted research on technology education teacher preparation programs to determine the differences between programs that have added engineering to their program title and those who have not. The results revealed that programs with engineering in their title did not significantly differ in their engineering content from technology education programs. The findings indicate that no matter how the technology education teacher preparation program was situated, the amount of engineering content was low compared to teacher preparation programs in other school subject areas. This leads many to question, "Are teachers equipped to teach the mathematics and science required by engineering design work?" As a result, many opportunities to connect student understandings of mathematics and science with engineering activities are overlooked (Nathan, Tran, Atwood, Prevost, & Phelps, 2010).

Currently, the STEM movement is influencing universities to offer STEM education degrees and certifications, which begs the question, "Are these STEM programs preparing future teachers to be highly qualified in these subjects?" Once again, did these programs just change their name or, did they actually change the pedagogical content knowledge required by pre-service teachers? As part of the increasing need for understanding and improving STEM education, more research is needed to better understand teacher attitudes, beliefs, values, and perceptions within the STEM teaching culture. Furthermore, if a STEM teacher mistakenly embeds mathematics and science concepts or overlooks opportunities to integrate these concepts, then these teachers may be hindering student academic success. As research in STEM grows and the education community develops a better understanding of teacher preparation and teacher perceptions, educational leaders will be better equipped to design effective PD and teacher education programs that suit the needs of K-12 education (Nathan, Tran, Atwood, Prevost, & Phelps, 2010). The research described in this document will help describe the current status of teachers implementing an integrative STEM program.

RESEARCH QUESTIONS

This study investigates in-service teacher perceptions regarding their preparation for teaching integrative STEM curriculum and approaches they believe effective when conducting PD with STEM educators. To achieve this end, the following research questions were addressed:

RQ_1: Among K-12 integrative STEM teachers, what are the most significant concerns to address when teaching an integrative STEM curriculum?

RQ_2: Among K-12 integrative STEM teachers, what are the general perceptions of their preparation for teaching major mathematics and science concepts for studying engineering?

RQ_3: Among K-12 integrative STEM teachers, what are effective professional development strategies for enhancing integrative STEM practices?

METHODOLOGY

The data for this investigation were collected from 63 participants attending five day 2012 summer *EbD*™ Labs offered in Maryland, Oklahoma, Ohio, and California. Participants within each lab were teachers of middle and high school *EbD*™ courses.

The information required to address the research questions was collected using two surveys. A pre-survey was administered to the participants before completing the *EbD*™ Lab to acquire the general perceptions and concerns of the teachers before they went through the PD. The teachers then completed the five-day *EbD*™ Lab where they were exposed to *EbD*™ core curriculum and instruction, as well as required to complete several of the student course design challenges. Following the PD experience, a post-survey was administered to the participants to collect their general concerns and perceptions before they implemented the integrative STEM program in their classrooms. Of the 63 participants, 53 teachers completed the pre-survey while all 63 teachers completed the post-survey. Selected questions from these surveys, as they relate to the research questions, can be seen in Table 1. Furthermore, a third survey, still to be analyzed, was administered to these participants three quarters of the way through the following school year to determine the impact the PD had on their classroom practices.

Table 1: Pre and Post Survey Questions

RQ#	Pre-Survey Questions	Post-Survey Questions
1	• Rate statements about STEM PD. • Rate your level of concern with STEM issues. • Rank issues with implementing an integrated STEM program.	• What is your biggest concern with implementing integrative STEM curriculum?
2	• What is the highest level of education completed? • What was your major and teacher certification? • How many years have you been teaching? • How many years have you been teaching T and E? • What other subjects have you taught? • How many college mathematics courses have you completed? • How many college science courses have you completed?	• Rate statements about mathematics & science preparation. • Describe how the PD prepared you to incorporate science and mathematics into your technology and engineering classroom.
3	• Are you receiving a salary supplement for undertaking the PD? • Why did you sign up for the PD?	• How can PD better prepare teachers to be highly qualified STEM teachers? • What can STEM PD do to better prepare teachers to teach the application of mathematical and science principles? • Provide recommendations for improving STEM PD. • What was your favorite aspect of the PD?

FINDINGS

The findings from the selected survey questions administered within the integrated STEM PD sessions are presented in categories based upon the research questions: STEM Teacher Preparedness, STEM Teacher Perceptions, and STEM Professional Development. Due to many technology and engineering teachers assuming roles as STEM teachers, the categories have been created to help form a picture of the current status of teachers teaching STEM, as well as recommendations for improving PD and preparation.

STEM TEACHER PREPAREDNESS

The pre-survey was used to determine the experience and background of the teachers who were implementing, or planning to implement, the integrative STEM program. Of the 53 teacher respondents, 25 held a bachelors degree, 23 held a masters degree, 4 held a master's degree plus 30 credits, and one participant held a doctorate degree. Of these degrees, only 17 participations had a technology education degree. However, 30 of the participants did have a degree involved in education and 24 held a degree involving one of the STEM disciplines. Additionally, 42 of the participants earned a teaching certification in technology education, and 15 of the participants earned a teaching certification in science or mathematics. Also, 48 of the participants held teacher certifications in non-STEM disciplines. Of these initial participants, 23 had less than 10 years of teaching experience and 5 of the teachers were first year teachers. Furthermore, 13 of the teachers have never taught technology and engineering education and 26 had less than 5 years of experience. Conversely, 33 of the participants had experience teaching mathematics or science.

In regards to understanding the preparation of these teachers for an integrated STEM program, Research Question 2 sought to determine their preparation and prior experience in mathematics and science. Figure 1 illustrates the coursework the participants completed in college mathematics and Figure 2 depicts the coursework completed in science. Figures 1 and 2 indicate the lack of mathematics and science requirements in the teacher preparation programs the participants completed, thus providing insight on teacher preparation for the purposeful integration of mathematics and science in engineering design.

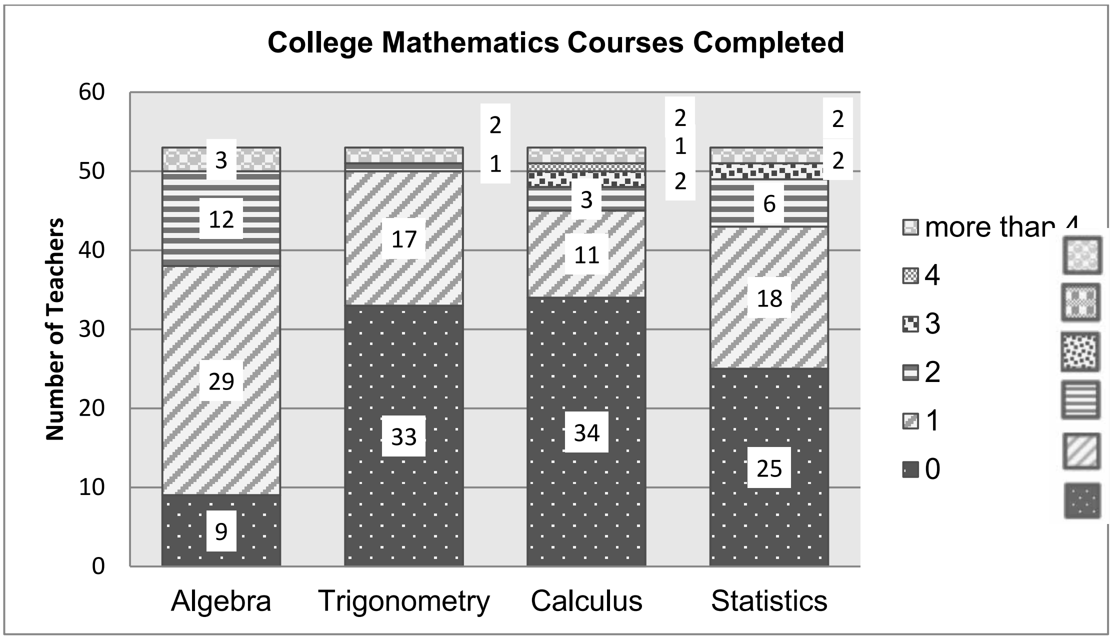

Figure 1: Mathematics courses completed by STEM teachers

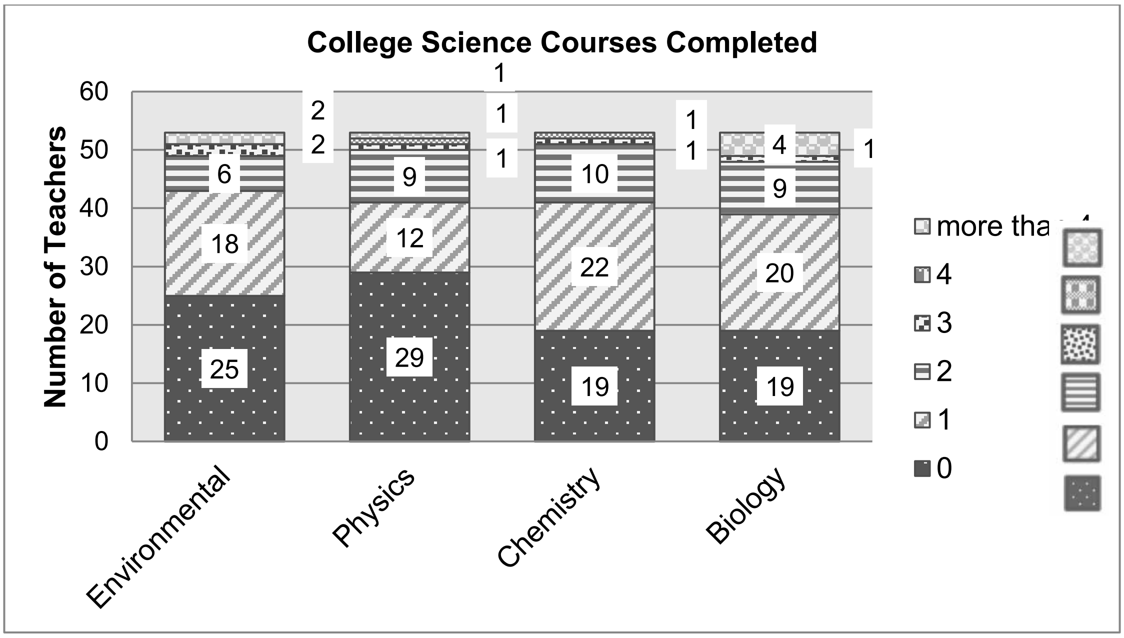

Figure 2: Science courses completed by STEM teachers.

TEACHER STEM PERCEPTIONS

Additionally, participants were asked to rate the level at which they agreed with a series of statements regarding their own belief in their preparation to teach integrative STEM. Figure 3 depicts the degree of participant uncertainty related to teaching rigorous integrative STEM programs.

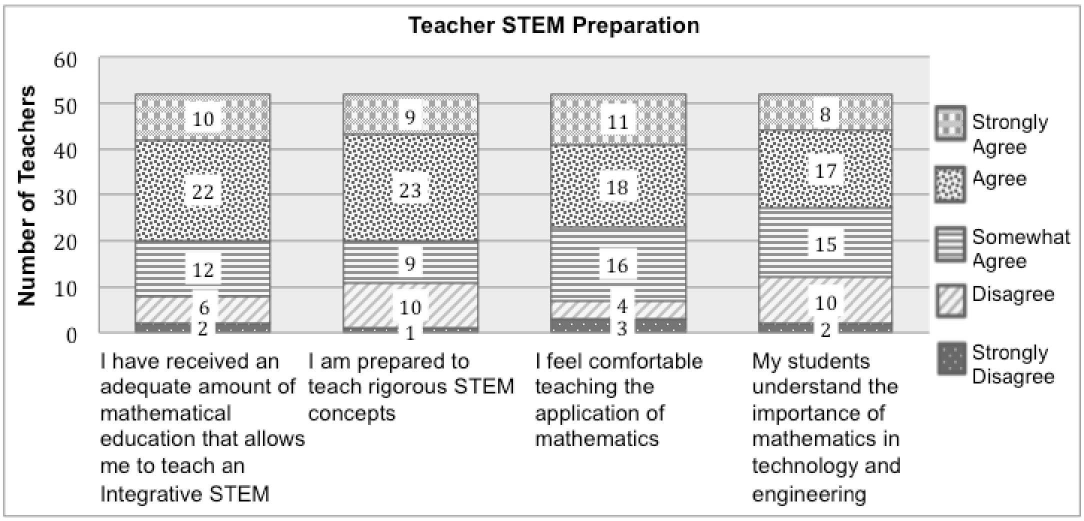

Figure 3: STEM preparation teacher perception.

The results from a series of Likert-scale questions, presented in Figure 4, provide the perceptions the teachers held concerning attending STEM PD.

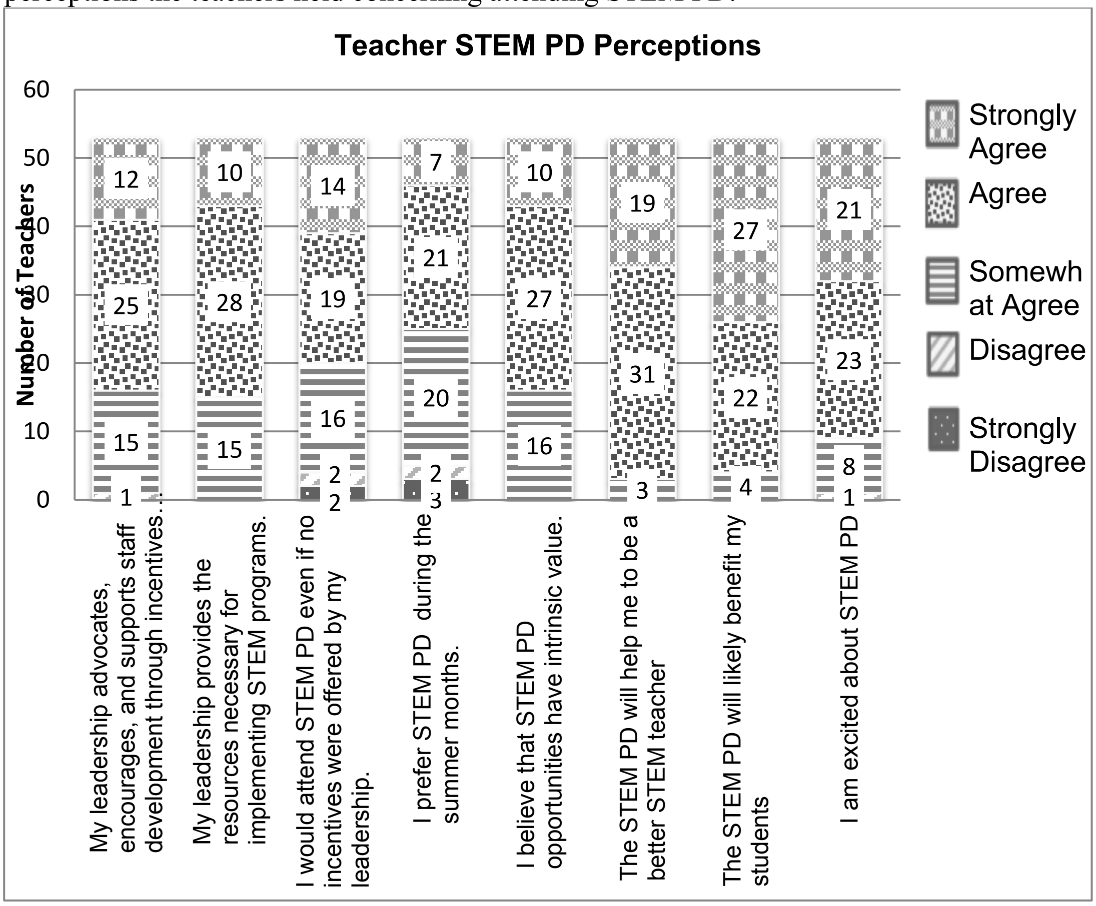

Figure 4: Teacher STEM PD participation perception.

STEM PROFESSIONAL DEVELOPMENT

Questions from both the pre-survey and post-survey were used to collect information to provide potential recommendations for improved STEM PD. Teacher responses on the pre-survey indicate that all but two of the participants were completing the PD outside of their workday, but only 15 of them were receiving a salary supplement. Table 2 illustrates the reasons why the participants registered for STEM PD.

Table 2: Reasons to Participate in STEM PD

Reasons to Participate in STEM PD	Response Percent
I believe it will increase the level of my students achievement	47.20%
I want to increase my knowledge in STEM	35.80%
I currently teach STEM courses	36.00%
I am interested in teaching STEM courses	32.10%
I want to learn about assessing STEM	20.80%
I am required	18.90%
To support others in implementing a STEM program	6.00%
To conduct research on STEM education	2.00%

Participants also ranked issues with implementing an integrated STEM program, which can be found in Table 3.

Table 3: Issues with Implementing Integrative STEM

Rank	Issues	Rank	Issues
1	Access to classroom materials	5	Time constraints
2	Program funding	6	Administration support
3	Maintaining student engagement	7	Parental support
			Student assessment
4	Access to curricular resources	8	Teacher evaluations

Post survey responses indicated that overall the participants agreed that the PD better prepared them to be a highly qualified STEM teacher and that it will increase their students' success in the application of mathematics and science to technology and engineering content and activities. On average the participants agreed that they are confident in teaching science and mathematical applications through technology and engineering classrooms. However, 41 of the 63 participants believe that they need more practice teaching mathematical applications in technology and engineering and 50 want more professional development on this topic. Additionally, 40 of the participants feel they need more practice teaching the application of science concepts and 51 would attend PD focused on this topic. Teachers were also asked open-ended questions concerning how the PD prepared them to incorporate the application of mathematics and science within a technology and engineering classroom as well as how STEM PD can be improved. The themes that emerged on these topics are found in Table 4.

