LEARNING IN TECHNOLOGY EDUCATION

CHALLENGES FOR THE 21ST CENTURY

VOLUME TWO

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Foreword

Technology education might be a product of the 20th century, but the real challenges will be encountered during the 21st. Indeed it could be argued that the last decade of last century was concerned more about becoming aware of the nature and dimensions of the challenges rather than in formulating responses to them. This book draws on a wide range of perspectives to show how the development of technology education is proceeding and the role research is playing in both identifying the important questions and helping to shape the kinds of answers that might meet the needs of students, teachers and teacher educators.

Contributors to the book come from America, Australia, Canada, England, Germany, Hong Kong, Japan, New Zealand and Taiwan. The papers cover a wide range of contemporary issues and themes in technology education, including, information and communication technologies, pedagogy, philosophy, teacher education, cross curricular issues and approaches, primary technology education, assessment, developments and research methods. However, many papers could not be classified into single categories and displayed the richness of the interconnections between issues. The one overriding theme to emerge is nevertheless, the centrality of understanding the process by which students learn about and through technology.

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December, 2002

The Use of Information Technologies in the Teacher Training Course for Technology Education, Production of Digital Contents: "Australian Life and Culture"

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The new curriculum for technology education in the lower secondary schools in Japan began in April of this fiscal year (FY2002). It consists of two area contents; "Technology and Manufacturing" and "Information and Computer". For upper secondary schools, the new subject, "Information Technology" will be started for all students in FY2003. In terms of teacher training courses for technology education, the new curriculum for teacher training for lower secondary schools began in FY2000. On the other hand, the new curriculum for teacher training for upper secondary school began in FY2001. The course "Australian Life and Culture" was established about ten years ago in the Faculty of Education, Shiga University. Deakin University staffs have continued to contribute to the Australian Studies Program in Shiga University, by attending to present specialist lectures on a variety of topics. The range of lectures includes Australian geography, education, history, environmental studies and so on. Video recordings of these lectures are currently being used as the basis for some interactive CD-ROM/DVD and Internet based learning materials, which were developed, through completely non-linear editing of MPEG 2-level digital processing, by DCPP (Digital Contents Producing Project in Shiga University) which consists of university stuffs and students. Students got the opportunity for learning about information technologies and taking in the skills of digital processing using information technologies.

Introduction

According to Communications Usage Trend Survey released by the Japanese Ministry of PHPT (Public Management, Home affairs, Posts and Telecommunications), the number of Internet users at the end of 2001 was 55.93 million - an 18.8% increase over the previous year. Thus, The number of Internet users in Japan has been rapidly on the rise the past few years. In terms of the status of personal Internet usage according to the type of terminal used, 48.90 million people accessed the Internet via PCs, while 25.04 million people accessed the Internet via cell phones, PHS, and hand-held terminals. The significance of information technologies will increase among university students even for the purpose of teacher training.

Information technology education in secondary school in Japan

Lower secondary school

At lower secondary school, the six areas in "Industrial Arts (technology education)" were Woodworking, Electricity, Metalworking, Machines, Cultivation and Information Technology before 2001. The six areas were integrated into two areas: "Technology and Manufacturing" and "Information and Computer" in 2002. Information technologies will become more and more important in the subject of "Industrial Arts" education.

Upper secondary school

New subject of "Information Technology"

The aim of the new subject "Information Technology (IT)" is not only to learn how to use a computer but also to develop information literacy so that students get important information without being confused by incorrect or unnecessary data. It also involves students being able to convey information about them. It is important that the new subject is needed even for scientific problem solving with computer.

Students entering upper secondary school from 2003 will study the subject "Information Technology (IT)". The subject "IT" is composed of three courses; IT-A, IT-B and IT-C. Students will have to study one or more of these courses before graduation. What course is studied and the grade in which it is studied will vary from school to school. In addition, the standard number of credits is two units, which means two hours of study per week. The subject matter and level is different in each course. The major difference with other subjects is that practical learning using computers and the Internet will be emphasised. In addition, all courses will focus on "the rules and manners" required in the information society.

IT-A: This course will focus on the practical ability to use information. Study activities will be conducted using the Internet and commonly used software to enable students to master the use of computers and the Internet in everyday life. More than one half of total class hours will be allotted to practical studies.

IT-B: This course will focus on the scientific understanding of information. Learning activities will be conducted in order to develop scientific comprehension of the functions and mechanisms of computers and how data is processed internally and to use the computers for problem solving. More than one third of total class hours will be allotted to practical studies.

IT-C: The course will focus on developing a positive attitude to participation in the information society. Learning activities will be conducted to study communication using the Internet and survey activities in order to develop a deeper understanding of the network society itself rather than the internal mechanisms of computers. More than one third of total class hours will be allotted to practical studies.

Advanced subject of "Specialised Information Technology"

There is also an advanced subject, "Specialised Information Technology" for people who want to specialise more in their studies. In addition to the common subject, "Information Technology" mentioned above, which all upper secondary school students will study, there will also be a advanced subject "Specialised Information Technology" for students with aspirations to work in an information-related field in the future. The subject "Specialised Information Technology" is composed of eleven courses, including Information Industry and Society, Algorithms and Computer Design. An Information Course in which students will study a specialised Information subject will be introduced in upper secondary schools. The Japanese Government are promoting the establishment of computer classrooms and the systematic installation of computers so that during classes there will be one computer for every two students in elementary schools and one computer per student in lower and upper secondary schools and in schools for the blind, deaf and otherwise disabled (1999 Japanese Government Policies in Education, Science, Sports and Culture, Educational Reform in Progress).

Production of digital contents: "Australian Life and Culture" for technology education in the teacher training course

International partnership of Shiga University – Agreements on co-operation and exchange

Shiga University has "Agreements on Co-operation" with Michigan State University in the U.S.A. since 1985, Deakin University in Australia since 1988, and Chiang Mai University in Thailand, as well as Xiangtan University in China since 1999.

Shiga University as a member of the Consortium of Kansai Teacher Education Universities, has established an "Agreement on Co-operation" with the Rajabhat Institute in Thailand. The Faculty of Education is chiefly responsible for activities with Education and Education Training.

Members of the Faculty of Education are pursuing a project of research in the field of regional studies and environmental education with Deakin University and Chiang Mai University, supported by a Grant-in-Aid for Scientific Research from the Ministry of Education in Japan.

Based on the above agreements, Shiga University sends students to Deakin University, Chiang Mai University, Rajabhat Institute and Michigan State University. Students usually stay at one of the above institutions for six months to one year. The Graduate School of Education and Faculty of Education has accepted Monbusho Scholarship Students from various Asian countries. They are teachers in their home countries and they stay at Shiga University for one year, mainly to attend seminars and to pursue their research.

Shiga University has organised English Language summer courses at Michigan State University since 1986, spring English Language and Culture Courses at Deakin University since 1998, and summer Eco-Study Tours in Thailand since 1999. Considerable numbers of students have participated in these programs and enjoyed extra-curricular activities besides coursework in the classroom (Shiga University 2002).

Australian Studies Program for the course of "Australian Life and Culture"

The course of "Australian Life and Culture" was established about ten years ago in the Faculty of Education, Shiga University. Deakin University staffs have continued to contribute to Australian Studies Program at Shiga University, by attending to present specialist lectures on a variety of topics. The number of visiting Deakin specialists increased, especially during 1998–2000 (Brumby 2001). The range of lectures includes "Australian geography", "Education in Australia", "Australian History", "Australian Animals" and so on.

Production of digital contents in a teacher training course

Video recordings of the lectures are currently being used as the basis for some interactive CD-ROM/DVD based learning materials which were developed, through completely non-linear editing of MPEG 2-level digital processing, by DCPP (Digital Contents Producing Project in Shiga University) with assistance from Deakin staffs (as shown in Table 1).

Table 1

Production processes

PROCESSES		MEDIA/FORMAT		
1)	Collecting AV data etc.	DV tape	VHS tape, 8mmVideo	Other media
2)	Media conversion to AVI format	AVI (D to D)	AVI (A to D)	AVI
3)	Translating to Japanese	text	text	text
4)	Editing		MPEG1 or MPEG2	
5)	Recording		CD-R, DVD-R etc	

Usage of digital contents for e-Learning

Video CD/DVD for interactive learning

These teaching materials are used in the lecture at the course of "Australian Life and Culture" as shown in Table 2.

Table 2

Process of the lecture

PROCESS OF THE LECTURE	THE TIME REQUIRED
Guidance: How about Digital Contents	30 min
Lecture: "Australian geography" using VideoCD	30 min
Evaluation: Questions and Questionnaires	30 min

Ten questions were given to students after the lecture. Table 3 shows ten questions and the correct rate of each answer.

Table 3

Questions and rate of correct answer

NO.	QUESTIONS (Translated to English) (original questionnaires are written in Japanese)	RATE OF CORRECT ANSWER [%]
Q1	Show the reason of the naming of "a bottle tree" in north western Australia?	85.6
Q2	Why is it called "blue mountain"?	95.8
Q3	When do tourists climb Ayers Rock in a day?	97.5
Q4	Where is Ayers Rock located?	46.6
Q5	What are the original inhabitants of Australia called?	100.0
Q6	What purpose do the original inhabitants use the boomerang for?	97.5
Q7	What is the capital of Australia?	98.3
Q8	How many states and territories are there in Australia?	83.9
Q9	Show three animals in Australia?	61.9
Q10	Show the size of the Australian continent?	94.9

And at the end of the lecture, the questionnaires were given to students. Table 4 shows ten questions and the positive rate of each answer.

Table 4

Questionnaires

NO.	QUESTIONNAIRES (Translated to English) (original questionnaires are written in Japanese)	YES [%]
1	Was this class easy for you to understand?	90.7
2	Do you want to take the class using digital media like this from now?	86.4
3	Do you think that this AV information is better than OHP?	95.8
4	Do you want to use this materials for self-learning?	63.6
5	Show good points and bad points in these materials.	(Abbreviation)
6	Were superimposing subtitles easy for you to understand?	73.7
7	Were pictures easy for you to see?	78.8
8	Did you have interest in this contents?	87.3
9	Was effect on pictures good when switching the screen?	61.0
10	Do you think opening and closing scene are necessary?	60.7

WBL (Web Based Learning) for flexible learning

The VideoCD format files are transformed to web page format files and put on the web site (http://www.mlab.sue.shiga-u.ac.jp/).

Digital contents are used for "Flexible Learning". And also web page teaching materials are used for flexible and interactive learning through the Internet technology.

Opening Address
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1. Location and Size
2. Geographic Regions
3. Western Plateau
4. Central Basin
5. Eastern Highlands
6. Towns and Cities

Closing Address
Staffs
Problems and Answers

Slides
Manuscript of this lecture
(Japanese/English)

Home
Japanese

Figure 1

Menu in the web page

Conclusion

In this paper, the use of information technologies to learn about other cultures is reported. A description of how these technologies are used with university students is also provided. The production of digital contents is a good activity for learning IT in the Teacher Training Course in Technology Education.

The new subject "IT" will start in the fiscal year 2003. We are preparing for publishing the textbooks for students of upper secondary schools, and I will publish two textbooks for the students of teacher training course of IT. However, many kinds of teaching materials are needed for education and various kinds of media must to be used for flexible and interactive learning using Internet technology. This learning style means just WBL and is called "e-Learning". In an advanced information society, we have to promote research and development of teaching method using information technologies.

And I think the partnership (Griffith University and Shiga University) is needed for Research and Development (R & D) of teaching method and materials in the teacher training course of technology education.

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A Very Different Experience: Teacher Practice and Children's Learning

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The impact of teacher constructs of technology on their teaching is now well recognised, but little has been published on the actual impact on children's learning. This paper outlines the experiences of children in three, year one/two classes who were taught a commonly developed unit of technology education. It describes the quite different learning experiences of the three groups and explores the teacher attitudes and practices which gave rise to this diversity. Finally it discusses the wider implications for the implementation of technology education from this study.