Table 4: Themes to Improve STEM PD Success

Themes of STEM PD Successes	Themes of Improving STEM PD
Provided various mathematics and science application examples	Provide on-going STEM PD
Demonstrated the application of mathematics in design problems	Continual problem-based STEM curriculum development
Provided additional mathematics training	Engage in real-life STEM career experiences
Shared a wealth of teacher resources	Create online networks for connecting teachers
Required participants to experience activities as a student	Incorporate more mathematics and science connections to design challenges
Deliberately tied mathematics and science together through design challenges	Assist in informing the public on STEM
Consistently reminded participants about the importance of integration	Provide more STEM pedagogical content

DISCUSSION AND CONCLUSION

Preliminary findings indicate inconsistencies in teacher preparation for technology and engineering within STEM education, as well as the lack of trained technology and engineering teachers in the United States. Out of the 53 pre-survey participants, 36 never completed a technology education teaching degree and 11 were still not licensed in technology education. Overall, the results showed a lack of experience with regards to teaching the technology and engineering portion of integrative STEM curriculum. It seemed that many of the participants were originally teachers of other school subjects who were moved into a technology and engineering teaching position, indicating an inadequate amount of trained technology and engineering teachers. This can lead to a lack of passion for the subject, thus increasing the need for more improved PD, as well as incentives for becoming a technology and engineering teacher.

An examination of the college courses teachers had completed showed that 9 out of 53 STEM teachers had never taken a college algebra course, 33 had never completed a college trigonometry course, 34 never completed a calculus course, and 43 completed one or zero courses in statistics. Moreover, 25 of the participants had never taken a college course in environmental science, 29 had never taken a course in physics, 19 had never taken a chemistry course, and 19 had never taken a course in biology. Properly teaching engineering principles within an integrative STEM program requires some knowledge of applying concepts and procedures in trigonometry, physical sciences, and calculus. Achieving technology and engineering literacy also requires students to utilize, create, assess, and evaluate technologies, which cannot be successfully done without the application of concepts and procedures in life sciences, earth sciences, and statistics. The point should not be that technology and engineering teachers need to spend their time teaching mathematics and science in their classrooms, but as it becomes integrated within STEM, it needs to be determined how and to what level they are prepared to properly demonstrate the application of math and science to a technological problem in need of a solution. At the primary level of STEM education, in depth knowledge of the application of mathematics and science may not be as necessary. However, it is important for students to understand the importance of those concepts.

Technology and engineering can be an asset for engaging primary students into STEM education and careers at a young age. In secondary STEM education, a teacher needs to be ready for assisting students to properly apply the concepts and procedures developed in other core disciplines to address problems that have relevance to their lives. The recommendation is that adding engineering to technology education should increase the requirements for science and mathematics in teacher preparation programs. Additionally, new STEM teacher development programs should determine what it is that these teachers are responsible to teach. Even though nearly half of the participants felt prepared to teach the application of mathematical and science concepts in their classroom after completing the PD, practically all of them embraced the idea of more rigorous PD in the application of mathematics and science to teaching pedagogical content knowledge.

PD is a major way to address the needs of teachers and support a consistent implementation of an integrative STEM program that enables a more reliable way to evaluate the impact STEM has on student achievement. However, integrative STEM PD is in its infancy and participants can provide insights into teacher needs and recommendations for improving the PD. These findings can assist in the creation and re-design of STEM programs. For example, the first step for improving STEM PD is getting more people to participate. Interestingly, the results showed that monetary reward was not a motivation factor for most to enroll in the PD. The motivation was more intrinsic and the teachers wanted their students to reach a higher level of success, leading to a need for more research on the impact integrative STEM education has on student success.

Future research should include determining a general consensus on requirements in STEM teacher preparation, as well as where technology and engineering education should fit. As Sharkawy, Barlex, Welch, McDuff, and Craig (2009) declare, the blurring of boundaries between the STEM school subjects requires clarity about the purpose of the subjects to carefully anticipate their interactions. In the midst of major STEM educational reforms, technology and engineering education must establish a clear identity, but as the results show, this may be difficult amid the current inconsistencies within the preparation of these professionals. Approaching STEM without this caution may result in the decimation of technology as a distinct component of the school core curriculum (Williams, 2011) as in the case in the U.S. as projected with the *Next Generation Science Standards* (2013) including technology and engineering in its themes.

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Design and Statement: The Understanding of 'Sustainability' in a Design Learning Activity

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ABSTRACT
According to the activity theory, design students plan, realize and describe the tasks they have to perform. This process is a specific way of expressing their design learning process, within the curriculum in which they are interacting. The curriculum contents are discussed within the Pedagogical Contents Knowledge (PCK) framework to improve the teachers' methods. Sustainable development (SD) should be treated as a priority in the specific Technological Pedagogical Contents Knowledge (TPACK) research, since SD is a technical and social issue.

In this paper we study the methods used in two Masters of Arts courses to teach SD. The design students' statements are psychologically and semiotically analysed. Examination of the students' verbal and non-verbal utterances or iconic and non-iconic signs show hesitant, diverse and weak-structured statements.
Numerous indecisions emphasize their contradictory conceptions of SD. The lack of SD specifications in the syllabi opens a wide space of discursive perceptivity, in which students build their own design idiolect. They acquire design skills and abilities challenging the design PCK.

In this way, we can use these skills and the students' understanding of SD to develop the TPACK. In comparison to previous studies on SD learning, this paper emphasizes the need for combining these approaches to structure 'design didactics'.

Keywords: design statement, design activity, design abilities, sustainable development

INTRODUCTION

The design activities of teaching and learning are examined in this paper according to the activity theory. This involves the analysis of the ordered, planned, situated, verbalised interactive and completed tasks the students perform to model an artifact (Lebahar, 2007; Kaptelinin & Nardi, 2009). In a further theoretical framework, the PCK approach, specifically the TPACK, allows us to better understand the design learning context, such as the curriculum organization and teaching methods (Williams & Lockley, 2012). In other terms, 'didactics', which in French corresponds to the teaching and learning process in the context of a classroom, in which the teachers give tasks to the pupils who have then to organize how they will act in order to complete each task (De Vries, 2008; Ginestié, 2009).

The 'design didactics' could be structured through examination of the students' and teachers' activities, i.e. how the students organize the specified tasks and how they socially interact using ‘verbal modelling techniques’ (Trebell, 2010). Thus, from a semiotics point of view, the statement or the ‘enunciation’ is the event underlying utterances produced by a speaker (Jakobson & Halle (1956, p. 58). When they are involved in a design activity, as ‘semiologically conscious designers’ (Wolf, 2011), students enunciate the tasks the teachers require them to do. They have to communicate as clearly as possible their design plan (Baldwin, Austin & Waskett, 2009). They attempt to reduce a type of uncertainty in the design process (Lebahar, 2007) to achieve a ‘pertinence’ or a ‘relevant message’, i.e. the progressive elimination of the signifiers which perturb the utterances’ understanding (Sonesson, 2006). The ‘relevant message’ is a ‘rhetorical design’ (Newcomb, 2012) which leads the learners to use a design ‘idiolect’, a ‘private code’ (Eco, 1979) with the aim of_“greater efficiency in cognition” (Wharton, 2013, p. 249).

In a way, when they are uttering verbal or non-verbal statements, the design students are learning. However, the question is also what are they learning about SD in a design MA. Generally, the main concepts in the SD field are based on three criteria (ethics, technological fixes and social interaction) supported by three theoretical approaches (Keitsch, 2012):

- the social and training dimension (Papanek, 1984; Ramirez, 2012);
- the Design for Environment process (Baeriswyl & Eppinger, 2011);
- the organic vision of methodologies, tools and strategies for the integration of environmental requirements into product development (Vezzoli & Manzini, 2008).

In these three theoretical approaches the learning dimension is a significant issue.

No one studying sustainability in the design learning field is looking at the impact of SD in the student statements within the activity theory or TPACK frameworks. On the one hand, some studies present examples of transposition between integrated systems design, based on ecological principles, and learning situations emphasizing the positive impacts of the three previous criteria towards more sustainable ways of living and working (Birkeland, 2002; Fuad-Luke, 2009). On the other hand, some studies illustrate methods in which education in SD can be addressed through technological education focusing on creativity and skills (Pavlova, 2006, Stables, 2009).

WORKING HYPOTHESIS

One of the features of design, is that it is a ‘rhetorical activity’, since designers’ statements are manifold and have a variety of artifact meanings, i.e. “Design and rhetoric are inextricably intertwined, and both are about action and ‘creation’ in the world” (Newcomb, 2012, p. 599). Thus, the design learning process could be considered as a structured thinking in design, in which the dialogues take a pivotal role (Tortochot, 2012) between the student and

- himself,
- the other students involved (or not) in the designing process,
- the produced signs the students learn about and analyse (from teachers, specification authors, other specialists, etc.).

The designer can communicate about the performed tasks and the plans for future tasks, i.e. his design activity schedule (Baldwin, Austin & Waskett, 2009). This proceeds in a spiral of steps, each of which is composed of a circle of planning, action, and evaluation of the results, in order to reduce the design uncertainty. The students’ enunciation activity (the ‘verbal modelling techniques’) helps us to understand how they link the tasks they have to perform to the teachers’ requirements, i.e. the TPACK.

We can speculate that the statement activity within the scheduled tasks plays a significant part in design skill achievement. Students verbalise their activity when they produce signs (a ‘design rhetoric’) as they want to show they have followed more or less the teachers’ requirements. They converse and subsequently they become more aware of their design.

To test this assumption, the experimental part of this paper was aimed at bridging the gap between curricula statements, design representations, and student utterances. More precisely, we focus on sustainability in students' designs and statements which are analysed and compared. Moreover, in the discussion we specifically raise the question of how to build a complete TPACK based on SD as a main subject matter.

METHODOLOGY

The survey was conducted on students' activities in order to carry out qualitative research on the design learning process (Tortochot, 2012). Examination of the students' statements leads to a psycho-semiotic analysis (Lebahar, 2007).
This analysis is based on four samples. First, we observed the design learning situations. Secondly, we analysed the syllabi of two schools: UCA (UK) and ESADSE (France). Thirdly, four semi-structured interviews (Wengraf, 2001; Radlovic, Lemon & Ford, 2013) were carried out in each school: they provided a rich individual picture for each distinctive case. Fourth, in interviews, the designs were examined through representations (sketches, plans, 3D pictures, and other drafts), writings (sketches' comments, concepts, MA dissertation, abstracts), volumes (maquettes or prototypes).

We analysed two design learning situations:

- four English students were working on a 'locations project' in a creative module of their MA course;
- four French students were working on their MA dissertation preparing the MA project.

Students were observed during design learning situations in which SD was not the primary objective. However, all the students were systematically interviewed regarding SD issues as constraints.
The main design objective in both situations was not specifically SD, but it was an underlying factor. Interviews in French school were translated 'offline' into English by a native speaker.

INTERVIEWS AND COMPREHENSION FROM STUDENT MEB

Iconic system (verbal and non-verbal)

One of the British students, MEB, designed a covered footbridge over a river in a park (Figures 1 & 2). (NB: Before her MA studies, MEB had worked in an interior design agency for two years.) She associated an English garden with "Clair de Lune", Verlaine's poem and the Debussy's sonata, and with "Figures in a Landscape" from Watteau. The contents of her slide show (an obligatory part of students work) are very representative of her design project (Figure 3).

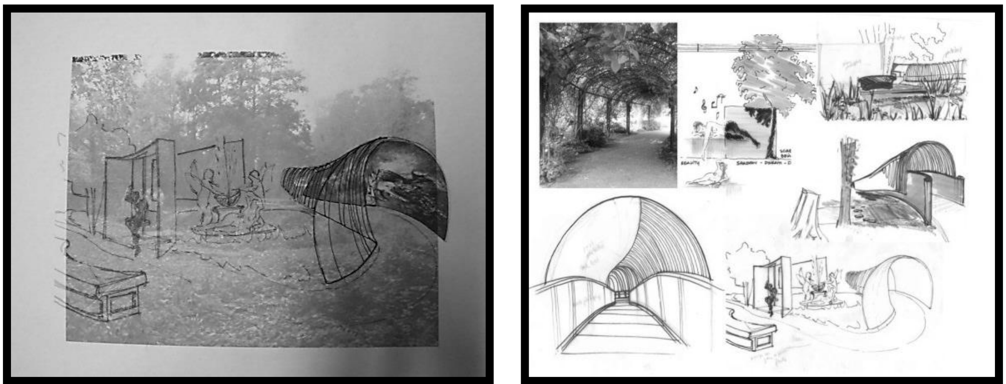
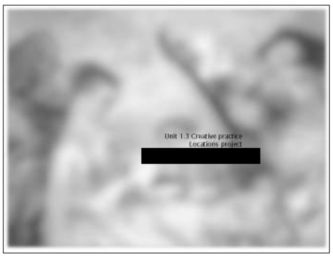
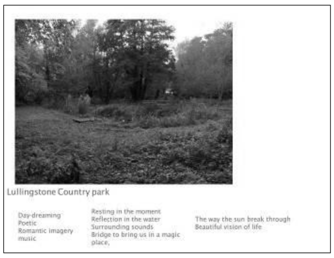


Figure 1 & 2: some drafts of the meb project which is an ephemeral installation in an English garden



Slide 1
Title with a blurred Watteau picture in the background.

Slide 2
Image of the English garden with significant features: contrasted and dark photograph.



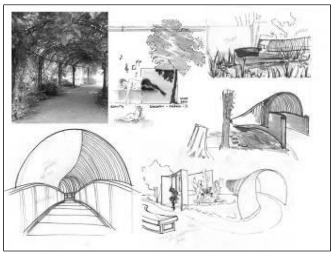
Slide 3
Image of the garden (same features). Feelings in the park are in comments below the image.

Slide 4
The three French artists mentioned in the project are presented using paintings, photos and dates.

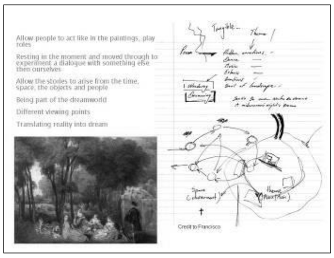
Slide 5
The three French artists mentioned in the project are presented using representative masterpieces. Some comments below complete the presentation.

Slide 6
The Verlaine's poem is transcribed in French and English and commented using a lexical analysis.

Slide 7
A Watteau painting is presented (Figures in a Landscape) along with short comments and some interpretations.

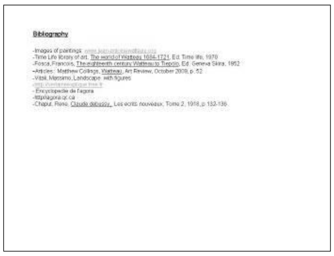


Slide 8
Some project sketches, along with a photograph of the site, without comments.



Slide 9
Some other project sketches, with a Watteau painting. The comments allow us to understand the author intentions, especially the goal of the installation (the spectators moving, the points of view, etc.)

Slide 10
Image showing the superimposition of the Watteau painting detail on the garden landscape.



Slide 11
The author references.

Figure 3: The description of the eleven slides made by MEB to explain her design

MEB's verbal statements

MEB was questioned on SD considerations when designing in a natural site. The literal and figurative senses of the sentences are examined in the tables 2 and 3.

Table 1: Quotes from MEB's answers and segmentation in elementary propositions

Context of the answer elements	Elementary sentences quotes Selected propositions for the MEB discourse on the 'sustainability' (in *italics*)
"What are the main design criteria for you ? Esthetic, ergonomics, technology, ethics, sustainable development, etc.? - (Long silence of thought.) Uh, if I am looking at the two projects I have made, there, those aren't necessarily ecological, I can't say that. But the environment respect in this way, but respect the place in which you are working, this isn't necessarily being sustainable or whatever dealing with the design, no, this is… It's on the tip of my tongue: 'obviously'. That's sure, that's obvious that we have to work in this way. But this is more matching the place. Is this a real criterion? And taking pleasure. It can be another criterion? Taking pleasure, I think, it's important, because we have to pay the courses (laugh)."	1. (Long *silence* of thought.) 1a. If I am looking at the two projects I have made, there, those aren't necessarily ecological. 1a.1. If *I am looking at the two projects*. 1a.2. *The two projects I have made*. 1a.3. *Those aren't necessarily ecological*. 1b. I can't say that. 1b.1. *I can't say*. 1c. But the environment respect in this *way*… 1c.1. *Environment respect*. 1c.2. *Respect* in this *way*… 1d. … but to respect the place in which you are working, this isn't necessarily being sustainable or whatever dealing with the design, no, this is… 1d.1. *To respect the place* in which you are working. 1d.2. To respect *the place in which you are working*. 1d.3. To respect the place, *this isn't necessarily being sustainable*. 1d.4. To respect the place, *this isn't dealing with the design*. 1e. It's on the tip of my tongue: '*obviously*'. 1f. That's *sure*. 1g. That's obvious that we have to work in this way. 1g.1. *That's obvious*. 1g.2. *We have to work* in this *way*. 1h. But this is *more matching the place*. 1i. Is this a real *criterion*? 1j. And *taking pleasure*. 1k. It can be another *criterion*? 1l. *Taking pleasure*, I think, *it's important*. 1m. Because we have to pay the courses (laugh).

The discourse form: towards a 'rhetoric'

The segmentation of the discourse about SD and her difficulty in talking about it (1., 1.e.) shows that MEB hesitates a lot (1., 1b., 1i., 1k.), cannot make a complete sentence (1c., 1d., 1h.), suggesting that she has not integrated SD in her design cursus.

She is obsessed with the 'criterion' (1i., 1k.) because she was questioned on the 'main design criteria'. In addition, she begins to be aware of the importance of SD, but she is not convinced

(1c., 1g.). She searches for her words and uses ‘obvious and ‘sure’ when trying to explain her work (1e., 1f., 1g.).
At the end, she makes fun of the ambiguity between her curriculum and her desire to ‘take pleasure’ in design (1j., 1l.). She emphasizes that she pays for her education (1m.). She worked for two years and she wants to increase her autonomy (1l.).