Introduction

This paper documents and discusses a unit of technology education undertaken by three, year one/two classes at an inner city Auckland school. The author is currently engaged in a longitudinal grounded theory study of the development of technological literacy in a group of twenty five children. In their first year at school the children were all in the same class, but in their second year of school, during which this unit was undertaken they were spread across three classes. Seventeen were in a class of twenty five children taught by Mary. Mary was in her mid-fifties. She had a Master's degree in Music and had most recently been teaching on a pre-service teacher education programme in England. Mary had also taught Design and Technology at the primary level in England and felt herself to have a very good understanding of technology education. Three children were part of a class of twenty five children taught by June. June was in her mid-twenties and in her sixth year of teaching, two of which had been in London. She felt very uncertain about her understanding of technology and her ability to teach it. One child was in a class of twenty four children taught by Ellen. Ellen had just turned forty and was studying part time at the Auckland College of Education to upgrade her qualifications to a Bachelor of Education. Ellen was in charge of Mathematics in the school and felt reasonably confident about her understanding of technology and her ability to teach it. Only Ellen had been involved in any formal professional development programme in technology.

It became increasingly obvious as the unit progressed that the different way in which the unit was being taught by the individual teachers was resulting in quite different learning experiences and outcomes for the children in the study. This paper examines the impact of teacher's classroom practice on the learning experiences of children.

Teacher constructs and technology education

The impact of the conceptions, beliefs, views and attitudes of teachers on the successful implementation of new curricula, no matter how well founded on learning theory, pedagogy and empirical research is well established (Goodson 1985; Richardson 1989) The dichotomy between teacher perceptions of technology, and the philosophical basis of new technology curricula around the world has also been well recognised (Anning 1994; Aubusson & Webb 1992; Compton & Harwood 1999; Jones 1998; Jones & Carr 1992; Limblad 1990; Mittel & Penny 1997; Symington 1987).

The impact of subject subcultures, previous experience and ingrained teaching practices when faced with the challenge of new curriculum approaches is also well documented (Aubusson & Webb 1992; Mittel & Penny 1997; Newton & Hurn 1996; Paechter 1995; Shield 1996; Stein, Campbell, McRobbie & Ginns 2001; Symington 1987). Even when teachers had undergone intensive guided reflection on their delivery of technology units, many felt their original concepts reinforced, even though it had been the researchers perception that there appeared to be a change away from these initial constructs towards a construct more consistent with the curriculum (Jones, Mather & Carr 1994).

The different range of teacher constructs within a school has also been noted. Jarvis and Rennie (1996) found it "particularly worrying" that teachers in the same school did not have common views of technology despite there being a school wide policy on technology. The impact of teacher constructs has been highlighted by Alister Jones. Discussing the implications of the research in technology education concludes that appropriate implementation is impossible if teachers hold inappropriate constructs of technology and technology education (Jones 1998).

Background to unit

The school plans for the year on the basis of term long themes to be covered by all classes from New Entrant to year six. At the end of each term small groups of teachers work together to develop school wide unit plans in all the seven essential learning areas within the NZ Curriculum Framework. Teachers from the various year level syndicates then come together to modify and adapt the school wide generic plan for their particular classes. The children who were being tracked were all with one syndicate, the teachers being Mary, Ellen and June. The theme for the term was Natural Forces, and the technology unit was preceded by a science unit on volcanoes. The technology unit was to be focussed on the technological area of Electronics and Control, and the brief was to provide a warning device for flooding in a local waterway. The learning outcomes for the three classes were; 1) can produce a valid concept for a warning system, 2) can discuss how warning devices affect people, 3) can manipulate materials to connect elements of a simple warning device. A range of introductory activities and suggested learning experiences were provided to the teachers within the unit plan.

Methodology

As noted previously this unit of work was observed and documented as part of a wider, three-year study. Two units of work were covered and documented in the first year (classroom games, bird feeders/nesting boxes) and the unit on warning devices was the first undertaken in the second year. It was completed in term three by which time all the children had been at school between 14 and 20 months.

Data was collected by use of audio taped teacher and student interviews, video taping of selected lessons, collection of children's written work, audio taping of selected group collaborative working experiences, and digital photographs of the making process.

Results

Mary's class

The actual written unit supplied to Mary did not play much part in her own planning, "No, I haven't really used it much". Mary started out with a clear concept of what she wanted the children to concentrate on and the outcome that she wanted. Her initial approach did not focus on the scenario or brief of the actual unit. "Measuring the shaking on the ground, and I'm kind of working on that project first that's my focus for the first week", (Interview 23/8/01) nor was the proposed outcome (a seismograph) an appropriate solution. She also had a firmly set image of the product, "I know how to build it, you know and the kids won't", (Interview 23/8/01). Her focus at this stage was on how the children could be shown how to build her seismograph. "So would it be good at first if I brought all the things for my seismograph so to speak, if they put it together", (Interview 23/8/01). She had also decided to introduce the topic by making up a story about a boy in a tower and setting the task of designing and making a device to warn him of an earthquake.

The unit began with an ad lib story about Max. In brief, the story was about a village that was having its animals stolen so they built a high tower in which Max lived. His job was to warn the people if robbers were coming but one day there was an earthquake and Max was killed when the tower collapsed. At the end of the story there was a discussion about how earthquakes work and then the children were sent into groups to build towers out of cuisinaire rods, put a Lego™ figure on top and then test them for strength by shaking the cardboard base they were built on. There was no attempt to pursue an understanding as to why some towers were more stable than others.

The second session began by revisiting the Max story. The children were then asked to draw a method of warning Max in tower that an earthquake is about to happen. There was no discussion on the drawings and the feasibility of the ideas. At this stage the concept of a seismograph introduced. The next session consisted of a brief review of Max story and a review of seismographs by Mary with the children on the mat listening. Again the next session began with a review of Max story and a review of seismographs on the whiteboard by Mary. The children were then set to work in groups to build a seismograph, using a range of materials provided by Mary.

The unit then moved away from Max and seismographs. Another story about a boat siren was used to introduce a discussion on nature of warning devices. The children drew warning devices in groups, and reported back. Mary used photographs of warning devices to introduce them to the class and the children in groups divided warning devices into those that we hear and those we see. The knowledge gained was not related to the flood warning scenario in the unit plan.