Discourse contents and representations: a specific ‘idiolect’

Even though MEB is designing a footbridge in a park, and respecting the site, she does not recognize the relevance of SD. Her sketches, photographs and comments, show in fact that her project is perfectly integrated. Her installation shows she assumes the circular lines of the existing footbridge or garden path. She uses multiples tracing papers to shape the installation according to the ‘site specificities’.
However she does not seem to be interested in sustainability in itself, even if she agrees with the ‘obviousness’ of respect for the site. In other words, MEB does not believe in SD as a main design criterion, but she is concerned about the requirement of respecting the ‘location’. In a way, she says she has no choice: “*we have to work*”. According to her slide show, the main interest of her project seems to be based on the interrelation between the three masterpieces. Thus she does not pay attention to sustainability as she is focused on other priorities ‘as criterion’. As a result, she speaks in clichés and her ideas on SD are poor.

THE OTHER STUDENT ‘STATEMENTS’: HOW DO THE OTHER STUDENTS CONSIDER SD?

Using the same methodology as with MEB we here try to generalize our analysis of the other students.

MUCH 'RHETORIC' AND MANY 'IDIOLECTS' FOR A SD DEFINITION

	Verbal / non-verbal	Agree	Disagree	Indecisive	Syllabi & instructions
MEB An installation in a park	V	*Environment respect* Respect *the place in which you are working*	*The two projects I have made aren't necessarily ecological*	This *isn't necessarily being sustainable*	"Such thinking recognises the potential role for the designer in realising a sustainable future (environmentally, culturally and politically) at both a local and global scale. However, it also acknowledges that, in order to realise this potential and to participate in the challenge of designing the future, the design profession is required to rethink the traditional boundaries and systems of design itself" (UCA, 2009, p. 4). A design project within a creative unit of the MA; it required them to work with a particular location: they had to choose and explore a specific site in order to produce a design which interprets or gives meaning to the place.
	NV	Sketches, photographs show that the project is perfectly integrated in the site			
JD An information booth	V	Generally, trying to improve situations for people, making it an easier, *nicer place to live*, perhaps			
	NV	Photographs show the destroyed telephone boxes as a disaster			
BS A theatre event in old castle ruins (Macbeth)	V	No verbal mention		No speech	
	NV	Photographs and sketches show an old castle ruins by the sea Sketches and video show the spilled blood in the sea	Sketches on tracing papers show the event installation without empathy with the site	No pictures	
FRP Furniture in the Dover's white cliffs	V	*It's not something about fashion* *To focus on material development*, precisely because of that			
	NV			Photographs show the cliffs, the blue sky on the sea the sand and the port with the ferries	
ED A children's book	V			I should say maybe *ecological*. So, after, for me, the design, it has to be something *humble*	"Knowledge of materials and their innovative potential in creation is a major challenge for designers and artists. Using cutting-edge materials, eco-conception and the Rhône Alpes know-how, the materials 'bank' allows students and teachers of ESADSE to base their projects and teachings on a high level of knowledge combined with close relations with industry and research." (ESADSE, 2011, p. 37). The MA dissertation preparing for the MA project: they had to examine in more detail the balance between the theoretical part of their project and the practice of the 'plastic creation', i.e. the design.
	NV			Some graphic illustrations without relationship with sustainability	
JBB The disturbing artifacts	V	The *fine values of the design*: the sustainability (without conviction)			
	NV	Photographs and models show artifacts and various materials hand made			
JM The funerary ritual artifacts	V	*Thinking* about *the making with which kind of materials* and *how*			
	NV	Photographs of the Asian funerary ritual sites			
MJ The narrative artifacts	V		"The ecology, *I don't give a damn*, because *it's a pretty stupidity*"		
	NV			Graphic illustrations with half urban and half rural topics	

Table 2: the collected verbal and non-verbal students' statements on SD compared to the SD topics in the syllabi

What do the students understand by SD?

The students are not interested: SD is 'bullshit': Sustainability does not find favour with student MJ (ESADSE) but perhaps she is not speaking seriously. "Ecology, *I don't give a damn*, because it's *bullshit*. But, really, *reading some things*… Because for the last ten years *we keep saying it's a disaster, nothing was done*."

They are not convinced: SD is not a priority: Student JBB (ESADSE) distinguishes the 'fine' design values (ecology and technology) used when the students are studying, from when they will become professionals "*I think that*, maybe, *when we'll start working*, it won't be, *it won't be a priority in our job*." Without conviction, JBB prefers to wait until he starts a job to choose good values.

They are indecisive: maybe SD is a value*:* Student ED (ESADSE) designs books, so the link with SD does not seem to be not relevant, even if she thinks that sustainability is a design value: "the design, *it has to be something humble*. Something *that can be intelligible*. […] In which *the form follows function*, […] but I am *making layouts*. This is *not the same relationship*…".

They are interested: SD is a tool and requires a strategy: Student JM (ESADSE) says the relationship with the materials is significant and also the ecological aspect which is behind that. He considers more important the popular, humble and intelligible dimensions of the design: "And now, we *have to think* about the *making (of the object) with what kind of materials and how*. And, so, furthermore, instead, with the *materials on which I am working* […]".

They are convinced: SD as an ethic: SD cannot be just a fashion. Indeed, Student FRP (UCA) is afraid of the fashion trend of SD. He regards ecodesign as a solution for helping our world and our future: "*when I was beginning my studies* in C., *I wanted to*, *like*, *focus on material development*, *precisely because of that*".

All students state they have more or less a positive opinion about SD but do not necessarily integrate it into their design. Students MEB and ED are the most *indecisive*. MJ is *uninterested* and angry at the sustainability lies. In addition, the graphic statements sometimes do not match the verbal statements. MEB and MJ disagree with sustainability in design, but their representations contradict this. For the *convinced* FRP, his SD conception does not match his representations. None of them refer to the schools' syllabi when they speak about SD. To sum up, there is no relationships between the aims of SD in the syllabi, and the students' conceptions and statements.

DISCUSSION

Thus results show that some students talk about their own superficial ideas (MEB, JM, etc.): stereotypes, weak arguments, etc. However others express their opinions more decisively; FRP and MJ have sharp, smart but opposite points of view. Thus, all the students organize their values, skills, and design abilities in a vague disorganized way. They do not take into account SD as a constraint and some would prefer to wait until they have a professional activity, after the MA (JBB). The analysed utterances shed light on how design students express themselves in a particularly self-conscious and self-reflexive way which opens up a space of 'discursive perceptivity' (Paton, 2012).

The less precise or directive the requirements, the wider the space. In the absence of a SD specification, the students challenge the design pedagogical content (Tortochot, 2012). Both as novices or future experts, the students' awareness does not hide their ignorance about SD. Instead of keeping their doubts to themselves some of them try to reduce uncertainty in order to product a relevant message through a new 'design idiolect'.

All the MA students consider the importance of sustainability, more or less, as a value, when considered as a topic which they shared socially through various media, at school, with relatives and friends. Mawson shows that the "well-developed ability of children in their play" allows them "to establish and solve technological tasks" (Mawson, 2013, p. 449). So, students build themselves the pedagogical contents instead of the current and confused PCK. In fact, they gain a design skill (Lebahar, 2007).
The students express a peculiar 'design rhetoric' when they do not seem to master the SD topic. They are not aware of its three underlying criteria: the social and training dimension, the Design for Environment process, the organic vision for the environmental requirements. Considering the criteria as a knowledge, the analysis shows that the syllabi do not convey those ideas as pedagogical contents.

Using TPACK framework, SD in which the designer plays a pivotal role, could be defined as a specific topic based in the literature. The students' statements could help them too, to achieve a PCK: they could increase the consciousness of the design activity and show the teachers their skills, knowledge or abilities. It could enhance current weak syllabi.

A valuable contribution to a design TPACK should take into account that students never quote their teachers or the syllabi, but prefer to use their own knowledge. The TPACK framework "does not speak about what kinds of content need to be covered and how it is to be taught." (Koehler et al., 2014, p. 109.). In a predictive answer, Chai, Koh & Tsai (2013, p. 38) reported that "more investigations about students' learning in general and for specific content areas" are needed. If the teachers used the students' feedback, they would improve their teaching methodologies. In fact, Stables (2009) examines the expected harmony and dependability between creativity and ecodesign through partnership with professional practitioners. So, the analysis of the students' activities shows the significance of the partnership of learners in the building of TPACK.

CONCLUSION
This paper is a development of 'design and technology didactics' research to:

- organize the SD issue as a subject matter;
- adapt it to the diverse interests and abilities of learners;
- consider multiple dimensions: curriculum organization, teaching methods used, and their effectiveness in enabling and enhancing student learning (Williams & Lockley, 2012).

As Stables (2009) points out, the aim of such a study is to emphasize the need for further research on SD. SD could be a relevant topic in the pedagogical content or activity types in design learning situations within a TPACK framework. The design rhetoric and idiolect expressed by the students could be analysed to build PCK using SD.

This rhetoric and idiolect tell us much, perhaps even more than the pedagogical specifications, even if the utterances made by the 'semiologically conscious designers' are confused, uncompromising, or even paradoxical.

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Identity Theft! Are New Age Teachers Changing The Identity of the Technology Teacher?

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ABSTRACT
Throughout history education has born the responsibilities of producing qualities in our students which were essential for the times. The 21st century now requires new qualities and skills to be developed in our future citizens. The ability to think creatively, innovatively in order to solve problems of today is a central focus for education in Australia.

It is time, in light of the newly structured Australian National Education Curriculum, to re-examine and raise the prestige of Technology based subjects. This paper considers the implementation of Technology Education within the National Australian curriculum. It is suggested that the Technology curriculum has potential to evolve from a centric focus on technical skills to become the platform which can foster the "new qualities" and "skills" required of the students of the 21st century. Fostering an appreciation for creative thinking and application to real world design issues is the first step to change the current perception of Technology Education.

To raise the standing, it is apt to, again ask the question, what exactly is Technology Education? A clear definition of the technology curriculum has been identified by researchers such as Wicklein (2004) Within technology classrooms the focus needs to be directed to fostering creativity, future innovations, sustainability, future problem solving, experiential and life-long learning.

There is much confusion around how students, teachers and parents perceive this subject. To persuade them of its importance, Wicklein 2004, suggests that one must use this new clearly defined structure to take forward and to shape the minds of tomorrow students. Along with the ongoing support of prominent educationalists, such as, Sir Ken Robinson, 2006, who claimed that creativity is just as important as literacy and numeracy, so it is anticipated that with a progressivism curriculum ideology focus and time, the prominence of this subject will rise.

This paper examines the current Australian educational system through the lens of The Technologies, defining its current position and examining the reasons for this.

Keywords: Professional Teacher Identity, Technology Education, The Technologies, Creativity,

INTRODUCTION

Professional identity frames ones perceptions and professional behaviours, attributes and, to an extent, the acuity of a professions significance within society. The perceived substance and subject content of Technology Education within society is frequently seen to be contradictory to the innovative and emergent role it is anticipated to offer the future of the nation. This contributes significant confusion to the professional identities held by Technology education teachers throughout Australia. If the professionals themselves cannot come to consensus on their professional identities then how can the subject evolve?

Formal recognition of technology into the Australian education system was enacted in 1989 by the Australian Education Council with the Hobart Declaration; since its emergence Technology educators have struggled to define their identity in accordance with their diverse subject content and pedagogy (Hamilton & Middleton, 2001). The Hobart Declaration (1989) proclaimed a significant goal, to develop student's ability, to analyse and to problem solve; The Melbourne Declaration (2008) superseding this goal aims to develop creative individuals. The current syllabus and the proposed National Technologies curriculum, identify sustainable design and its role as a higher order thinking problem solving practice that stimulates innovation, ecovation (sustainable design thinking) and creativity. However, the transition from traditional vocational teaching practises into value laden, divergent problem based learning has been a slow evolution for Technology educators (Williams & Keirl, 2008).

A design focused curriculum has challenged traditional technology based education to move away from instructional teaching methods into more collaborative, creative, higher order cognition techniques and sustainable value based design. Secondary educators often misinterpret design, implementing it as a form of decoration rather than an innovative and ecovative practice (Trevallion, 2011). Authentic design education develops and encourages student centred, autonomous learning; however the implementation of design into the Technologies, due to this misinterpretation has not achieved the professed results. (Hamilton & Middleton, 2001).

A CONFUSING PROFESSIONAL IDENTITY

Deconstruction of Technology teachers' professional identities requires first the need to determine identity before contributing factors regarding the development of 'technology teacher identity' could be ascertained. Olsen (2008) believes identity to be the frame in which a teacher is able to view themselves against 'workplace characteristics, professional purposes, and cultures of teaching. He continues to explain that the professional purpose and cultures of teaching could be considered a core issue where technology teacher identity begins to be skewed. One must consider whether the Technology teacher identity can be segmented into two parts: design educators, and skills educators, both cohabiting under the Technologies subject umbrella and then merged into one professional identity. If this practice was made clear and taken on board, one should be able to achieve optimum curriculum outcomes more effectively

Currently Home Economics' (including food and textiles), Industrial Arts' (including timber, metal and graphics based subjects); and Information Communication Technologies are all part of the Technology and Applied Sciences Key learning Area. Framing workplace characteristics within each of these areas find a considerable point of difference in the materials, tools and techniques being used but commonality is seen in the implementation of a sustainable design approach to using these materials.

Beyond the divide of specialisation materials lies the greater divide which is seen in teaching culture. Traditional technology based subjects are very much a part of the traditional skills based learning, preparing young people for trades based futures. This culture of trades based skill development is still very prominent within NSW education today (Williams & Keirl, 2008). The implementation of eco-design and problem based learning has added a further dimension to Technology education; furthermore conflict between how technology subjects should be taught, either a skills based or a design centred focus.

Prodigious confusion regarding professional identity for Technology teachers could be said to have commenced with the propulsion for design based thinking to be implemented into the traditional Industrial Arts and Home Economics based subjects. The current NSW Design and Technology syllabus rationale states ‘Australia needs future generations who understand the holistic nature of design and its processes’ (BOS, 2003); Design focus can be found within many of the NSW Technology based subjects syllabus documents; with design thinking being woven into syllabus outcomes, furthermore design process being the fundamental procedure that every project should be outworked. The BOS (2003) syllabus documents for the following find that the Industrial Technology, Food Technology, Textiles Technology, Information and Software Technology and Graphics Technology syllabus document promote ‘critical thinking skills being developed through engagement with creative practical problem-solving activities.

PROGRESSING ALONG THE CONTINUUM

The ACARA(2013)draft curriculum proposes that design and technology enables the bringing together of two strands of learning; one being the area of design and the other being the intricate and rapid emergence of technology. ACARA (2011) states that design understanding is crucial for the future innovation of the nation. Williams and Keirl (2001) accredit the problematic implementation of technology education to be, in part due to the problem based nature of the current curriculum, which requires building on past practices. Seeman, (2004) explains that the problem is compounded by the vocational focus traditional Technology educators attain, due to this focus they apply vocational methodology and content throughout their practise, while treating design as secondary in importance.
Technology education is a curriculum in transition, moving from its Industrial Arts instruction based past, to its superseded problem based, authentic, modular learning (Walmsley, 2009), which many teachers have still not defined; a result of this transition teachers are found at various points along the Technology Teacher Pedagogy Continuum.

X ———————————————— X ————————→

Vocational Learning — Design based Learning

This indicates that students’ themselves are encountering varied styles of teaching in the areas of technology education. As Technology subjects have always been associated with providing skills and knowledge to meet labour requirements of an expanding industrial economy to ultimately increase global competitiveness (Barlow, 2012). The traditional skill based approach to teaching Technology education is still valued by students and the community.

A NEW ROLE AND DIRECTION

As Australian society has emerged and developed technologically, Technology education has been forced to take on a different role. Students need opportunities to experience and critique a range of technologies as part of their compulsory education. (Williams, 2006), states that the most significant change to Technology education is the concept that, as a learning area, Technology education contributes to all students’ general education. Technology education has many links to other learning areas in schools such as research, analysis, creativity and information technology skills and is a useful path to university study and vocational education and training.

The famed educationalist Sir Ken Robinson at a TED: Ideas Worth Sharing, seminar in 2006, claimed that creativity is just as important as literacy and numeracy and must be implemented as we reform schooling around the world. The current and new national Technology curriculum within Australia demands that teachers’ develop, in their students’ the skills to be innovative and creative thinkers as opposed to crafts persons alone. Here students build their understanding of creativity, design thinking, problem solving, communication, project management as well as building traditional practical skills and knowledge (Barlow, 2012).

THE IMPORTANCE OF DESIGN THINKING

Design holds an important place in student's education as it provides them with essential, life-long skills that will support them across the entire curriculum. One of the world's greatest lateral thinkers, Sir Edward De Bono, advised the British Ministry of Education in 2007 that we must teach our children to think before we teach them to write. To this end he has designed a range of cognitive tools for individuals to use that promotes lateral and creative thinking and develops problem solving. Design is a medium for problem solving that gives opportunities for students to step outside the conventional reasoning process that is imposed by the rest of the NSW curriculum (Lewis, 2005). He further explains that the open-ended nature of design makes it specifically suited to student's, there is more than one right answer and more than one right method of arriving at the solution. This allows students to gain confidence in their reasoning, their problem solving skills and in building innovative ideas. In support of Sir Edward De Bono's and Sir Ken Robinson's position on the importance of creativity as an essential skill for all children that must be included in school reformation (Lewis, 2005, Druin & Fast, 2002), explain that the process of innovation and design in the classroom can strengthen student's ability to use creativity, critical thinking and problem solving skills, synthesise different ideas from a variety of sources, assist in learning subject matter and teach students the necessary technical skills involved.

Technology Education, using the design process is the perfect medium for fostering and cultivating student's creativity in the context of this real and changing world (Wong and Siu, 2012). The Technologies curriculum must develop student's knowledge and skills to prepare them for the challenging decisions they will face in the future (Nicholl, Flutter, Hosking and Clarkson, 2013).

Students must be encouraged to think, to create novel solutions to everyday problems and to take risks when doing so. To gain a sense of achievement, students must foster both well-developed practical skills and autonomous design thinking.