The unit then petered out with the children completing two assessment sheets focused on the knowledge of warning devices and their importance to people. The assessment sheet had two questions for the children; "what I know about warning devices?, and "how warning devices help people?". There was also a section for the teacher to fill in assessing the appropriateness of the children's design of a device to warn people of rising water. Prior to administering the assessment sheet Mary held a class discussion focussed on the assessment questions. She put the following words on the whiteboard to help them – sign, alarm, noise, flash, smoke, telephone fire. Most of the responses used these words. With regard to the second question Mary explained it by saying "They alert us to danger" which she repeated three times, (classroom observation, 12/9/01). Ten of the seventeen children in the study wrote those words as their only response to the question. No comments were made by Mary on any sheet regarding the appropriateness of the children's design solution.

When reflecting on the unit after it was completed Mary felt that her approach was appropriate "I think using a personalised example was valuable in them understanding the notion of warning devices", (Interview 18/10/01). She tended to see any problems as situated in the children, "Well I guess the unit itself I felt was probably a little bit beyond the reach of my children . . . the concept that they were down low and Max was up high perhaps was more problematic than I'd imagined . . . .What I was surprised to realise was that they really had no idea of the functioning, how they functioned, and so I guess that's to be expected", (Interview 18/10/01). Lack of support was also seen as a constraint, "I suppose I would have quite liked to have done something about water rising and triggers and so on and so forth but um, because I didn't have any parents able to come in and take the rest of the class while I dealt with a small group um yes, end of story we didn't do it".

The learning that took place was seen by Mary in quite low level terms, "All I did really in this unit was to give them some experiences of technology rather than explicit, solve the problem issues . . . .I guess in that sense they were beginning to apply some very fundamental knowledge and I suppose that's all we can do".

Mary was able to articulate a sophisticated pedagogy with regard to technology which she contrasted to that of teachers who did not have her perceived knowledge of technology.

> "Well I think too, part of the problem with that, is that teachers who are very busy all of a sudden and don't know anything about technology, suddenly get thrust upon them that they've got to do this three week unit and they get all the pieces of paper, they read it through and with their, you know, with their head in a little box they do it for three weeks and sort of wash their hands like Pontius Pilate, and in actual fact that is contrary to anything I understand about learning. . . .I mean that's why I've been trying to kind of continually make the link because I have a pedagogical belief about the role of that spiral and the notion of revisiting and becoming more sophisticated as the revisiting occurs and although we are just touching on it and we can't revisit warning signs every year, . . . there is a degree of the bigger, the higher concept and to me its about cause and effect and adaptability really, how one community might adapt a warning device or warning system to another".

In the case described above, the practice clearly did not match the rhetoric.

Ellen's Class

Ellen had a clear concept of technology which focussed more on the process than the final outcome, "The good thing about technology, it's intent is to, to create thinkers of children.

I always sort of think of the technology as a thinking thing", (Interview 8/8/01). She valued the collaborative nature of technology, " I work the children into groups . . . by doing it in the main group you are getting those thinkers to give the other people who don't have ideas, ideas." Ellen was also very aware of the danger of adults intervening and directing children's work, "I think as adults we can see a better way . . . and we go "Well no, you should do it" you know so we put our knowledge onto them", (Interview 8/8/01.

Ellen had firmly fixed ideas about encouraging independent learning and student ownership of the task, "My expectation is that hopefully the children will do something and they will get to the result by themselves with a little bit of input, you know I mean that's the ultimate . . . They do have real ownership and there is real purpose behind it", (Interview 8/8/01). She also acknowledged the importance of the initial introduction of a unit in creating ownership of the task, "If you create a good scenario I think they will understand why they are wanting to do something".

Although one of the suggested outcomes of the unit was a electrical or electronic system, Ellen rejected this possibility very early in the planning stage. There were a number of factors behind this decision. Cost was one factor, "I think anything like . . . electronics . . . it's going to cost a lot". Time and the children's ability were other considerations, "and I don't know if I have got the time to go and do it and I don't know how well they will cope with that being six years old so I'm going for like something I think will be simpler and successful". A final factor was her own level of knowledge and competence in the technological area, " And the other thing is personally for myself I don't know a lot about electronics and switches and I, I wouldn't be able to assist them", (Interview 8/8/01).

Ellen's delivery of the unit tallied very closely to the pedagogical approach she had identified. The first session was taken up with introducing the unit. She did not use the local scenario laid out in the school wide unit plan, instead talking in general about lahars and the flooding problems they created. Her explanation for this modification of the unit was," I didn't talk to them about it happening locally because with them being only seven I didn't want to frighten them too much. . .". She took great pains to develop the children's understanding of the problem and then sent them away to draw a design of their proposed solution. The second session began with a review of the nature and concepts of warning devices and then the children were provided with a wide range of construction materials and fixing/joining materials to start making their designs. The remaining five sessions all followed the same pattern of the children talking to the class about their ideas and problems and working independently to test and refine their ideas. The children worked as individuals but there was constant interaction taking place. Some children failed to reach a successful resolution to the design they had produced but all children stayed focussed and on task for the whole of the unit. Ellen's role during this time was as provider of materials and a sounding board for the children. She consistently avoided giving them the answer but instead used pertinent questions which enabled children to see a way forward for themselves.

When reflecting on the unit Ellen was happy that her intended approach had worked, "I tried to do a real hands off so that I didn't direct them . . . . because of that they were really enthusiastic and so it did actually work . . . . I had no expectations about what they would finish with except that perhaps it worked in their minds . . .", (Interview 16/10/01).

Ellen saw the children's ownership as significant and attributed this to her teaching approach, " The strengths, I think that the children took ownership really, they worked quite co-operatively . . . .For some reason they got right into it, and I think a lot of it had to do with the fact that I wasn't trying to get them to reach what my expectation of what a warning device should look like or should end up being", (Interview 16/10/01).

The importance of the resourcing on the success of the unit was acknowledged, " It was just lucky that we had enough stuff . . . . They weren't inhibited by having nothing".

She saw the process as being more important than the final product and highlighted the independence of the children, ". . . they completely kept modifying it and they kept changing it and they actually worked a lot co-operatively together . . . They took complete control and so I actually stood back and watched the whole process which I think is very difficult for a teacher because we always have in our set mind that this is what we want to achieve and often everything ends up looking exactly the same as we have set what we want to do", (Interview 16/10/01).

Ellen was less clear as to what technological knowledge the children gained. She identified some behavioural learning, "that you can keep trying and keep trying until you make something work. . . . they learnt that they can always access other things, try out other things." Knowledge of other curriculum areas was also identified, "I suppose about things that float and sink but that's more sort of a science thing". The formal assessment sheets provided with the unit focussed on the children's understanding of the nature of warning devices and did not assess the warning device they had designed and modelled. Some informal reflective discussion took place but it was not recorded.

For Ellen personally the unit was a success, "I did do what I wanted to do which was to try and set them up with as much information . . . from then on I wanted it to be their direction . . .. I completely left it up to them and from that aspect I think the unit was successful because I didn't own the product at all and the hardest thing was that I felt like I wasn't teaching . . .I actually sat back and watched and through that they probably did more and learnt more".

June's class

June approached this unit with some trepidation on two accounts. Firstly she felt unsure about her ability to teach technology, "I really feel anxious about technology, I'm never sure if I'm actually teaching it", (Interview 9/8/01). A week before the unit started she had not begun to plan for it," I'm avoiding it really". Her second concern was her lack of knowledge and skill in the area of electronics.

June introduced the topic with a picture interpretation exercise using photos of the Tangiwai disaster.

> "I think I approached it a little bit differently than other people because I really focussed from that first part of warning devices in the community and what they're used for (all the quotes in this section are from an interview, 29/10/01).
>
> The hypotheses developed by the children during their analysis of the photos led to a discussion of possible warning devices. The children were then assisted to start thinking about problem and possible solutions. When June moved on to the second step of the school-wide unit where the children were asked to draw a plan for a warning device, a problem emerged, "we did the plan, that first stage and that really didn't work, it was mainly fantasy".

At that stage June changed the focus from an individual approach to a group approach, " I just had four groups and we chose one plan that was the most practical for them to follow and they liked that actually, they didn't seem to mind developing somebody else's plan because they actually did quite a lot of talking about it", The children chose which of the four solutions they wanted to work on and the next four sessions were taken up with the groups making, testing and modifying their warning devices. In the final session the groups reported back and demonstrated how there device worked.

The feeling of personal lack of knowledge and uncertainty as to the nature of the unit which June expressed prior to the unit continued throughout the unit. "That's where I fell down a bit because I didn't really feel like I could extend them. I could get them making but then for them to put their ideas into practice I didn't really feel like I had the know how to do it". She saw this lack of her own knowledge as a factor in the simple nature of the solutions, "but they didn't really do much more thinking of the mechanical side of it, and because I don't really think that way myself, I couldn't really encourage them too much towards that" However, despite her initial diffidence she viewed the outcome of the unit in quite positive terms, "I was surprised how well it worked just because when we first given it I was a bit like bamboozled by it all, I didn't really know where to begin".

June felt that some clear learning had taken place, although she identified the limits of it, "I would say that they could identify warning devices, name some examples of them, they would be able to say why they are necessary and what particular ones are specially, used for, but in terms of features of them I don't think I would get much from them in that sort of sense. . . . They would probably all remember what they made".

Another area that she particularly noticed was the degree of collaborative work that occurred. "I really noticed a lot of co-operation and that surprised me with certain children as well, because usually they would take a step back and let someone else run it. . . . in some of the groups they were the ones that sort of came the furtherest because they were listening to each other and sharing ideas".

One problem that June identified was the nature of the scenario that had been set for the children in the school wide unit. "Because we had to follow that scenario, that was quite difficult for them to understand in the beginning although we had done quite a lot of talking about lahar and all the rest of it, . . . we sort of had to keep reminding them why they were making it because they sort of forgot halfway through and thought we'll just make a raft Why are you making this?, They couldn't remember".

Discussion

Children in the different rooms clearly had very divergent experiences within this common unit. In Mary's room children worked within a non-authentic, fantasy context to design warning devices that were not modelled or critiqued for practicality and effectiveness. Any making was carried out using inappropriate materials and was not related to the purpose of the unit. In Ellen's room children worked individually to produce a model of a warning device that was contextualised within the children's own neighbourhood and which related to the overall purpose of the unit. However many children failed to achieve a successful outcome, largely due to the totally hand's-off approach of the teacher, having to rely on input from other pupils. In June's class children worked collaboratively on practical solutions that were clearly situated within an authentic social and environmental context. The designs had been evaluated against clear criteria, and the selection of the designs to be pursued was carried out by the children with an understanding of the relevant constraints involved. All four groups achieved a workable solution to the problem.

The explanation for these different experiences would seem to lie within the beliefs and classroom practices of the three teachers. They all started with exactly the same unit, they all took part in the same planning discussions on implementing the unit, and they all had the same resources available to them.

Paradoxically it was Mary, who was the most experienced, both in terms of general teaching and teaching technology, and who was the most confident about her ability to teach technology who provided the least satisfactory experience for her children. On the other hand June, who was least experienced and confident who provided the most satisfactory experience.

Mary's initial fixation on the children making a seismograph distorted the whole of the unit. It led to her inventing a fantasy story about Max, which changed with each retelling. This caused much confusion to the children when they were asked to design a device to warn Max of an earthquake, as by that time it was not at all clear what the tower was for and what was the relationship between Max and the villagers below. Although the children were able to follow Mary's instructions to build a reasonable model of a seismograph at no stage was there any consideration of how it could be turned from a recording device to a warning device.

Ellen at this time was upgrading her teaching qualification through part-time study at a local College of Education. A prominent feature of the College is its promotion of a constructivist pedagogy within the classroom and the view of the teacher as a "facilitator". This seemed to underlie Ellen's extremely hands-off approach, even though she found it difficult to maintain. By using this approach she denied children access to the knowledge that would have allowed them to move through some of the barriers that prevented them from achieving a successful solution to the problem set them. It would seem that it was therefore not a lack of understanding of the nature of technology which was the negative factor in this case but the choice of an inappropriate teaching model.