Student centred design is prominent in the Technology education syllabus but it has not made a strong transition into our classrooms (Nicholl, Flutter, Hosking and Clarkson, 2013). explain that students need sufficient challenge and opportunities for autonomous decision-making and risk taking including real life, authentic, design problems providing opportunities to motivate and engage students.

A NEW PROFESSIONAL IDENTITY

Teachers need to adjust their teaching approach, taking on board design thinking and problem solving. This will promote change in own professional teaching identity. It has been found that students who are intrinsically motivated, who set interests and skills overlap demonstrate optimum creativity. This level of creativity is ultimately supported and influenced by the teacher. Research shows that if the teachers do not possess these abilities and skills themselves, their students will be unable to achieve this level of thinking (Nicholl, Flutter, Hosking & Clarkson, 2013).

Teachers without design understandings may find it difficult to make these professional identity changes, this will inhibit student's creativity (Nicholl, Flutter, Hosking and Clarkson, 2013).

Barlow, (2012), espouses that the expansion of the national curriculum's educative efficiency may be compromised due to the required management, monitoring and evaluation. This provides the Technology Educationalists with a dilemma, do the individuals who view technology education as a vocational based subject continue to teach it as just that or do they taking upon themselves a design approach. Before professional identity changes occur each must determine the meaning of "a design based focus". Currently Technology education is presented in two ways, thorough deliverance of production and the steps it takes to manufacture and design is presented as decoration, and is taught as the process with which a project is completed. (Hamilton & Middleton, 2001), found that students undertake their studies without holistic understanding of how design should interact with product. The implementation of authentic design based learning would make a significant step toward achieving syllabus ideals.

A PEDAGOGICAL APPROACH

There is conflict in that the very nature of design education conflicts with traditional vocational skills based learning. Design requires divergent and convergent thinking along with the merging of science and art to solve problems (Lawson, 1997). Vocational skill building requires students to be taught step by step processes to develop understanding of essential manufacturing techniques. As students build on those skills and practise learned techniques they will develop their craftsmanship.

Technology education requires two disparate processes of teaching to enable holistic understanding of both areas; both design and manufacturing skills are essential for the future of Australia. Currently Technology educators are educating students quite successfully in the processes of producing and making. However design education is typically misunderstood and misinterpreted (Hamilton & Middleton, 2001). Design education should not be a linear process; authentic design education should be approached creatively, and motivate a student to, identify and map attributes, make possibilities, change and shift perspectives, make associations and develop analogical thinking, probe emotion and the subconscious; to inspire design thinking within a student requires a creative teacher, who is able to design creative teaching strategies (Fisher & Williams as cited in Law, Ng & Lee, 2009).

The Introduction of Technology educators trained in design may mean a move toward implementing classroom environments and teaching programs dedicated to design. Here, students will learn core skills and gain knowledge through the practice of design. Spaces may be developed where students can use combined skills and materials from different fields to produce novel, sustainable and innovative ideas and solutions using the design process.

The development of practical skills will continue to be provided to assist students with their future career aspirations but potentially in a design environment with a real world, user-centred, design focus that promotes lifelong learning.

The concept of a shared design environment will not be ideal for teachers who are experienced in one field, whether it is timber, metal, textiles or food technology. This may lead to a demand for staff to up skill as a part of their professional learning. This is a complex and a more difficult concept, but with it we would see students designing and producing projects, with a heavy emphasis on design thinking, problem solving and user-centred design innovation, using the technical skills they have previously learnt.

Hamilton and Middleton's (2001) case study investigating factors that hinder and enhance the implementation of technology education, identified a significant enhancer to successful implementation being strong leadership and the impact of personal teacher qualities and their passion for this emergent thinking. This needs to be a focus for Technology teachers in schools and also in their tertiary training programs.

CONCLUSION

Regardless of the direction taken, to ultimately teach design all technical fields need to be embraced and students need to have freedom with materials, tools, ideas and concepts.

Whether we see a change of teaching and learning environment for Technology Education one must ensure teachers are fulfilling syllabus requirements and embracing the power of design.

The evident changing identity of technology teachers from one who solely values skill based learning to one who also values and promotes a design focus will see a change in the Technology classroom environment, a change in students' thinking and learning and a change in the Technology teacher's professional identity or at least an acknowledgement of the importance of design.

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Using Design Thinking to Raise the Status of "Technology Education"

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ABSTRACT
For as long as there has been education, there has been a social current guiding students learning, this can be seen in the lessons teachers' prepare as well as the written and hidden curriculums they teach. This social current is not merely reflected in what is taught in the classroom, it is also echoed in the structure of the Australian education subject classification and hierarchy.

The traditional secondary school subjects and their associated prestige, developed during the time of industrial revolution. This historical development impacts heavily on our concept of what education courses entail and our opinion of how important they are. This has resulted in status being placed on subjects, as individuals decide which courses are more important than others. This model almost universally places literacy, in the form of language, numeracy in the form of mathematics and science at the top of the hierarchy, followed by the humanities and the arts. So where does that leave "The Technologies"?

As Australia's education system is currently being restructured, moving towards a national curriculum, it is apt to ask the question, is this structure best suited to take forward and use to shape the minds of tomorrow students. Where does "The Technologies" curriculum belong in this structure?

Within "The Technologies" we teach: creativity, thinking skills, innovation, communication, reflection and sustainability and we provide experiential learning and research opportunities as well as higher order thinking. This results in experiential learning and life-long learning. Global leading educationalists agree that it is just as important to teach creativity as it is literacy and numeracy, so why, in Australia are The Technologies subjects held in low esteem and what can be done to change this?

This paper will examine the current Australian educational status system through the lens of The Technologies, defining its current position and examining the reasons for this. The authors will present insight on how a subject gains status within the community and suggest strategies for increasing the status of "The Technologies" both in schools and in the wider community.

Keywords: Curriculum Hierarchy, Subject Status, Prestige, Design and Technology, The Technologies, Creativity, Teacher Identity, Thinking Skills

RATIONALE:
The full potential of technology education in Australia is linked to the very fabric of societal change. The expedient and evolving needs of the 21st century require different skills from the

area of technology education than was required in the past. Technology education was initially developed to meet the needs of the industrial and manufacturing sector of its time (Williams & Williams, 1997). Since its birth much has changed, globalisation and technological advances have evolved and shaped the landscape changing the currency of the future. In this new world key corporations are built to harness "the fields of communications, information, entertainment, science and technology" (NACCCE, 1999). With this in mind technology education must be re-conceptualised as a platform to impart critical thinking, problem solving and creativity, skills which meet the needs of not only the current societal backdrop but which will help our students succeed well into the future. By focusing on transferring these critical skills to our future citizens we will enable their successful navigation of the global economy, firmly grounded within a sustainably responsive consciousness.

In light of these societal changes, technology education has the opportunity to redefine its place and status within the Australian national curriculum and rise like a phoenix from the industrial roots of the past to embrace what is required for the future. In defining the current status of technology education in Australia, there is a need to look at what has been done in the past and the myriad of changes that the curriculum area has experienced. According to MacDonald and Gibson (1995) the technology curriculum has been significantly affected by change more so than any other curriculum area. Each change has influenced and shaped the nature of technology. The key driver for this change in New South Wales was through the Government commissioned paper Excellence and Equity. This paper identified the need for technology education to become more relevant to the changing needs of society (Williams & Williams, 1997).

BACKGROUND

Further recommendations for the restructuring of technology education were encapsulated in the Carrick report (1989). This report outlined recommendations that technology education should offer a wider selection of subjects within its domain. The motivation behind this recommendation was to facilitate student's appreciation of the more "practical applications of technology" and meet the technological needs of society (Williams & Williams, 1997, p. 92). These policy documents were the impetus for the reorganisation and renaming of the technology curriculum as Technological and Applied Studies (TAS) Key Learning Area.

This broadening of the curriculum included the amalgamation of the traditional subjects of Industrial Arts and Home Economics together with other subjects such as Computing Studies and Agriculture. Furthermore, it was also recommended through the Excellence and Equity paper that all students were required to study 200 hours of technology education via the Design and Technology 7-10 syllabus (MacDonald & Gibson, 1995).It is important to note that although these changes occurred within New South Wales. It was a reflection of a global trend at the time, to broaden the technology curriculum's scope within education (MacDonald & Gibson, 1995).

The decisions of the past still resonate; currently Australia is undergoing the implementation of a national curriculum in which the "Technological and Applied Studies Key Learning Area is now known as "The Technologies" **.** The Australian Curriculum, Assessment and Reporting Authority is responsible for the implementation of this national curriculum and is in the process of assisting the states and territories during this period of adjustment. This government agency is guided by two key policy documents: the Shape of the Australian Curriculum and the Melbourne Declaration on Education Goals for Young Australians (Trevallion & Owen, 2012).

THE CHANGING CURRICULUM

It is interesting to note that the name change for the technology curriculum as The Technologies is not the only changes which have taken place. Two strands will be offered; design and technology and digital technology. Furthermore, implementation of mandatory years 7-8 design and technology study will be rolled out nationwide, with years 9-12 remaining an elective subject area. Another deviation is the mandated 200 hours of study for technology subjects has been significantly reduced (ACARA, 2012).

It would appear that we still have a broad area to cover within a limited time frame. Within the field, it will be an opportunity to showcase creativity and innovative thinking skills when delivering relevant learning experiences which are constrained by time and resources. This should be seen as an opportunity to model first-hand creativity and design thinking to our future technology colleagues. The perceptions of technology students and their potential to contribute to the technology education field should not be forgotten amongst the endeavours to locate technology education's "academic identity" (Barlow, 2012, p. 37) and the recycling of past and present issues surrounding this field.

THE PERCEPTION OF TECHNOLOGY EDUCATION

Therefore, during this transition period within Australia it is imperative to consider how technology education is perceived by all stakeholders. One cannot discredit the importance of a subject's status not only within the school but in the wider community. Martin (1998) states during the period of curriculum restructuring the focus, is often on the transformation of the content and pedagogy. How a subject is perceived, is often forgotten. As a direct result "subjects continue to be perceived and described using the same old language and clichés" (Martin, 1998, p. 41).

This significance in understanding how a subject is perceived allows the opportunity to clarify misleading impressions to those external of the field. Martin (1998) further extrapolates that design and technology is more likely affected by negative perceptions, due to stakeholders such as educators, students, parents and politicians not understanding the very nature of the curriculum area. Wicklein (2004) supports this and states that it is the misunderstanding of what technology education encompasses which allows these inadequacies to infiltrate the field of technology. Australia is not alone in this regard, the perceived status of other countries share similar sentiments. Ferrari et al (2006) offers a perspective from Israel stating too often parents and students view science as being more relevant than technology education.

GLOBAL UNDERSTANDINGS

This sentiment is also echoed in Hong Kong whereby, parents will suggest the more "academically-attractive options available such as mathematics and science, there is little to assume D & T will be selected by students" (Volk, 2006, p. 224). In Japan, students recognise the "main subjects" due to the requirement of these subjects as entry points for further study. The other "subjects" are thought of as a form of relaxation and are not viewed as serious to furthering their education (Matsuda, 2006, p. 234). These attitudes and constructivist understandings need to be addressed, if any change in attitudes towards Technology Education is to be achieved.

If the consciousness of teachers and the public remain unchanged, then technology education in schools will remain unchanged. In Japan, it is said that the number of retiring teachers will increase dramatically over the next decade (Matsuda, 2006, p. 235) and this is not an isolated occurrence. In Australia an estimated 30,000-40,000 teachers left the workforce in the lead up to 2010 and in the coming 5 years another 15% of the workforce will reach retirement age (MCEETYA, 2008). This new cohort of teachers arriving to take their place will be better educated in design than ever before, and in collaboration with a new national curriculum in Australia it provides technology education with a window of opportunity to re-shape the future of the subject.

For real change to take effect, it is imperative that technology educators reframe (Schon, 1983) their traditional interpretation of how technology education should be delivered in the field. Matsuda (2006) offered this insight into the Japanese perspective and believes that the key to change within the field is the willingness of technology teachers to re-conceptualise traditional representations of technology education. Walmsley (2003) elaborates on this idea further and states it is not the devaluation of the traditional practical skills. Rather, it is the revaluation of such skills guided by a sustainable consciousness and in conjunction with a strong design orientation, problem solving and creativity focus. If harmony is to be achieved within technology education, there must be the holistic embracement of all these elements and the need for these learning opportunities to be explicitly delivered into the field.

RAISING THE STATUS

What needs to be communicated to all stakeholders is the very fact that "there is no other curriculum area in which students have as significant an opportunity to think and reflect and develop ideas, and then test their ideas in a practical context" (Williams, 2000, p. 48). Therefore focusing on developing an accessible image of design and technology which is meaningful to stakeholders may be, the catharses needed to elevate the status of the subject internally and externally to the field (Martin, 1998). Adding to this line of argument Wicklein (2004) believes the best way to elevate the status of technology education is to "identify and communicate a clear and understandable purpose of technology education to all populations" (Wicklein, 2004, p. 9).

How this may be achieved is suggested by Sharpe (1996), as cited in Martin (1998), who articulates how New Jersey developed a campaign to promote technology education to the public in terms that educators across the educative spectrum and the general public could understand. It is now the right time to market technology education to assist in reconceptualising the perceptions of stakeholders. It is also imperative to use this marketization to encourage more teachers into the field and motivate students to be a part of the technology education community (Wright and Custer, 1998).

With this in mind it is equally important to examine the footprints of subjects outside the area of design and technology, subjects which came before, in order to understand both how they achieved their position and why they have remained there. Goodson (1993) explains that education systems worldwide have been built upon a similar structure when it comes to prestige, at the top are paradigmatically decontextualized subjects such as mathematics, science and languages, these are followed by the humanities and situated at the bottom lies the arts. The upper most subjects within this proposed hierarchy are unsurprisingly the classical or traditional subjects which have held a place in Australian schools since the birth of free, secular public education in the nineteenth century (Teese 2011).

It is important to note the strong bond with tertiary education these subjects had forged and it was due to this that they were the focus for high achieving students, while technological subjects prepared the rest of the student body for industrial careers (Robinson 2001). Goodson (1993) contemporises this through stating that the process of moving the underachieving students away from academic subjects and towards practical focused areas is still a mainstay of the current educational climate. This secondary-tertiary bond also directly relates to the perceived value of achievement in these subjects held by both the student body as well as their parents. With this perception harnessed it provides these areas with more leverage when competing for teaching time and timetable positions (Paechte, 2003).

A statistical analysis of uptake data for secondary subjects conducted by Rodeiro (2007) during the years 2000–2006 demonstrates the effect this is currently having on the Design and Technology Key Learning Areas. The study extrapolated that overall The Technologies were not favoured by the majority of high attaining students (Rodeiro, 2007). This encourages the schools to redistribute resources in order to fund their academic student body which in turn creates a self-perpetuating cycle continually propping up the upper tier of the subject hierarchy.

Formal examinations, which can provide a tangible, comparable measurement of student achievement, play a key role in the status of a subject (Goodson 1985). In Australia the introduction of the 1999 Adelaide declaration on national goals for schools, saw a strong emphasis placed on measuring student achievement in relation to a set of national goals (MCEECDYA 1999). This led to the creation of the National Assessment Program or NAP, which was designed to collect and analyse nationally comparable data on student achievement in literacy, numeracy, science, ICT and civics and citizenship. At the release of the Melbourne declaration in 2008 a key focus was placed on improving literacy and numeracy for all Australian students (MCEECDYA 2008). This led to the removal of the previous NAP assessments in favour of literacy and numeracy focused testing regime called NAPLAN. It has been noted since as early as 1934 that this form of national testing leads to schools "directing all instructional and learning activities toward the cramming of those things which can be measured by written examinations" (Douglas p 500). This provides a greater focus on the subjects sitting at the top of the hierarchy; those which can be more easily evaluated through a series of questions constrained by the examination process.

NEW PERCEPTIONS

Currently the Australian national curriculum is positioned to create a stronger bond between technology education and science, with the inclusion of the K-6 combined Science and Technology syllabus implementation (ACARA 2012). This would appear to be a suitable combination, quashing problems arising over technologies support and collaboration with other STEM subjects, specifically science and maths (McGimpsey, 2011), and in turn boosting its status in the quickest most efficient fashion. However De vries (2006) proposes a negative spin on this collaboration in which the nature of technology could become lost in the shadow of science. The curriculum for technology , more so than any other, calls for the blending of social, economic, historic-cultural and psychological thoughts and processes which in a close partnership with science, could be swallowed up by scientific precision and exactness. It then becomes important that design and technology does not lose what makes it a valuable subject in an attempt to gain social position. In moving forward technology education must continue to associate and form ties equally with the arts, as it is these subjects which allow students to use knowledge "not for its own sake, but in support of thought leading to creative expression" (Lewis, 2005 p 46).

In 1992 Buchanan put forward the notion that people continue to think of technology in terms of a product, forgetting the systematic and creative thinking that lies at the heart of the discipline. It is this type of misunderstanding that plagues not only the general public but professional educators alike (Wicklein, 2004). With the release of the national curriculum documents and a definition of technology education to be spread to the whole of Australia, researchers and educators must work together to promote knowledge on two fronts; internally focusing on teachers, careers advisors and students and externally with constituencies such as parents, employers, politicians and others in the public arena.

Within the school walls subjects are constantly reinventing themselves to stay relevant to the needs of students and the community, it is important that they do so. Design and technology as a subject area has experienced this more than most in recent years (Martin, 1998). It is for this reason we must provide educators with the best support to fully immerse themselves in the content of a new curriculum and allow time for collaboration of all teachers across the country and globally to aid in forming a unified identity. Technology education must concern itself with self-image, not because it is more important than performance or content, but because it is in this image that we can discern how our signals are received by those looking in (Bernstein, 1984). It is only when we have a unified image that we can provide a consistent message.

CONCLUSION

The perception of those outside the gates of the school is equally important in raising technologies status. Through a process of opening communication channels and creating human interaction we can provide access to our internal processes, and in turn allow the public to re-conceptualise the critical core themes at the heart of technology education. This will allow D&T

to cast off the firmly embedded perceptions created by its manufacturing history. To strengthen this shift, new academic ties with tertiary education could be formed. Verner, Waks & Kolberg (1997) examined the integration of technology education in 3 advanced secondary schools. The top students in maths and science were encouraged to participate through a system of tertiary credits which could be used towards an engineering degree. While this process may be removed from Australia's current education system, the concept could be extrapolated and developed. Offering students a slight increase to their ATAR score when applying for industrial design programs would increase the perceived validity of the subject.

Change is an inevitable occurrence; the very nature of our fast paced society delivers ongoing challenges which our future citizens need to be able to meet head on. Technology education is the best medium through which we can demonstrate the educative value in providing future citizens with the skills required to make a difference. With education teetering on the cusp of change in Australia with the national curriculum and changes occurring globally we must ensure that our future populace becomes sustainably conscious, critical and responsible citizens by tapping into and reinvigorating technology's educative potential. The path to achieving this lies in clearly understanding how the curriculum area is perceived both internally and outside of the field. It is also imperative to ensure the future direction of technology education is clearly communicated and promoted in ways that are clearly understood by all stakeholders. Technology education should be seen as the new frontier of the 21st century, pushing the boundaries and remaining adaptable in the face of change.

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The Utility of Technacy Genre Theory in Technology Education: A Case Study into Food Technology Teaching

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ABSTRACT
There are many and varied forces that shape school curriculum, but one that is of specific interest discussed in this paper concerns the perception of Food Technology secondary curriculum in Australia. Maintaining and fostering a coherent and accurate perception throughout the food technology career, from school leaver to professional undergraduate studies, is critical for both the evolution of the field of knowledge and the need to keep up with increasing world demand for food technologists and food innovation. Food Technology is a well-established secondary school elective in curriculum offerings, yet a contradiction has emerged between the 'school view' of Food Technology and the 'professional view' of the same – career pathways are confused due to the use of identical labelling to describe two different practices, causing a significant problem for the food industry profession. With both the school sector and the professional sector each asserting their respective perceptions of Food Technology as correct, a method for clarifying and classifying the nature of the disjuncture between the two claims has been illusive. This paper asserts that at the heart of the problem was the lack of a theoretically valid and reliable framework that may help clarify and articulate exactly what form of technology capability is being taught in secondary schooling according to current curriculum. The research reported here draws on an empirically tested framework – Technacy Genre Theory. The framework offers an indexing system that can define the nature of the degree of agreement between two forms of technological practice. The research confirmed that the label of 'Food Technology' is perceived significantly and substantially different between schoolteachers and the wider, relevant food profession. The paper concludes with the proposition that Technacy Genre Theory offers a new method for comparing and clarifying many combinations of technological typologies of practice.

Keywords: Technology, Food, Technacy Genre Theory

INTRODUCTION
What do we mean when we say 'Food Technology' and its practical manifestation? While dictionary definitions may appear to be the obvious source for resolving the meaning of Food Technology, in practice the task is far more complex given the considerable systemic investments different stakeholders have made in the field of food technology studies. Additionally, the need to clarify and classify all forms of technology knowledge and practice emerges as significant given the plethora of materials, tools and techniques school students, school teachers and food professionals each need to navigate in differing context and purpose.

This paper draws on Turner's 2012 Doctoral dissertation which critically analysed Food Technology in schooling and how well their form of practice aligned with that of the professional food technologists. In this context, the professional food technologists were identified as the reference group while the food technology and secondary teachers were identified as the comparative group. The study revealed differences so great between the two group's knowledge and practice, that the 'supply' pathway from school to the 'demand' entry into professional Food Technology careers and higher education was dislocated.

Nutrition, healthy lifestyle and nutrition related adolescent food issues are the most obvious aspects of food content included in the curriculum. Many educators consider food preparation and safe handling essential life skills. Stakeholders report that students generally respond favourably to this aspect of the subject and utilise the experiences as a useful background to part-time employment and perhaps a later career. Students generally do not view food production and food processing in the same light and generally equate food technology with the hospitality industry (KPA, 2003, p. 40).

The study aimed to clarify a long-standing problem between two groups using the same label, each claiming their version as correct for Food Technology, and establish the best way to identify the forms of technology practice to facilitate best practice in Food Technology education. Yet, little theoretical work was evident that sought to assert a universal and transferrable foundation to the ontology of technological knowledge itself. Literature surrounding the study and form of technological knowledge suggested the field remains essentially disaggregated but there are associations of durable value proposed (Barlex & Rutland, 2003; Barlex & Trebell, 2008; Compton, 2009; Dakers, de Vries, Custer, & Martin, 2008a; de Vries & Ilja, 2006; Dugger, 2010; Elshof, Keirl, McLaren, & Seemann, 2010; Feenberg, 1991, 2006, 2009; Ihde, 1979, 2009; Jideani & Jideani, 2010; Keirl, 2009, 2010; Misa, 2003; Owen-Jackson, 2001; Petrina, 2007; Rutland, 2009; Seemann, 2003, 2009, 2011; Slaughter, 1999; Williams, 2011). Yet common to contemporary technology education learning, independent parts tend to segregate rather than act as a whole system of integrated learning. A limitation of many school design-oriented frames for the study of technology is that the process approach is often formulaic with little reference to the technological form of the knowledge being studied. A risk with such approaches is that while design studies may enable higher order thinking in the process of designing, very little of the same is offered to the form of technological knowledge itself. This dominant focus on design at the expense of technology studies, can introduce an element of risk with the task of technological judgement and choice.

Furthermore, in terms of formal technology education, the diverse ways society seek to conceptualise technology practice suggests that while we may all see intuitively some aspects of technical knowledge linking together, we equally struggle to clearly articulate it all into one whole universal model. Technacy Genre Theory referred to hereafter as TGT, offered a way to value a proper place for both a cogent examination of technological understanding as well as the role that design plays in the educational process. The universal structure of TGT contains an interrelated outside genre system (knowledge, tools and ingredients, materials and ecological elements) that define the purpose and context parameters and as such provide a lens to identify different types of technological practice and knowledge. One of the key ideas underpinning TGT is that the form it takes as an explanation of technological knowledge, is that it repeats upon itself as well as links to other forms in a 'fractal' relationship. This proposition makes TGT scalable and offers a way to see how complexity may arise out of simple relationships between people, tools and ecology when they are combined to meet a purpose in an applied context setting. In concert with this theory, historical western proponents for a schema that integrates social, cognitive and material experiences have been identified through the literature and writings of Dewey (1938); Hegel (1989); Marx (1974,1967).

METHOD

A mixed-method design using a triangulation approach was chosen to compare historical literature with contemporary knowledge and understanding between teachers and non-teachers. A cross-sectional survey instrument was designed so that a systematic investigation of relationships between two variables could be compared and to what extent two groups differed on the outcome variable: Food Technology. Although the research contained a particular focus between the two groups, sub-groups containing the same characteristics (used to create the strata related to the dependant variables) were built into the research design. Perception grids, Likert and Ranking scales were used to measure items in the instrument. The questionnaire, validated by four pilot surveys prior to distribution, involved a multi-mode method using both paper and electronic format. Participants were previously informed about the nature of the survey, as well as their voluntary and confidential participation. The validity for using both qualitative and quantitative research within the same framework incorporated the strengths of both methodologies and responded to the need for clarification across multiple issues, thereby providing a complete picture of the analysis of findings in a single study (Creswell, 2003; Johnson & Onwuegbuzie, 2004). This allowed for pragmatic assumptions that sought improved reasoning for educational policies and arguments concerning social and human factors.

The overarching umbrella question that addressed this research was:

1. To what extent is Food Technology in schooling well placed to meet emerging policy and economic demand for food innovation expertise as innovative and sustainability informed Food Technologists?

The two sub-questions were:

2. What is the evolution of policy and industry knowledge in Food Technology?
3. How can forms of technology practice be identified in Food Technology education?

The theoretical framework, the methodology for this research was structured around contextual and goal orientated aspects of practice through three phases: 1) Historical and contemporary literature review, 2) Scoping study (interviews and discussions; classroom & fieldwork observations), and 3) Data collection and analysis (survey instrument). For each phase, the key elements of TGT, human agency, tools and materials, and ecological aspects of practice were of a specific interest. This allowed for meaningful dimensions in the study to be collected in different ways and patterns identified.

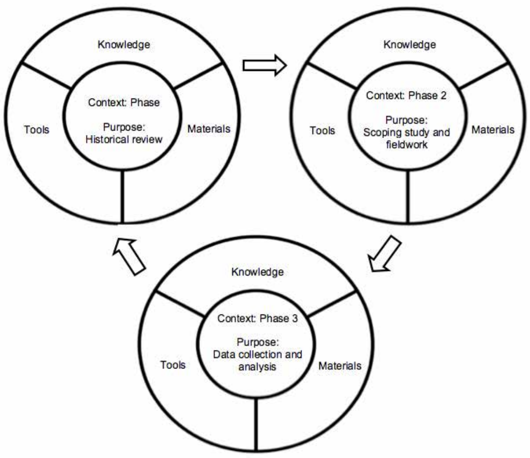

Diagram 1: Research method (Turner, 2012)

DATA SOURCES

A stratified random sample method was used to collect data. Both Teacher Training (the comparative group) and Non-Teacher Training (the control group) equaled 191 participants each. Four groups and three consecutive sub-groups for each group were classified as:

A) Teacher Training: Food Technology (n=78)
   - Secondary food technology teachers; undergraduate students training as teachers in food technology; academics

B) Teacher Training: Areas other than Food Technology (n=58)
   - Secondary wood, metal and computer teachers; undergraduate students training as teachers in Industrial Technology; academics

C) Teacher Training: General Secondary (n=55)
   - Science teachers; undergraduate students training as teachers in the sciences; academics

D) Non-Teacher Training: Food Scientist Technologist (n=191)
   - Food technologists and scientists; undergraduate and post graduate students; academics

Theoretical Framework

TGT was used to guide the direction for collecting, analysing and mixing qualitative and quantitative aspects for the various phases in the research process. It was hypothesised TGT could empirically measure a high degree of precision between two different types of technology genre and thus articulate their specific form of knowledge, technique, tool and material elements. The classes for this study included food technology as a science index and food hospitality as a vocational index. Therefore, the stronger the participant was in choosing food science or hospitality, the clearer the participant was about the technology genre they practiced. The weaker the participant was in choosing food science or hospitality, that is, alternates between the two, detected confusion about their technology genre. Science was allocated a higher score, while hospitality was allocated a low score. The genre instrument was able to detect where a participant was positioned in genre. For example a high Technacy Genre Index approaching 1.0 suggests a strong science, innovation and food design orientation; a low index approaching 0.0 suggests strong vocational, cooking-skills, conservative orientation to the purpose and practice of Food Technology. (Alpha = 0.05, n=382).

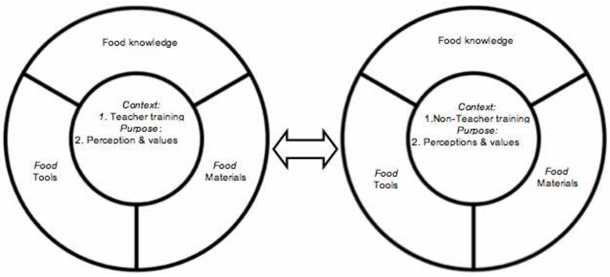

Diagram 2: Framework to classify forms of Food Technology knowledge and practice (Turner, 2012)

TGT provided a robust frame of reference and organisational guide to gather and examine data and information of the perceptions and values between the teacher-training group and the non-teacher training group for food knowledge, tools, material and ecological elements of food technology practice.

KEY FINDINGS

Conventional standards were used for the reporting of statistical tests where the significance level was stated (α), and degrees of freedom (df), probability value (ρ or .sig) and type of test (T-Test-*t*: ANOVA-*F* or Correlation-*N*) declared. Where a statistic was declared as significant, (ρ) was less than or equal to (α).

Understandings of, and expressions common to food science and technology, were compared between the teacher training and non-teacher training groups using perception matrices. This technique was adapted from a single grid method used in a similar study designed to discern psychology student views about the nature of human knowledge by Provost, Martin, Hannan, Bath & Lipp (2007). In Turner's study, three matrices of twenty-five questions contained mixed 'food' related phrases used in food technology and hospitality settings under TGT headings 1) Knowledge and techniques, 2) Tools and equipment, and 3) Materials and Ingredients. Participants were asked to circle up to 10 phrases they had used or that best described their understanding in knowledge and techniques, tools and equipment, and ingredients used in Food Technology. Data was analysed through a scatterplot matrix to identify relationships or differences between three variables: 1) Knowledge and techniques, 2) Tools and equipment, and 3) Materials and Ingredients. It was hypothesised that two different forms of Technacy Genre practice would be evident: food science and vocational operational skilling. The stronger participants were in choosing either of the two, the more determined the clarity of their technology genre. The Pearsons 3x3 correlation matrix shows a very strong three-way interdependent pattern, as predicted in Technacy Genre Theory. Knowledge-Tools (n=382, r=.823, p<0.000, 2-tailed); Knowledge-Ingredients (n=382, r=.742, p<.000, 2-tailed); and, Tools-Ingredients (n=382, r=.790, p<.000, 2-tailed).

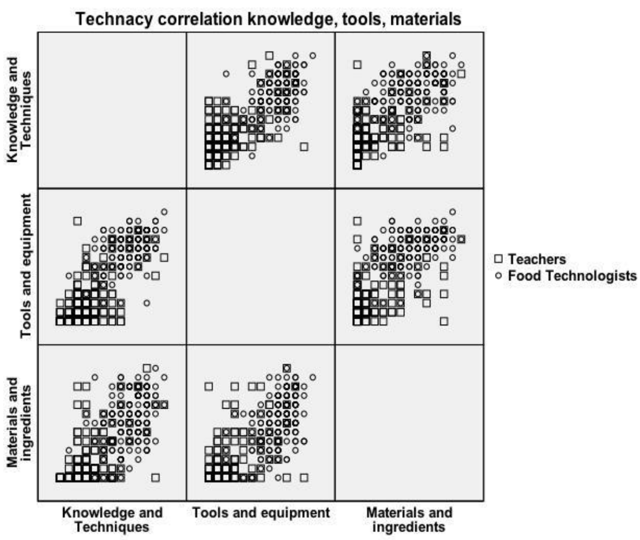

Figure 1: Correlation matrix for Food Technology priority systems

A Technacy Genre index score of 3-4 was applied to seven questions out of fourteen questions in a four point Likert Scale. These indicated a strong science, innovation and food design orientation theme. The remaining seven questions were indexed as indicating strong vocational cooking-skills and conservative orientation in theme (Alpha=.05; n=325). Table 1 and Figure 2 display group mean scores from question bank 2 in the Likert Scale. In this question, participants were asked for degrees of agreement for the purpose and practice of Food Technology as a learning area for self-sustainable cooking skills. There was a significant difference between the teacher training and non-teacher training groups. Teacher Training (n=164; Teacher index=4.11) vs. Non-Teacher Training (n=125; Food Technologist index=3.06); (df=1, t=8.593, p<.000, 2-tailed).

Table 1: Food Technology as self-sustainable life skills and cooking

Group Statistics

	2_groups	N	Mean	Std. Deviation	Std. Error Mean
In Food Technology, secondary students learn self sustainable life skills such as cooking	Teacher Training	164	4.11	.836	.065
	Non Teacher Training	125	3.06	1.230	.110

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
In Food Technology, secondary students learn self sustainable life skills such as cooking	Equal variances assumed	93.213	.000	8.593	287	.000	1.046	.122	.806	1.285
	Equal variances not assumed			8.176	207.266	.000	1.046	.128	.794	1.298

ANOVA data analysis revealed teacher perceptions of Food Technology were strongly skewed toward vocational cooking-skills and conservative orientation in theme. This suggests the Food Technology 7-10 syllabus may not provide an adequate lead into the senior Food Technology syllabus as well as what it was designed to do or perhaps teachers are misinterpreting the syllabus. Teacher Training: General secondary index=4.25 (n=48); Food teacher index=4.09 (n=68); Areas other than Food Technology index=4.00 (n=48). Non-Teacher Training: Food scientist technologist index=3.06 (n=125); (df=3, F=25.061, sig.=.000).

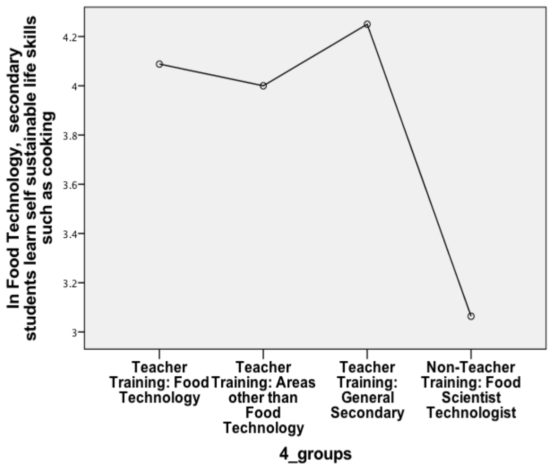

Figure 2: Food Technology as self-sustainable life skills and cooking

In addition, qualitative data was tested and compared in purpose and context of written and verbal feedback with the quantitative data. Although smaller in sample size, nonetheless Figure 3 further substantiates a heavy emphasis toward cooking and food processing (Teacher Training group, n=54). In comparison, the Non-Teacher Training group display a small mean score for cooking (n=19), yet this overlap suggests not all food industry processes occur in a laboratory or a processing plant, but often cooking is a process undertaken during preliminary food design and development in a domestic style kitchen. The small response for food experiments by the teachers suggests that some in the teaching collegiate engage in the science of food through experiments to better understand food-processing outcomes. Figure 3 suggests a heavily skewed view toward nutrition. Although nutrition is an important element, marginalising other elements constitutes an uneven outcome in technological learning, thinking and practice. Closer parallels were evident for food safety and quality and food sustainability, but given much less importance (n=92). The food profession also valued nutrition the highest (n=56) and for both groups this shows an interest to maintain healthy food choices. However, ecology and food sustainability were noted as the lowest for both groups and this suggests the importance to raise the bar in training to link eco-footprint more deeply into teaching and learning and the expertise and purpose of food research.