In June's case it would seem that her lack of confidence in her understanding of technology and her ability to teach it was actually fundamental to her greater success. She made consistent efforts to seek advice from specialists in the field of technology education and reflected regularly on the progress of the unit. She recognised when the aims of technology were being distorted and modified her programme to correct the problem. She encouraged parents to be involved in the room and they provided much of the expertise that she herself had identified as lacking.

A number of other relevant factors are also played a part. The constraints imposed by lack of teacher content and skill knowledge in electronics, the resources available and the distorting nature of the school planning process all influenced classroom experiences.

Another concern which arises from this study is the lack of reference by any of the teachers in their planning or teaching to technological knowledge and understanding gained in previous technology units experienced by the children. In the post unit interviews no teacher was contemplating developing any conceptual knowledge gained by the children in the warning devices unit into the unit to be done in the next term. The aim of technology education is the progressive development of technological literacy during the school career, but this isolated delivery of technology would seem to preclude this happening in any coherent manner.

This small study has indicated some serious flaws in the delivery of technology education in our schools. There would seem to be some serious implications for the future of technology education if the diversity of practice seen within these three classrooms is typical of the situation in the rest of the primary education system. Although the curriculum has been a compulsory essential learning area since 1999, and professional development contracts have been in place since 1995 it is clear that appropriate teacher constructs of technology are still not well established.

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Collaboration: The Challenge of ICT

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Information and communications technology (ICT) brings many potential benefits to technology education, though the evidence of improved performance on traditional tasks is not yet proven. Areas such as computer-aided design and manufacture are now becoming standard elements of any student's technology education. These applications of ICT require changes to the arrangements of the teaching and the learning, but may have few implications for what is learned. Network technologies, on the other hand, offer a new dimension of ICT for tasks such as designing. These dimensions may require a transformation in some aspects of technology education. This presentation will outline what such networking could do for collaborative learning in technology education, drawing on recent findings from research on learning. It will explore an example of joint designing, to see how its potential can be exploited and how it may transform learning in a way that ICT has probably not done so far. Such an exploration will look at both learning to collaborate and collaborating to learn, two inter-related themes that are important in modern design practice in the world outside schools as well as in research on learning. Although the technologies may yet have to reach maturity to become reliable and easy enough to use in schools, technology educators must be prepared to exploit the learning potential, and this paper is intended to start that preparation.

Introduction

Throughout the world school systems are introducing the use of information and communications technology (ICT) in an effort to improve teaching and learning. Some see it as an opportunity to transform teaching and learning, others to make it more effective or efficient. In the world of design and technology education (the subject name in England) there is the added impetus coming from the ubiquity of computers in technological activity outside schools. I will argue that the evidence that ICT will make learning more effective or efficient is mixed in general (and almost completely unproven in design and technology education) and that, if its potential to transform education is to be realised, then we will have to pay more attention to learning issues. Whatever our scepticism about how ICT will affect the quality of learning in terms of the current curriculum, there are important aspects of designing that can only be represented if we adopt some of the new network ICT finding its way into schools.

First let me start with what we know about the way ICT has improved teaching and learning.

The impact of ICT on teaching and learning

Does ICT improve teaching and learning? In the UK research project in the early 1990s, usually referred to as the first ImpaCT study, the answer to this question was mixed

(Watson 1993). The study of both primary and secondary schools used mainly specially constructed outcome measures, to see if high use of ICT resulted in the higher attainment of students. It matched pairs of schools (20 in all) of high and low ICT use and tested 2,300 students. Overall the study could only show mixed improvements in test scores, and indicated a complex impact on pedagogy that depended on many factors. (The methods were disputed at the time of publication of the report, e.g. Hammond 1994.)

More recently the Teacher Training Agency in England funded a study at the Universities of Newcastle and Durham that was more developmental, but one confined to primary schools and in particular to literacy and numeracy (Moseley et al 1999). This study used existing test data on schools. The researchers carried out assessment in aspects of literacy and numeracy as measures of outcome before and after the development activity in a 'test/retest' model. The findings were as mixed as in the first ImpaCT, with qualifications in the report that gains could not be directly attributed to ICT.

A recently published study for the UK government uses Ofsted data (taken from inspections of 2,594 schools inspected in 1998–99) to investigate the relationship between ICT and primary school standards (BECTa 2000). Standard test data in English, maths and science were related to a measure of 'ICT resourcing' (the latter taken from one of the criteria in the ICT subject record form of regular school inspections; i.e. the resources used to teach ICT as a subject, which may or may not be available for maths, science and English, the three attainment areas). The study showed a correlation of the two types of measures, i.e. schools that had good ICT resources also performed well in the standard tests. The study's authors point out that correlation doesn't mean causal relationship. However, despite the limitations of the study, the impression given is that ICT *improves* performance on standard tests.

Currently another study is underway (ImpaCT2), which focuses on network technologies. The initial literature review concluded that in curriculum subject terms, improvement in student outcomes is mixed, but more consistently shows an improvement for such things as specific skills and problem solving (McFarlane *et al* 2000). Unfortunately, where these measures of skills are used, they show no impact on subject learning. The interim report of ImpaCT2 notes that there is much more use of ICT at home than in school and, that in schools with high ICT resources, more ICT was used in lessons (BECTa 2001).

In the USA, where the availability of ICT in schools is higher, the results of either large-scale studies (e.g. Becker 2001), or detailed case studies (Cuban 2001) points to the problem of the lack of use of computers, to the extent that it would be hard to expect much impact.

Given the apparent pessimism in finding improvements in the 'conventional' learning outcomes reported above, it is perhaps more productive to explore what ICT can add to learning. Some might argue that it is not sensible to try to say something in general about the effectiveness of ICT, just as you wouldn't about books or educational technology in general, as Schramm concluded in his classic study review of all we knew about educational technology:

> ....given a reasonably favourable situation, a pupil will learn from any medium - television, radio, programmed instruction, films, filmstrips or others. This has been demonstrated by hundreds of experiments. In general, the same things that control the amount of learning from a teacher face-to-face also control the amount of learning from educational media…(Schramm 1972).