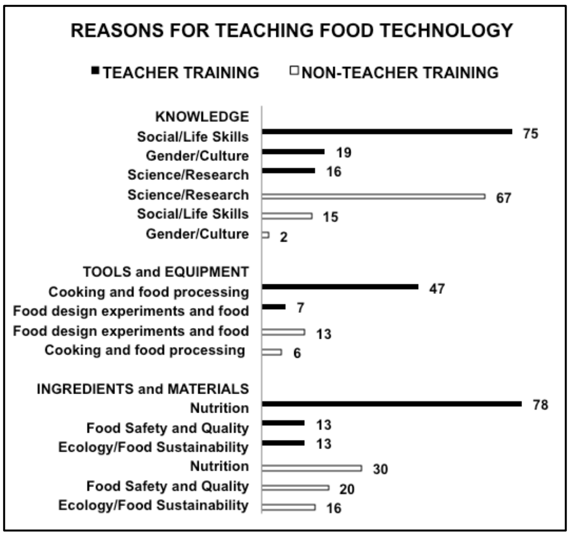

Figure 3: Reasons for teaching Food Technology

CONCLUSION

The results from this research identified a perpetual problem of a flawed knowledge base in curriculum representation and teacher interpretation that has affected rigorous study in food technology. While it could be argued that the differences are too great and not in agreement between the school view of Food Technology and the wider professional view of the same, the point of concern is that the subject has not evolved due to the curriculum writers and teacher's historically acculturated view of the subject. Consequently, this has had a major impact in 'supplying' people into professional studies towards a career as a food technologist in the agri food industries. The research established two contrasting and emergent themes that may contribute to the disparity in teacher training and non-teacher training contexts − Teacher training is humanities oriented, emphasising 'food technology' as a general education while non-teacher technologists training is sciences oriented, emphasising 'food technology' and 'world food demand challenges' as a scholarship in innovation. These opposing background disciplines between the participants present disagreement due to generalist knowledge rather than specialist knowledge for discipline content.

The research highlights the importance of purpose and context, which plays in technical activity as the association with human agency, determines the type of experience learnt and the material and environmental interconnections that may be valued. This paper asserts the empirically tested Technacy Genre Theory underpins conceptual and praxeological understanding of technology as a universal framework for all its forms. While the research uses Food Technology education as an example of a contested field of knowledge, the ideas and methods presented in this research make a case to be transferrable to other forms of contested technology knowledge and practice.

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Measuring Pupils' Design Skills in Primary Science and Technology Education

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ABSTRACT
This study is part of the Dutch Curious Minds research programme that aims at providing an evidence-based and usable framework for improving the quality of science and technology reasoning and skills of 2 to 14-year-old children in the Netherlands (Van Geert, 2012). The Curious Minds programme is carried out at seven universities, each with a different focus (e.g., neurocognition, perceptual learning and development, language acquisition). This paper focuses on monitoring the development of design skills in the context of a school system that does not clearly distinguish between science and technology, or design and inquiry. In this context, an observation instrument has been developed that primary teachers can use to monitor and evaluate the skills of their pupils for inquiry and design (Authors, 2012). We present the general psychometric qualities and applicability in the teaching practice at eight schools of the first version of this instrument. In the discussion, we concentrate on the question whether design skills, which find their rationale in technology and engineering practices, can be taught and evaluated in combination or integration with inquiry skills, which are more closely connected to understanding and practicing natural science.

Keywords: Technology education, Design skills, Assessment

CONTEXT
Many countries stress the need for a greater number of students pursuing training and careers in design and technology in order to keep their economies at a competitive level. All countries need citizens that are informed and well educated in all the STEM disciplines (science, technology, engineering and mathematics) and hence are able to make wise decisions with respect to the consequences for society of old and new technologies in relation to the inevitable trade-offs (Carter, 2007; NRC, 2011b). STEM learning, which comprises both the development of professional technological competences and general technological literacy, begins directly from birth, when children start perceiving their surroundings and explore what it affords them to do (Smith & Gasser, 2005). Pre-school and primary education can and should build on this natural curiosity before it is too late: "…pupils' attitudes towards science are mainly set at an early age in primary education. […]. The Yr 2 pupils' (age 6-7) enthusiasm for their science lessons diminishes as they proceed through primary school meaning that some pupils reach secondary school feeling hostile towards science. The results for pupils in Yr 6 (age 10-11) showed that, for the majority of pupils, attitudes towards science are already fixed" (Turner & Ireson, 2010). In this citation the focus is on science and we may well wonder whether the

conclusion also holds for design and technology. The research interest in science education has always been greater than the interest in technology education. From the point of view of the needs of society this is surprising, since the economy needs vastly more technicians than scientists. Moreover, in daily life, many people accept the constraints of nature while overtly struggling with technological artefacts and processes. Also, democratic decisions may pertain to nanotechnology but not to gravity or erosion. One expects education therefore to prepare children for living and working in this technological world. In this respect, the development towards STEM education that many countries seem to make is sensible. For example, the United States of America's *Framework for K-12 Science Education* (NRC, 2011a) uses 'scientific and engineering practices' as a key organizing dimension and puts science and engineering more on a par. The STEM disciplines science, technology, engineering and mathematics have much in common and may benefit from an integrated, inclusive approach. According to this Framework, "the goal of engineering design is a systematic approach to solving engineering problems that is based on scientific knowledge and models of the material world". This definition contains an important caveat. The tacit presumption could be that design, one way or other, is applied science, and that problem solving in design and technology is more or less the same as answering research questions in science. The relation between science and technology, however, is richer and more complicated. Many scholars stress that technological knowledge and engineering and design practices have their own identity and cannot be reduced to science (cf. Mitcham, 1994; Arthur, 2009).

At the level of primary science and technology, several countries (e.g., England, Australia) have a curriculum with two school subjects (e.g., science versus design & technology). In such a context, design skills can, at least in theory, be developed without interference from the teaching of science and inquiry skills. In other countries, a high level of integration is common. Teachers in these countries may not feel the need to reflect on the nature of their assignments and the learning results, leaving it implicit whether they foster inquiry skills, design skills, both, or an amalgam.

In primary education in the Netherlands, science and technology have always been closely connected. Core objectives from both disciplines are grouped under the heading 'Nature and technology' and include 'The pupils learn to research materials and physical phenomena, including light, sound, electricity, power, magnetism, and temperature' and 'The pupils learn to design, realise and evaluate solutions for technical problems' (Ministerie van Onderwijs, Cultuur en Wetenschappen, 2006). The use of 'research' and 'design' in these core objectives suggest an inquiry and design oriented pedagogy. Indeed, this is widely advocated but rather sparingly put into practice (cf. De Vries, Van Keulen, Peters & Walma van der Molen, 2011). For example, the TIMSS 2011 investigation reveals that all countries except Norway do better on the index 'Teachers Emphasize Science Investigations'. In the Netherlands, only 5% of the pupils engage in inquiry based activities in at least half of the science lessons, whereas the international average is 40%. Total teaching time devoted to science in the Netherlands is 4%, according to TIMSS, with 10% as the international average. 13% of teachers never engage in hands-on activities whatsoever (Meelissen et al., 2012). It is not completely clear whether 'science' in TIMSS includes or excludes 'design & technology' but there is little reason to expect that primary teachers in the Netherlands emphasize design assignments any more than they emphasize science investigations, since national surveys (cf. Van Keulen & Walma van der Molen, 2009) indicate that teaching time devoted to technology is about one to two hours per month, on average, with an emphasis on instruction and 'making'. One can expect that only a minority of teachers teaches design full circle, starting with a technical problem and ending with an explicit evaluation whether the problem has been solved.

An explanation for this rather bleak picture is that there is little incentive for primary teachers to engage in science or technology. Despite the fact that there are core objectives to be attained, national tests do not assess these, and quality control bodies also largely ignore the domain. The focus is almost exclusively on literacy and numericy. Moreover, many teachers have little knowledge of science and technology and low self-efficacy with regard to teaching it. Furthermore, judging the quality of design education requires shared and explicit standards and the availability of instruments to determine learning outcomes. This is not just the case in the Netherlands: the National Research Council (2011b) stresses the difficulty of identifying successful STEM approaches because shared constructs on all levels are lacking (also cf. National Academy of Engineering, 2010). When we expect teachers to provide their pupils with informative feedback on their skills for various aspects of design and technology, we have to provide teachers with such standards and instruments.

METHODOLOGY

In this study, we investigate the psychometric qualities and the applicability in normal teaching practice of the 'Skills Monitor Inquiry & Design' (SMID). The SMID is a six scales and 16-item observation instrument based on the steps of the empirical cycles that are used in investigation and design. It has been developed on assignment of the Dutch government funded Science & Technology Platform by Authors (2012) in cooperation with a national group of experts who safeguarded both the content validity from the viewpoints of science and technology and the applicability by primary teachers. The developers chose to integrate inquiry skills and design skills in one instrument with six scales, arguing that there are more similarities than differences between the steps in inquiry and the steps in design (cf. Roth, 2001). Also, teachers will not wish to use two very similar instruments to monitor and assess two very similar sets of skills. The scales coincide with the steps and are called wondering (1), translating (2), gathering (3), processing (4), interpreting (5), and presenting (6). Each scale has two or three items that are to be scored by teachers for individual pupils, e.g., 'explores the problem (1), 'carries out a design' (3) or 'accounts for the results' (6). Also included are four affective dispositions ('pleasure', 'system', 'fairness' and 'imagination') and some space for qualitative remarks. The SMID comes with a 23-page guidebook that explains scoring and provides examples and alternative formulations for each scale and item, in order to do justice to both inquiry and design. For example, item 1, 'asks a question', could also be 'poses a problem'. See Appendix 1 for the full instrument.

The SMID focuses on skills that are developed in lessons or projects during a longer period of time. Reflecting on their pupils and their performance throughout science and technology activities, teachers can use the SMID two or three times each year in order to provide pupils and their parents with specific and content rich feedback and to enable improvements to assignments, pedagogy and/or facilities in case certain scores would fail to meet expectations or pre-set criteria. The insights gained from the SMID, in time, should help schools and parents to give pupils a more fitting, more objective and more content-laden advice on decisions pertaining to secondary school and future career possibilities.

The SMID was tested in eight schools considered to be (relatively) outstanding with regard to teaching science and technology. Most schools participated in the Curious Mind programme. Teachers were instructed and asked to score the skills for inquiry and design for their pupils using the instrument. The scores were quantitatively analysed and interpreted using SPSS to determine reliability (internal consistency) and M*plus* to run a confirmative factor analysis. We used *Mplus* to test whether the items of the SMID pertain to one factor (to be labeled skills for inquiry and design) or six factors (corresponding to the six steps of the cycle for inquiry and design).

Afterwards, teachers were interviewed to investigate the applicability of the instrument in practice, to harvest suggestions for improvement, to gain more insight into the various classroom practices with regard to teaching science and technology, and to discuss the results, such as differences between scores for certain steps or differences between girls and boys.

RESULTS

The results pertain to 22 teachers of eight different primary schools who scored 243 pupils, aged 6 to 12 years old. The full psychometric analysis is reported in Authors (2013). The mean scores and reliability data are presented in Table 1. Scoring options for each item were 0, 1 or 2 and these were aggregated and normalised to a range from 0 to 6. Normalising was necessary because four scales have three items whereas two scales have only two items. Overall reliability was high (Cronbach's *alpha* = 0.94). The reliability of the individual scales was also sufficient, although a bit low for 'gathering'. The average inter-item correlation was .53 (should be higher than .3), indicating a high internal consistency and high coherence between the items.

Table 1: Mean scores and reliability

Scale	***k***	***N***	**Min**	**Max**	***M***	***SD***	***SS***	***Alpha***
Wondering	3	243	0	6	4.34	1.70	.11	.81
Translating	3	242	0	6	3.81	1.76	.11	.76
Gathering	3	238	0	6	4.31	1.50	.10	.67
Processing	2	243	0	6	2.44	1.27	.08	.81
Interpreting	2	242	0	6	2.50	1.28	.08	.73
Presenting	3	241	0	6	3.85	1.90	.12	.88

Exploratory factor analysis with SPSS indicated that the scales cohere (all item-rest correlations are higher than .5) and appear to pertain to one construct, which could be labeled 'skill for inquiry and design'. We further analysed this 'one-factor' model of one scale with sixteem items in a confirmative factor analysis with M*plus*. The resulting fit was sufficient but not excellent ($\chi 2(101) = 215.55$, $p < .001$, CFI = 0.93, TLI = 0.92, RSMEA = .069, SRMR = .05). The six-factor model, with the six scales of the SMID as the factors had a better fit ($\chi 2(87) = 174.30$, $p < .001$, CFI = 0.95, TLI = 0.94, RSMEA = .065, SRMR = .04).

We interviewed most of the participating teachers with a semi-structured set of questions. All teachers had a positive attitude towards teaching science and technology but they and their schools differed widely in experience, knowledge of science and technology, pedagogy, facilities and the topics they teach. Notwithstanding these differences, the teachers in this pilot found the instrument very helpful, especially for focusing on what their pupils actually do and say (or not) during inquiry and design activities and for giving precise feedback to pupils. In their opinion, the instrument combines very well with the empirical cycle of doing investigations and designing solutions to problems. It stimulates reflection and improvements: several teachers stated that using the instrument made them aware that not all steps in de empirical cycle received sufficient explicit attention and they were going to act on this.

The major and obvious disadvantage noted was that observing and scoring is rather more time consuming than just organising and supervising the activities. One has to concentrate on each pupil and reflect on behaviours this pupil showed for the past period of time from 16 different perspectives. Even when teachers have developed experience and routine (which was of course not yet the case during the pilot), scoring takes several minutes per pupil, which adds to the already considerable adminstrative load of teachers.

Several suggestions for improvement of the instrument were made. Many teachers, for example, remarked that the items were rather difficult to interpret because of their abstract character. What exactly counts as 'demarcates the question/goal'? Another important suggestion was to replace the scoring options ('hardly'-'sometimes'-'often') with rubric-like categories, in order to help teacher provide content-rich feedback, and to stress the quality instead of the quantity of pupils' performance.

CONCLUSIONS

In many respects, the instrument fulfilled the expectations. The psychometric qualities are highly satisfactory. The existence of the six different skills that are presumed to explain performance with regard to inquiry and design is supported by the empirical data, and the teachers in our pilot were able to use the instrument as it was intended. Moreover, although teachers quite rightly noticed that scoring takes time, the instrument is applicable in practice and may very well have a positive impact on teaching and learning, since it provides teachers with detailed formative feedback information. Of all teaching strategies, providing such feedback has one of the highest effects on learning (Hattie, 2007). Feasible ways for further improvement of the instrument have been indicated. On the basis of this study, a large scale introduction of a second version of the instrument as a longitudinal monitor of inquiry and design skills seems justified.

DISCUSSION

In the introduction of this paper, we sketched the context in which the instrument is applied, that is, in a school system that does not overtly discriminate between inquiry and design. The instrument fits well into this system, providing teachers with one, instead of two, observation and feedback instrument. The question now is whether observation, scoring and feedback pertain to inquiry, to design, to both, or to an amalgam ('inquiry & design skill').

We had selected the schools on the basis of their reputation with regard to teaching science and technology, and had expected all schools to bring an inquiry and/or design oriented pedagogy into practice. However, one school's assignments clearly were instruction driven and hardly had pupils clarify the problem or generate design specifications. Consequently, teachers of this school experienced difficulties in scoring their pupils on scales like 'wondering' and 'translating'. This is an important lesson. When using the SMID in schools where teachers instruct instead of activate, facilitate and help pupils to reflect and explicate what they have learned, results may be artificial.

We also noticed that most schools' assignments which more or less explicitly followed an empirical cycle were inquiry oriented rather than design oriented. Or rather, there seems to be a tendency to devote the minds-on part of assigments on explaining how things work. Questions like 'How does this work?' and 'How can we explain and understand this?' apparantly impose themselves with more force than questions like 'How can we make this?' or 'How can we make things better?' Consequently, the observed behaviour that led to the SMID scores seem to have been inquiry behaviour rather than design behaviour. It is quite revealing that Cronbach's alpha was lowest for scale 3 ('gathering') in which one item most clearly discriminated between inquiry and design ('carries out an experiment or design'). This was the item teachers found most difficult to assess reliably, and this makes sense when 'designing a solution to a problem' (technology and engineering) is essentially different from 'suggesting an experiment to answer a research question' (scientific inquiry). Not all top professional designers are also excellent natural scientists and vice versa, and this may as well hold for pupils in primary school.

Further research will have to shed more light on this issue. Integration of science and inquiry with design and technology has many advantages but when this means that the differences between answering research questions and solving technical prolbems are rendered implicit we run the risk that we provide pupils with partial and biased feedback on their real talents for design.

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Politicizing the Discourse of Consumerism: Reflections on *the Story of Stuff*

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ABSTRACT

This paper identifies the need for teachers and students to analyze and challenge the relationship between design, technology and consumption. Following a brief analysis of how children's consumer identities are discursively constructed by school curriculum, *The Story of Stuff* online video is showcased as an educational exemplar that mediates an entry into a cultural critique of technological products and systems. Key elements of this teaching resource are discussed with reference to existing literature that focuses on environmental and social issues. It is argued that to prepare an ethically and critically literate citizenry for the future, a more politicized form of technology education will be necessary.