None of this sheds much light on how ICT has helped design and technology (D&T). Computer-aided design (CAD), whether for conventional design drawing or for designing electronic circuits, and computer-aided manufacture (CAM), are the most commonly found uses of ICT, other than its general purpose use for word processing, recording work using a digital camera, and Internet searching. Where good practice does exist, students use CAD to explore 'what if' questions, to explore 3-D shapes (through CAD as a drawing and modelling tool), or technical functioning, as in circuit simulation programs (e.g. *Crocodile Clips*). These are good examples, where ICT goes beyond just being more effective at what can be done by traditional methods, to *extending* the capabilities of students. However, there exists almost no research on these uses.

CAD/CAM applications, enable students to achieve something they cannot do by conventional means (by definition, as they introduce new tools in designing and in making). However, this innovation is in bringing a new technology to schools as the *subject* of study, not as a *means* of study. McCormick and Scrimshaw (2001) consider examples of how ICT can *transform* teaching and learning of the subject. For example, where the use of electronic multimedia provide new forms of communication that transform both the substance of literacy and the means by which is taught and learned. Such transformations imply a change in teacher pedagogy to accommodate the developing subject *and* means of study.

The next section of this paper considers how changes in technology in the world outside schools requires them to change both the subject and the means of study, if they are concerned to reflect that world in the activities students undertake within schools.

Designing in the world outside schools

It is almost a cliché now to say that design in schools focuses on individuals designing and making, whereas in the world outside these activities are team or organisational efforts. Indeed Scrivener, Linden and Woodcock (2000a, p.463) say that the individual designer is a myth; said in the context of a specialist conference on collaborative design, entitled *CoDesigning 2000*. Not only does collaboration reflect the most common form of designing to cope with complex projects, but it is also seen as a more creative approach, such that "collective generativity is beginning to replace individual creativity" (Sandes 2000, p.11). But the issue of collaboration goes beyond just having a team of designers, and also embraces the involvement of customers, clients and consumers in the design process. Thus we have the area of professional design changing in the world outside school, with a considerable research effort trying to understand its collaborative nature (e.g. Austin 2001; Baird, Moore & Jagodzinski 2000; Craig & Craig 2000; Macmillan et al 2000; Scriverner, Ball & Woodcock 2000a, Part III *Studies of Collaborative Design*). ICT, through the development of CAD and the creation of collaborative environments, is a major development in professional design. It is also seen as a key area for improving the productivity of engineering and manufacture not just through CAM, but through design that can allow designers all over the world to collaborate in product design.

Schools are now familiar with the development of CAD and CAM and most students will experience these as part of their D&T education experience in secondary schools. But, at a time when we may just be understanding the teaching and learning issues in the process of designing as an individual activity (McCormick 1999), we are being presented with a world outside that is changing. These changes link both the collaborative aspects of design with the use of ICT to enable collaboration.

There is a substantial body of research on how ICT can aid collaborative work for professional designers (and those being educated to become professionals). In the mid-1990s universities were experimenting with collaborative design (Wojtowicz 1995), when the ICT systems were quite primitive, probably equal to that found in schools today! Now there are whole books devoted to ICT-based collaborative designing (e.g. Maher, Simoff & Cicognani 2000). The concern is not just with the ICT systems themselves (e.g. Nam 2001), but with how the electronic environment affects the design process. For example: how different kinds of drawing are used (Garner 2001); the role of gesture in the communication of ideas (Turner & Cross 2000); and the preferences for synchronous or asynchronous communication and the role of face-to-face communication (Garner & Hodgson 2002; Turner & Cross 2000). Collaboration in these systems is not always successful (Craig & Craig 2000), and there appears to be a need for a better theory of collaborative design (Scrivener, Ball & Woodcock 2000, Part IV Mediated Communication; Summary, p.403). However, this developing field does recognise an important element of collaboration, namely the creation of a common frame of reference among designers (Scrivener, Ball & Woodcock 2000, Part IV Mediated Communication, p.402). Maher, Simoff and Cicognani (2000, p.103) go as far as to characterise collaborative design development in a virtual design studio (i.e. a studio mediated by ICT) as "a process of construction of individual and shared understanding and the mapping of this understanding onto a shared design representation". Unknowingly they are using an idea that has arisen in the learning literature on collaboration, as I will shortly show.

The importance of all of these developments is that they pose challenges to schools. In as much as schools see themselves as reflecting the world of design and technology outside, then they first need to encourage collaborative design for their students. Second, ICT as a tool in design is increasingly a collaborative tool and students will need to use it in this context. Such collaboration will not be just as a convenience (because there are insufficient computers) or as collaboration around a single computer, but also remote collaboration, where students are physically separated.

I will return to this issue, after examining learning theory, which as I hinted, might give us some insight into the theory to help us to understand collaboration.

Collaboration and learning

Contemporary views of learning privilege collaboration in particular ways that are important for network technologies. Specifically, the social dimension in social constructivist, socio-cultural and situated views, lead us to think in new ways about the nature of collaboration and the skills associated with it.

There are in fact two competing views of collaboration in contemporary theoretical approaches to learning. Those who take a cognitive constructivist view (focusing on an individual mind) will see peer collaboration in terms of creating and resolving cognitive conflict. The different views that individual peers bring to understanding an idea or concept create the conditions for them to rethink and construct their understanding. The promotion of individual learning through collaboration leads to *individual* construction of knowledge (a Piagetian stance). Those who take a social constructivist or situated view will not look for individual creation of knowledge, but the *joint* creation of knowledge. This kind of approach privileges the social dimension in learning, and is the one I take as the basis for this paper. I will not elaborate the complete background to this approach, but (below) present a selective number of ideas that are important to this view and to the situation in D&T, which I will consider later.

Intersubjectivity

Intersubjectivity is a central concept in collaboration and it arises between participants from the:

> shared understanding based on a common focus of attention and some shared pre-suppositions that form the ground for communication (Rogoff 1990, p.71).

It therefore requires an appreciation of the mental states of others (Crook 1994). The elements that are part of creating intersubjectivity are:

- shared problem space;
- shared objects;
- shared or distributed cognition.