Keywords: design and technology education, critical literacy, teaching resource

INTRODUCTION

In response to Sue McGregor's (2010) claim that a consumer culture requires a *political* consumer education, I submit that we also need to *politicize* design and technology education by developing learning experiences that encourage young people to critically analyze and question ecologically unsound processes of a market economy and in particular, the relationship between technology and consumerism (Elshof, 2005; Margolin, 1998; Petrina, 2000a). I locate my work within a critical practice perspective and stand with others who argue that conventional technological practices that narrowly address needs-wants issues can no longer be ethically justified and are therefore inadequate in terms of education for the future (e.g., Elshof, 2006, 2009; Huckle, 2010; Keirl, 2006, 2007; Petrina, 2000a). Like McGregor (2010), my utopian vision for the future is an education system that helps empower "citizens concerned with sustainability, solidarity, justice, peace, and the human condition" (p. 122). In this paper, I first reflect on Sandlin and McLaren's (2010) call for a "critical pedagogy of consumption" in relation to teaching for an ethical and critical literacy of the built world (Keirl, 2006; Petrina, 2000b). Next, I examine a small section of the Ontario school curriculum in an attempt to answer two questions: "What kind of consumers are being created?" and "In whose interests do those constructions work?" (Sandlin & McLaren, 2010, p. 15). Following this, I draw on key ideas put forth by these and other scholars to consider the merits of using Leonard's (2007a) video entitled *The Story of Stuff* as a teaching resource to problematize the discourse of production and consumption and to reorient design thinking for longer term prospects (Pilloton, 2009). My paper concludes by suggesting that the politicizing of discursive practices will be necessary to prepare informed, critical, and caring citizens for ecological and social good.

A CRITICAL PEDAGOGY OF CONSUMPTION

Viewing consumer education as critical practice, Sandlin and McLaren (2010) call on educators to push past the pedagogical frame of consumption with its acquire-use-dispose logic of products. They imagine school as a place of contestation where consumer capitalism is questioned, and consumer resistance works as a space of learning (see Denzin, 2001). Clover and Shaw (2010) also wish to interrupt the dictates of a consumer ideology that are tied to notions of "free and abundant choice of goods" as symbols of "freedom, affluence, and the good life" (p. 204). Similar critiques have been leveled by Elshof (2005, 2006) and Petrina (2000a, 2000b), who argue that technology education with a cultural studies perspective can play a key role in exploring how the making of artefacts and consumption-driven lifestyles contribute to the sustainability problem. A "critical ethical consciousness" that explores the intention, use and consequences of design activity is essential to democratic practice according to Keirl (2006), who advocates for an ethical technological literacy as the keystone for curriculum that values and serves democratic interests.

WHAT KIND OF CONSUMER IS BEING CREATED AND IN WHOSE INTERESTS?

It has been noted by many critics (e.g., Foster, 2002; Molnar, et al., 2010; Schor, 2004) that commercial advertising promoting the consumption of goods and services has saturated our cultural, economic, and social worlds. Indeed, learning to consume has been "one of the deepest and most pervasive educative processes at work since the Second World War" (Clover & Shaw, 2010, p. 203). Neoliberal notions about individual choice "celebrate the singularities of individuals by valorizing the desire to obtain and consume objects of pleasure" (Clover & Shaw, 2010, p. 206). Conversely, when companies are caught destroying the planet or other people, the consumer is blamed for demanding cheap products. In an online article about consumer guilt, activist Annie Leonard (2012) wrote, "Whether it's electronics from unsafe factories, clothes from oppressive sweatshops or coffee from the rainforest, we blame ourselves and our fellow consumers for our complicity in an unjust and unsustainable system" (n.p.). In answer to Sandlin and McLaren's (2010) question about what kind of consumers are being created, it might seem that we are apolitical and dupable pleasure-seekers who can be manipulated into thinking we need the goods and services we are offered. This may be an oversimplification but it behooves us to consider in whose interests such constructions work.

One of the assumptions operating in our hypercapitalist world is that individuals are free to choose from a range of goods and services. Contrary to the misguided notion that "the right to choose from a menu is the essence of liberty", Barber (2007) argues that "the real power, and hence the real freedom, is in the determination of what's on the menu. The powerful are those who set the agenda, not those who choose from the alternatives it offers" (p. 139). Herein lies an answer to Sandlin and McLaren's (2010, p. 15) second question: "In whose interests are consumers constructed?" Considering that the proliferation of choices creates profitable niche markets, it would seem that acts of consumption primarily serve the economic interests of the corporations.

CONSTRUCTING CONSUMER IDENTITY THROUGH CURRICULUM

Children are socialized into their consumer identities through advertising, marketing, and television shows (Denzin, 2001; Foster, 2002; Giroux, 1999; Petrina, 2000a;). Consumer behaviour, identity, and consciousness are also constructed in schools (Elshof, 2006, 2009; Schor, 2004). In part, I would argue this work is achieved through school curriculum. For example, a number of considerations underpinning the fundamental concepts of sustainability and stewardship are identified in this excerpt of Ontario's science and technology education mandate: By the end of Grade 7 [year 7], students will:

> 1.1 evaluate the importance for individuals, society, the economy, and the environment of factors that should be considered in designing and building structures and devices to meet specific needs (e.g., *function; efficiency; ease of use; user preferences; aesthetics; cost; intended lifespan; effect on the environment; safety, health, legal requirements*). (MoE, 2007, p. 130; italics in original)

In subsequent guiding questions, however, this well-intentioned and ecocentric focus takes a market-driven turn: "Why is it <u>important for companies to find out what consumers want</u> now and what they might want and/or need in the future?" (MoE, 2007, p. 130; emphasis added). It could be argued that the question prioritizes the perspective of companies over that of consumers (as product users). From a critical practice perspective, other equally important questions could be: "What are some of the ways companies externalize their costs of production?" and "Why is it necessary for consumers to pay the true cost of a product?" Another question in the document focuses on environmental impact:

> What things might a company need to take into account when considering the construction of a new structure that consumers might not consider (e.g., the environmental impact of using certain resources to make the structure, the eventual disposal of the structure)? (MoE, 2007, p. 130; emphasis added)

The suggestion that "*consumers might not consider*" resource and waste management issues effectively positions commercial business as sole decision-maker. One might wonder why industrial designers, engineers, employees—even citizens—are excluded from this process. This simplistic division between business and consumer offers no place in which students can actively participate, although it is probably more likely that twelve-year-olds would identify themselves as having consumer interests, than to have corporate interests. Still, what is lacking is reciprocal accountability to offset the company perspective. Why not ask, for instance, "What courses of action can consumers, workers, citizens and governments take to hold a company accountable for breaking environmental protection laws or safe labour practices?"

The opportunity for finding personal relevance is also missed when, in the basic concepts section of the curriculum, technocentric expectations focus on design and manufacturing processes. The document states,By the end of Grade 7, students will:

> 3.7 identify the factors *(e.g., properties of the material as they relate to the product, availability, costs of shipping, aesthetic appeal, disposal)* that determine the suitability of materials for use in manufacturing a product *(e.g., a running shoe).* (MoE, 2007, p.131; italics in original)

With the exception of product disposal, design decisions are presented as straight-forward and value-neutral. Strikingly absent are issues concerning fair trade and social justice, despite condemning reports by Petrina (2000a) and others:

> Most of the assembly is done through the labour of children and women cutting, gluing, and sewing under sweatshop conditions of high temperatures (100 degrees F) and toxic fumes from solvent-based toluene glues and paint. Their average wage is about 15 cents per hour over their 65 hour work week… (p. 217)

The removal of such social and cultural "factors" helps to keep the study safe from moral or ethical redress, and is one more instance where child-consumer identities are constructed as "future technologists rather than technologically capable critical thinking citizens" (Elshof, 2009, p. 138).

THE NEED FOR POLITICAL LITERACY

These excerpts substantiate Clover and Shaw's (2010) criticism that Canada's environmental education policy "ignores the politics of over-consumption and waste" and "[leaves] corporations to carry out their activities unencumbered by critique or challenge from a politicized public" (p. 203). They argue that social change can be achieved by working and learning collectively through an arts-based environmental education practice to "[enhance] people's abilities to challenge processes and practices that marginalize and disempower" (Clover & Shaw, 2010, p. 207). A similar call to action comes from Huckle (2010), who encourages teachers and learners to engage productively in public debate and protest. Accordingly, he advocates for a more critical form of Education for Sustainable Development—

linked with global citizenship education—to "foster the values, knowledge, skills and competences required by citizens who are capable of critically assessing arguments and policy prescriptions from across the political spectrum, and acting on those they personally and collectively find to be most rationally and ethically defensible" (Huckle, 2010, p. 140).

A CREATIVE AND CRITICAL TEACHING RESOURCE

Despite our current ecological crisis, I am not aware of many high quality teaching resources that address technology-related issues from a critical practice perspective. In my view, the *Story of Stuff,* as a case study of the materials economy, offers a positive and engaging alternative to what Clover and Shaw (2010) describe as less effective "expository and didactic" approaches that tend to focus on "awareness-raising through information sharing from 'experts'" (p. 206).

Leonard's (2007a) short and fast-paced cartoon animation is an edgy anti-capitalist critique of problems inherent in the linear production-consumption-disposal thinking in American consumer culture. Sophisticated and creative use of visual metaphors help to explain social and psychological concepts related to the design and marketing of everyday products. Leonard deconstructs the discourse of consumption by describing a "system in crisis"—exploitation and over-consumption of the world's resources, the use of toxic chemicals in manufacturing, externalized costs of production for profit, planned and perceived obsolescence, and the unsustainable cradle-to-grave approach to waste management. What follows are seven screenshots that will illustrate how, in my view, critical literacy is fostered. These images are used with permission from *The Story of Stuff Project.*

A CRITIQUE OF HYPERCONSUMERISM

Figure 1 shows a person caught in a "work-watch-spend treadmill" (Leonard, 2007b, p. 13). This clever visual metaphor depicts a perpetual cycle of consumption driven by the desire to seek happiness through the accumulation of products. The image ties in remarkably well with Schnaiberg's (1980) concept of the "treadmill of production", along with Foster's (2002) characterization of the system as a "giant squirrel cage" (p.45) and Huckle's (2010) "capitalist treadmill….[that] manufactures consumer wants in a way that creates an insatiable appetite for more" (pp. 136-7).

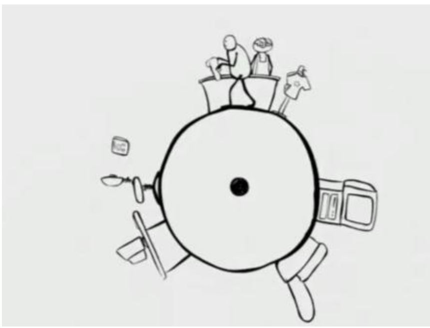

Figure 1. Work-watch-spend treadmill. [screenshot taken from The Story of Stuff video]. Retrieved July 22, 2013

DESIGN'S ROLE IN PRODUCT OBSOLESCENCE

Leonard (2007a) succinctly captures deliberate obsolescence with the clever alliteration "designed for the dump" (see *Figure 2*). By the 1950's, "forced consumerism was extolled by the markets as a must: things had to be consumed, burned, used, replaced and discarded at a constantly accelerating pace" (Lahaye, 1995, p. 60). In *Made to Break: Technology and Obsolescence in America*, Slade (2006) traces the history of product design and the underlying profit motive for technological, psychological, and planned obsolescence. Noting how unapologetically open industrial designers like Brooks Stevens were in those years about the underlying profit motive (see Adamson, 2003),

Figure 2. "Designed for the dump" (Leonard, 2007a). [screenshot taken from The Story of Stuff video]. Retrieved July 22, 2013

Slade (2006) states, "Not only did we invent disposable products, ranging from diapers to cameras to contact lenses, but we invented the very concept of disposability itself, as a necessary precursor to our rejection of tradition and our promotion of progress and change" (pp. 3-4). (see *Figures 3* and *4*).

It is my observation that many 12-year-olds' level of understanding of the materials economy goes only as far as thinking that cheap things usually break because they are cheap and they, as consumers, are the victims of a *rip-off*. *The Story of Stuff* reveals that they are not the only 'victims.' The reason why many products are so inexpensive is that the true costs are "externalized," meaning that other people are "paying" through poor wages, dangerous working conditions (see *Figure 5*), and the destruction of their local environment. The exploitation of others struck a chord with some of my students who thought that people should be paid fairly for their labour and their health should not be endangered (Wilkinson & Bencze, forthcoming).

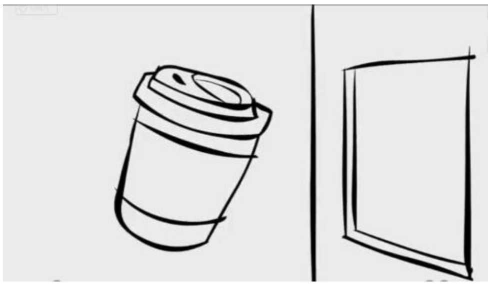

Figure 3. Products are designed to be useless as quickly as possible (Leonard, 2007a). [screenshot taken from The Story of Stuff video]. Retrieved July 22, 2013

Figure 4. The profit motive underlies deliberate obsolescence and the promotion of progress and change. (Leonard, 2007a). [screenshot taken from The Story of Stuff video]. Retrieved July 22, 2013

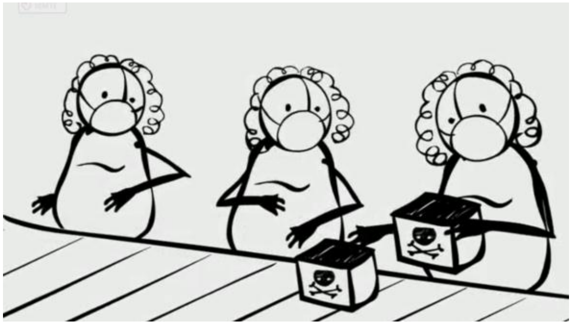

Figure 5. Factory workers of reproductive age are exposed to many toxic chemicals. (Leonard, 2007a). [screenshot taken from The Story of Stuff video]. Retrieved July 22, 2013

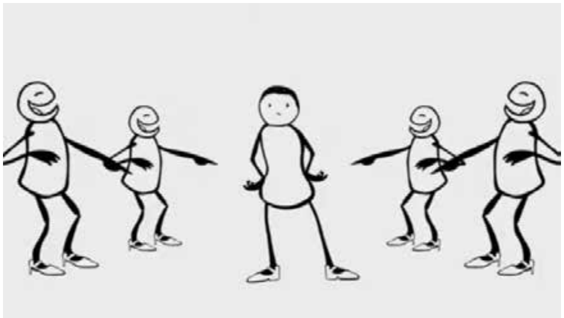

Figure 6. In our capitalist system, "if you don't own or buy a lot of stuff, you don't have value" (Leonard, 2007b, p. 4). Fashion designers are implicated in the making of desire, mass production and hyperconsumption of commodities. [screenshot taken from The Story of Stuff video]. Retrieved July 22, 2013

It might be argued that as a form of critical pedagogy, *The Story of Stuff* remediates the invisible processes of production and consumption. Young people are often surprised and perturbed to learn of the possibility that products are deliberately designed to break. Another revelation is the issue of *perceived* obsolescence (i.e., things that still work are no longer desirable). The video depicts scenarios in which new things are acquired to either establish one's social status, or to avoid shame (see *Figure 6*). In general, middle- and upper middle-class children are quite aware of the rapid turnover of electronic gadgets and clothing, and they readily admit having desires for the newest models and stylish fashions in order to either fit in or to be envied. Conspicuous consumption, as noted by Slade (2006), is in part manipulated by advertisers who psychologically target people's anxiety and "desire not to lose face" (p. 51).

A CALL TO ACTION

Figure 7. True recycling. Closed loop production seeks to eliminate natural resource input and waste output (Leonard, 2007b, p. 15). [screenshot taken from The Story of Stuff video]

Pronouncing that even our existing recycling practices are unsustainable, Leonard (2007b, p. 15) concludes with an open-ended call for "a new school of thinking" and collective action based on, among other solutions, a systemic approach to closed loop production (see *Figure 7*). In effect, viewers are addressed—not as compliant shoppers—but as capable agents of change. As a pedagogical model, the video is instructive because it avoids the pitfalls of what Clover and Shaw (2010) identify as the "stifling, limited, and pedantic aspects of so much environmental education" (pp. 206-207). Leonard (2007a) establishes and maintains her 'ordinary' citizen consumer status (as an iPod™ owner) and sidesteps the higher status generally attributed to experts. Rather than *The Story* ending, she invites her viewers to join in and "create something new" (Leonard, 2007b, p. 16).

The ability to act on ethically defensible issues is what Huckle (2010) considers a competence required by global citizens. I think Sandlin and McLaren (2010) would applaud the way in which *The Story of Stuff* locates human experience "within specific social relations of production" (p. 14). Leonard (2007b) achieves this by tracing back through the life of a portable radio from the shelf of a big box store, through the hands of a minimum wage cashier, shelf stocker, transport driver, ocean freight handler, "some 15 year old in a maquiladora [factory] in Mexico," and "the kids in parts of the Congo …[who] have had to drop out of school to mine coltan" (p. 8). Granted, it can be argued that simply watching this video does not make students active citizens, or designers, or activists. But an examination of social and material dimensions of production can potentially increase awareness about one's own role and is therefore, I contend, a good starting point for reflexive thinking about taking more informed and ethical action to address complex problems of inequality and injustice. As Elshof (2009) prudently reasons:

> Although young people are not responsible for designing or creating the technological systems within which they live, they are nonetheless active participants in its evolution. Long before they have become technologically literate, they are active as young citizen consumers. In this sense they do become co-creators of the world and technology education can help them understand why they must begin to share responsibility for its care. (p. 138)

IMPLICATIONS FOR TECHNOLOGY EDUCATION: POLICY AND PRACTICE

With the ecological health of our planet in jeopardy, our western "throwaway ethic" (Slade, 2006, p. 281) is no longer sustainable. Countries like Canada and the United States—which create the largest ecological and carbon footprints on the planet—have the added responsibility to encourage learners "to think and act differently in terms of the ways they use, consume and design technologies" (Elshof, 2009, p. 134). While the latest revisions in the Ontario curriculum are encouraging, I am troubled by the prevailing ideological discourse of neoliberalism that continues to prioritize values of individualism and economic competitiveness. More than a decade ago, Petrina (2000a) argued for a "political ecology of design" whereby ecological values of care, complex life cycles, and interconnectedness work in tandem with "political values such as control, distribution, equity, interests, justice, liberty, and power" (p. 218). Sadly, as the horrific deaths of more than 1100 Bangladeshi garment workers this past April stingingly remind us, a different type of critical education is still needed to problematise the interrelations between hyperconsumption and what Kelly (1994) describes as "issues of economic justice—the exploitation of the poor by the rich" (cited in Foster, 2002, p. 49).

Teachers carry out important policy work in daily pedagogical practice (Ozga, 2000). By appropriating powerful communication techniques that marketers and advertisers employ so well to socialize consumer identities (Denzin, 2001; Giroux, 1999; Petrina, 2000a), I propose that educators can politicize the discourse of production and consumption and help young people explore "reformist and radical social alternatives" (Huckle, 2010, p. 141). Instead of creating consumers, we create consumer advocates and cultural critics (Denzin, 2001). Instead of reproducing a mindset for designing *objects* as solutions, we reorient design thinking as an ethical solution-building process for "social good" (Chochinov, 2009, p. 8) that may not even create more products (Keirl, 2007; Pilloton, 2009). And instead of preparing future technologists, we prepare technologically literate citizens who will question and challenge "our *existing* technologies, systems and worldviews that contribute to the global environmental crisis" (Elshof, 2009, p. 142).

CONCLUDING REMARKS

As Keirl (2007) points out, it is through purposeful critique that students develop their voices "as would-be democratic citizens" (p. 310). I think there is much to learn from resources like *The Story of Stuff* in which alliterative, metaphoric, and visual forms are cleverly utilized to acquaint viewers with a language that embodies a critical discourse, models purposeful critiquing of cultural patterns of material consumption, and stimulates ethical design thinking with a care-driven sensibility for ecological and social justice (see Noddings, 2010). Perhaps it is Leonard's creative use of animation and humour—along with her message that we are all implicated—that helps to inspire and motivate people to search for better solutions. For what it's worth, my students' promising responses keep me hopeful about the future—just as the work of education scholars strengthens my resolve to advocate for a politicized form of design and technology education.

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Collaborations in Cyber-Space: Using Wikis as Group Presentation and Assessment Tools

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ABSTRACT

Wikis are websites where users are able to add, amend or delete content. Text, video, music, pictures or other Web 2.0 tools can be embedded in the wiki to allow the students to demonstrate their learning in a way that they choose. Wikis can be used as a virtual learning space for students to work collaboratively on a presentation while allowing the work to be carried out individually at a time and place that suits each student. While the initial setting up of groups and dividing the work amongst the group's participants is easier to do face-to-face, the students do not have the need to come back together as a group until they are ready to rehearse their presentation. All of the group members have access to the wiki and are able to see the progress and contributions of each member, ask questions, and provide feedback.

This paper reports on the experiences of two technology education lecturers using wikis as assessment tools for collaborative group assignments with students in the final year of their initial teacher education programme. Specifically, we identify the aspects of using the wikis that enabled or constrained the students and the lecturers in the process.

While this paper is based on the experience of using wikis as a form of assessment in an initial teacher education programme, with caution, this way of using wikis could be used in other contexts. However, the questions that need to be considered before embarking on using this tool for assessment are: 1) to what extent are teachers adequately placed to confront the challenges of learning about new spaces, tools and pedagogies; 2) how do we ensure that the (cyber) spaces of learning become places of learning; 3) what is the relationship between physical and virtual spaces in relation to learning; and, 4) what is the place of assessment in learning and teaching.

Keywords: Wikis, assessment, technology, collaboration

INTRODUCTION

The use of digital technologies in teaching and learning is becoming more prevalent. The number of users of Web 2.0 tools, has markedly increased which has led to new innovations being developed (Deters, Cuthrell, & Stapleton, 2010). A natural extension of this is for assessments to be able to be done digitally. Bruns and Humphreys (2005) state that there is a "move towards social constructivist pedagogical models in education which employ social and collaborative project-based strategies for teaching and learning" (p.25). The introduction and use of this technology in classroom teaching and learning programmes provides new and diverse ways for students to present their learning and to work collaboratively with others. Using wikis for assessment provides these opportunities for students as well as "a mechanism for faculty members to assess student learning" (Eddy and Lawrence, 2013, p.254).

As initial teacher educators, we need to provide opportunities in our courses that develop our students' capabilities in using a range of technologies as well as the ability to construct (and co-construct) new knowledge and present their understanding of content within collaborative environments (Bruns & Humpheys, 2005; Deters, Cuthrell, & Stapleton, 2010). Wikis are one such tool that allows students to co-construct and communicate their knowledge (Bruns & Humphreys, 2005).

Caple and Bogle (2013) state "the group assessment task is a fraught yet increasingly popular, indeed necessary, method of undergraduate assessment (p.198). The advantage of using group assessment to lecturers is the reduction in the amount of marking. However, there are concerns raised as to how the assignment will be assessed to reflect individual as well as group efforts and the commitment of time to the collaborative process. (Caple and Bogle, 2013).

This paper focuses on the use of the wiki as a group presentation and assessment tool. First, we consider wikis in the context of social constructivist pedagogy, before focusing on the aspects of wikis that enable or constrain students and lecturers. Next, we outline a collaborative group assessment task from a final year course in an initial teacher education programme. Finally, we discuss and summarise the knowledge gained from this experience.

SOCIAL CONSTRUCTIVIST PEDAGOGY

There has been a continual move in tertiary education to improve the strategies and methods used to increase the depth of student engagement and learning. A paradigm shift in educational thinking has seen a move from the traditional behaviourist approaches, such as lecture-based activities, to more social constructivist views where students are given the means and opportunities to construct their knowledge. Group work is seen as one of these student-centred methods as it provides opportunities "to develop new skills through interaction with their peers" (Witney & Smallbone, 2011, p.102).

In student-centred methods, students have a voice in the directions and outcomes of the learning. However, the role of lecturers in this process is still seen as crucial. The introduction of inquiry-based assessment tasks and the provision of the tools and opportunities for students to engage in collaborative group activities can be a more demanding process for the lecturer than traditional modes of delivery (Bruns & Humphreys, 2005; Witney & Smallbone, 2011). The overall aim of adopting social constructivist pedagogy is to encourage students to problem-solve, increase their conceptual understanding, and acquire knowledge. Bruns & Humphreys (2005) put forward that social constructivist methods need to have the following three characteristics: 1) realistic problems/issues and authentic contexts; 2) use of group collaboration, interaction and cooperation; and, 3) learners take responsibility for their own learning while lecturers provide guidance.

"Constructivism sees knowledge as well as meaning as being constructed rather than given" (Parker & Chao, 2007, p. 58). Constructivism is a means of describing how learning happens. The learner constructs knowledge through interaction and collaboration with others on activities, building on prior learning. They are able to review and critique the work of others while receiving feedback on their own work. Parker & Chao (2007) argue "collaborative learning becomes even more powerful when it takes place in the context of a community of practice" (p. 58).

As teachers, it is our responsibility to help prepare our students for successful participation in these social constructivist practices of creating knowledge. If students are expected to collaborate, be creative, and construct knowledge, tertiary institutions need to design curriculums and model environments that allow students to experience these practices with support and guidance from their lecturers. Bruns & Humphreys (2005) posit "wikis present themselves as an interesting tool for enhancing social constructivist learning environments (p.27).

WIKIS AS ASSESSMENT TOOLS

Wikis are one of the many Web 2.0 tools that facilitate collaborative work and provide a context for new forms of group work (Lai & Ng, 2011; Witney & Smallbone, 2011). Invented in mid-1990s, wikis were developed as a tool that allowed for collaborative work to take place in one online space. Wikis are accessed using a web browser and are able to be reviewed and edited by multiple authors (Deeters, Cuthrell, & Stapleton, 2010); Eddy & Lawrence, 2013; Witney & Smallbone, 2011).

The aspects of using the wiki that enable students and lecturers include:

- being used as a virtual learning space for students to work collaboratively on a assignment while allowing the work to be carried out individually at a time and place that suits each student (Lai & Ng, 2011; Witney & Smallbone, 2011);
- all of the group members have equal access to the wiki and are able to see the progress and contributions of each member, ask questions, and provide feedback (Benson et al., 2012);
- working and learning in a wiki environment is developing technical literacy (Bruns & Humphreys, 2005);
- development of and support for an online learning community (Deeters, Cuthrell, & Stapleton, 2010).
- being always available for further discussion, refinement, or alteration. “The state of knowledge on a wiki is always dynamic” (Bruns & Humphreys, 2005, p.28).

Bruns & Humphreys (2005) suggest that “social interaction can be a rich source of learning” (p.28). The interaction between group members working on a collaborative assignment has the potential to provide more powerful learning experiences than those between one student and the lecturer.

As well as the positive aspects, there are also constraints and challenges in using wikis for group assessment tasks. These include:

- challenges in keeping track of each student’s contributions (UNSW);
- technical issues or the capabilities of the specific wiki site (Deeters, Cuthrell, & Stapleton, 2010);
- time constraints;
- lack of teachers’ [and students] experience with Web 2.0 technology; (Deeters, Cuthrell, & Stapleton, 2010, p.130);
- students who do not contribute equally, but receive credit for the overall work of the group; (Witney & Smallbone, 2011);
- grade inflation – “where group assessments means less able students get higher marks than they would individually” (Witney & Smallbone, 2011, p.102);
- the challenge of designing assessments that support and foster collaborative learning, while not hindering individual achievement (Witney & Smallbone, 2011);
- lack of professional development and support for academic staff support learning new practices for assessment (Eddy and Lawrence, 2013);
- students being reluctant to edit or amend other students’ work and resistant to having their own work to be interfered with (Bruns & Humphreys, 2005);

Viewing and participating in a wiki can be limited if the education system “insists on students producing individual projects and that assessment needs to be of individual work” (Bruns & Humphreys, 2005, p.28). This stance can reduce the collaborative group learning possibilities and construction of knowledge that wikis can provide (Bruns & Humphreys, 2005). However, the grading of a group assessment needs to be fair and reflect the contributions of the individual members as well as the group overall. According to Forment, De Pedro, Casan, Piguillem, and Galanis, (2012) any technology used for assessing group work "needs to provide a way to easily track and assess each student's individual contributions" (p.75)

Through collaboration and co-construction of knowledge, students contribute to each other's skill base and understanding. Wikis provide a means of collaborating on an assessment task that supports individuals' circumstances, location and time schedule. Learners are able to develop skills, make choices, and take responsibility for their own learning.

THE GROUP ASSESSMENT TASK

Assessments should support learning and provide formative feedback for students. Assessments need to be integrated into the teaching and learning programme with students given the opportunity to take on a role as co-assessors (Lai & Ng, 2011). Deeters, Cuthrell, & Stapleton (2010) put forward that "wikis can be used to encourage collaboration among students by allowing them to read and edit each other's work" (p.123). Working collaboratively on assignments should "encourage students to review each other's [work] and truly reflect on and critique what is being put together instead of just pasting separate components together" (Deeters, Cuthrell, & Stapleton, 2010, p.123).

During a final year primary teacher programme paper, students worked in small groups of three or four students to develop a wiki around a selection of tools and strategies that promoted critical thinking. The wiki was used as the means to share researched information, construct shared knowledge and understanding, and to present key content. This description of the use of the wiki reflects how Deeters, Cuthrell, & Stapleton (2010) viewed what wikis had to offer, "the wiki provided a place to store, organise and display evolving content as the students worked together to post, revise, edit and respond" (p.124).

Students were randomly allocated a thinking strategy/tool to explore and develop content on a wiki. In most cases each tutorial class had seven groups each researching a different thinking tool/strategy. These included:

- Bloom's Taxonomy;
- Tony Ryan's Thinkers Keys;
- Buzan's Mind Mapping;
- Art Costa's Habits of Mind;
- Biggs' Solo Taxonomy; and,
- Howard Gardener's Multiple Intelligences.
- Edward de Bono's Six Thinking Hats

Initially students were provided with a basic instructional tutorial using Wikispaces (www.wikispaces.com). The Wikispaces platform was chosen as a tool to work with due to its accessibility, frequent use by teachers and educators, potential levels of security (Caple and Bogle, 2013), and "ability to be immediately updated" (Deeters, Cuthrell, & Stapleton, 2010, p.123). In the initial tutorial, students were guided through the process of registering their wiki, setting up key pages, exploration of basic editing tools. If any additional support was required (usually to help problem solve technical issues), it was provided by the teaching staff on an appointment basis. The wikis were set up with a privacy setting that allowed only invited members to view their wiki. Most of the technical problems that students encountered were solved independently through the Wikispace online helpdesk or through student trial and error. Guidelines were provided in the course book as to what content should be included in the wiki and students were given a rubric that would be used to mark the wikis and the group's presentation. Students were encouraged to use and appropriately acknowledge online, book, research journal and other printed material sources to populate their wikispace. They needed to consider their target audience and the way material is shared in an online environment – a very different way of presenting material to other more traditional methods of assessment e.g. essay form.

Prior to submitting their final wiki assignment, students presented their wiki to the wider tutorial group. All group members needed to have an active role in presenting. Through presenting their work it allowed the rest of the tutorial group to gain an insight into further strategies that they then could adopt in their own future teaching programmes. On presentation of their wiki – group members completed a "Participation Agreement" where students indicated the percentage of work they had contributed to within this group assignment. All group members needed to sign and agree on the percentage and be clear about who had contributed to each component. This agreement allowed students to be rewarded for individual contribution within a broader group assignment. The assessment task was outlined in a way that helped students to frame the look of their wiki – this allowed the teaching team to provide a clear marking schedule that would enable consistency in marking each group within each tutorial across the entire paper. Assessment feedback was provided by both peers and teaching staff. During the presentation of each wiki, each group had an opportunity to provide peer feedback on another group's presentation. This feedback was included with the formal feedback provided by the teaching staff.

DISCUSSION

The group assessment task was to give the pre-service students an opportunity to work in a syndicate (team) environment that they will experience when they are teaching. Using wikis for the group assessment and presentation task allowed students to cooperate and collaborate, organise their time to suit their schedules, and allow them to develop their understanding of a critical thinking strategy/tool. While the students produced and presented wikis to a very high standard, the process was not without its challenges. These challenges included: time management; confidence and competence with using Wikispaces; contributions of group members; and, concern regarding assessment.

Time management was a challenge to the students: in regards to being able to find times to meet as a group and working on the assignment individually. The assessment task was introduced in week 2 of the course and they had four weeks to complete the task before presenting it during workshop sessions. The ability to access the wiki at anytime allowed the students to work at a time that suited their schedule. In most groups the students organised deadlines for individual contributions to the wiki to be uploaded so that other members could review and give feedback to each other. This also allowed the students to see what the overall look and feel of their wiki was like for the presentation (Caple & Bogle, 2013). Groups did physically meet to practice their presentation.

Students had varying experience with using Wikispaces. They were given initial instruction on using Wikispaces and set up their wikis in class to allow for support to be provided by the lecturers. Some students needed additional support to be comfortable with uploading their work and being satisfied with the look of the pages. This technical support needs to be factored in the sessions provided in undertaking this type of task (Caple & Bogle, 2013).

The contributions of individuals within the groups were another aspect that challenged the students. Not all students had the same level of motivation for completing the task or understanding of the material. While the majority of groups worked collaboratively to create an informative and polished final product, some groups worked in a more cooperative way with each group member uploading their individual part with little regard to how this fitted in with the rest of the assignment. Caple & Bogle (2013) refer to this as "the silo format" (p.206). Again, instruction on how to collaborate when using wiki technology is an aspect that students need to be given explicit instruction on.

The students expressed concerns regarding how the assignment would be assessed and how marks would be allocated to group members. Not all students were able to contribute to the same degree, either through other commitments or lack of understanding, while others chose to limit their contributions (Caple & Bogle, 2013). We tried to limit the impact on the marks allocated to students by having participation agreements for the groups to allocate percentage of contribution by individuals that was signed by all members of the group. Where there was a disagreement amongst members and it could not be resolved, the lecturers acted as mediators.

In designing this group assessment, our aim and expectation was that students would work collaboratively to complete the assigned task with support provided by the teaching staff. We also wanted our students to develop competence and skills in using a technology that could be utilised in their future classrooms. Deeters, Cuthrell, & Stapleton (2010) state "perceived strengths of wikis include their potential for collaboration, information dissemination, and application in elementary classrooms" (p.130). The use of wiki technology was deliberate as it provided a platform that allowed group members to collaborate, synchronously or asynchronously, while gaining a greater depth of understanding of the topic and producing a polished product. Our decision to use wikis for this assignment is supported by the research carried out by Deeters, Cuthrell, & Stapleton (2010); Eddy & Lawrence, 2013; and Judd, Kennedy & Cropper (2010).

SUMMARY

Benson et al. (2012) suggest, "the ability of Web 2.0 applications to support online group interaction offers important benefits for teaching and learning" (p.2). Wikis provide an online space where students to write, review, edit and construct knowledge collaboratively, taking more responsibility and control for their own learning. According to Caple & Bogle (2013) using wikis for group assessment is "a method of making the group work experience more enjoyable and worthwhile for students: one that is compatible with the learning process, their own lifestyles and other commitments that impact on their studies" (pp.207-208). By having students use wikis in their initial teacher education, it is hoped that with the skills gained they will utilise this or other Web 2.0 technology in their own classrooms.

When using wikis for group assessment purposes, the academic staff need to consider the challenges of time (amount of time given for the assignment and time management for students), students and their own skills with using the application, collaboration and contributions of group members, and assessment of work (Caple & Bogle, 2013; Deeters, Cuthrell, & Stapleton, 2010; Witney & Smallbone, 2011).

This sharing of the experiences of two technology educators "contributes to the more general need to explore ways to assist academic staff to use Web 2.0 applications" (Benson et al., 2012, p. 14) for assessment purposes. This way of using wikis as a form of assessment, with caution, could be used in other contexts. Making our experience public and available for peer-review, critique and discussion with others is our small contribution to the field of using ICTs for teaching and learning programmes.

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