When students are collaborating, therefore, they need to establish shared thinking in these ways. Thus, for example, in a design project they would have to agree on the needs or problems they were trying to design for (this gives both shared goals and the basis for a 'shared problem space'), and to share the ways that they express them. The computer screen can be seen as a shared object, to establish shared thinking, particularly when there is a drawing on the screen. Shared cognition is a more complex idea. The creation of an understanding in a discussion of a design can give rise to the pooling of ideas and the bringing of different kinds of expertise to bear on a design problem or need. But what is created is more than the sum of the thinking of those collaborating. Such thinking is not just working together and helping each other (which is co-operation). The use of electronic networks extends, and has a potential to transform, collaboration from that usually found around a computer in the classroom (the conventional view of the computer and collaboration).

This aspect of collaboration will help to provide the theory that professional designers such as Scriverner et al (2000a) were calling for and reflect the idea of collaborative design expressed by Maher et al (2000). This theory has the potential to inform design and the teaching and learning of it.

Authenticity

Social cultural theory focuses on the *social and cultural significance of the knowledge*. This leads to ideas of *cultural authenticity* i.e. the extent to which the learning reflects the curriculum subject in the world (outside school) that is the focus of the learning. In situated approaches this is expressed in terms of the community of practice (e.g. how the school subject, D&T, reflects what designers and technologists do in the world outside school). Authentic learning is that which enables greater participation in this community of practice, what is referred to as 'cultural authenticity' (Murphy & McCormick 1997). It does not mean that learning in the classroom should try to be the same as in the world outside, something impossible given the age, experience and resources available to students. However, it should be coherent, meaningful and purposeful within a social framework that is within the ordinary practices of the culture of technological activity. Schools have particular problems in creating authentic activity because they have difficulty in setting up tasks which are meaningful, as opposed to being just 'things you do at school'. At one end of the spectrum are the 'egg race' type activities, where students have to see how far or quickly an egg can be carried across a room without breaking it. This is an activity that has no meaning in itself unless it is put in the context of an egg laying and packing plant etc. At the other end of the spectrum is where six year-olds are set the problem of designing a new airport for their area; an activity with apparent authenticity that is unrealistic for them to have the conception or the skills to undertake. It is a concern for cultural authenticity that gives a rationale for trying to represent the kinds of approaches to design put forward in the first section of this paper. Further, it can lead to developments in the tasks that students experience, for example linking to real experts in the community of (design) practice.

Tools of learning

A situated approach also focuses on the *tools and physical conditions of learning*. These affect thinking; 'tools' have physical and psychological dimensions, and reflect the community of practice. So, drawing can be a tool for thinking in D&T, and it comes with conventions and processes of use that need to be understood by students (it is not just a matter of technique). When drawing is carried out through the use of CAD, then this tool affects the way a designer thinks about and tackles a design. Students have to learn to use this tool as part of authentic activity, and in doing so their learning is affected by it. Research has shown how mathematical thinking is affected by conventional orthographic projection (Evens & McCormick 1998), and CAD is likely to add some particular features of the menus and facilities of the software package. For example, the grid available on such software (and the 'snap to grid' feature) frames the way a student considers the drawing space. When the software incorporates a collaborative element it is likely that their thinking will have other dimensions added.

The process of learning

The more problematic elements of the contrasting approaches to learning relate to the *process* of learning. The cognitive constructivist view uses the idea of *internalisation* i.e. the appropriation by the individual of a concept etc. In approaches that focus on the social side of learning the focus is not on what an individual appropriates, although some researchers talk of the idea of *participatory appropriation*, which is what happens at the individual level (Rogoff 1995). The complex part of the theory is how this relates to the earlier ideas of shared understanding and creation of knowledge and what it is that a learner 'comes away with' at the end of learning experiences. This links to the shared and distributed cognition element of intersubjectivity. Such ideas have as yet largely unexplored implications for assessment; measuring individual learning is somewhat problematic in the collaborative context.

In contrast to the role of peers in creating and resolving cognitive conflict as elaborated in Piagetian approaches (e.g. to create cognitive conflict and resolution), social constructivist views talk of *guided participation*, which implies a skilled person working with a less skilled person. So the learner is guided into how to participate until she is able to operate solo; this is the simple explanation for the idea of learners moving from *legitimate peripheral participation* to central forms of participation. Some claim that peers can fulfil this function (e.g. Moschkovich 1996, and Murphy & Hennessy 2001). If so, then students designing collaboratively can be seen in this light, again with students in different locations bringing different expertise.

The nature of tasks

Finally, much of the literature on collaboration ignores the nature of the task, i.e. the need for the task to *enable* or even require collaborative activity. Often tasks are co-operative without being collaborative. In co-operative tasks students will help each other as they work, but, for example, in the end produce their own individual product or outcome. This makes no necessary demands for them to share thinking; they can take or leave suggestions or merely rely on the other to carry out a sub-task for them (e.g. soldering a component). Even where a team may be set up to carry out a complex task, for collaboration there must be negotiation at the interface between parts of the task enabling students to explore each other's ideas or meanings, and this task must be carefully planned to require this interaction. Hennessy and Murphy (1999) and Murphy and Hennessy (2001) discuss the nature of tasks both in the general and D&T contexts, and I will consider their work in the next section.

There are two related themes that emerge from the research considered so far.

Collaborating to learn, where the collaboration processes aids learning. In this process the focus is on the creation of intersubjectivity and how this contributes to learning, including through guided participation. In addition the authentic activity that involves collaboration reflects the world of design and allows students to experience the tools and physical conditions of the contemporary practice of design. One very important idea is that participation in technological activity is collaborative and *learning to participate* is therefore a central feature of learning.

Learning to collaborate thus follows from this learning to participate, but the focus is on the skills and understandings that are necessary to ensure successful collaboration; the call from those in the professional design context (Scriverner, Ball & Woodcock 2000a). These skills and understandings are often overlooked in conventional collaborative activity in the classroom, and I will show how the use of ICT can create the conditions where the need to learn to collaborate becomes imperative.

Collaboration and design and technology

I have already noted the major work by Hennessy and Murphy (1999) and Murphy and Hennessy (2001), which brings together an understanding of the issues in learning reviewed above, along with rigorous empirical work and a knowledge of the field of D&T education. They put forward a table of preconditions for collaborative work in D&T, which lays out the teacher commitment, task context, school and classroom organisation, pedagogic strategies and students' perspectives as they relate to promoting and supporting collaborative activity. They stress that, in an effort to focus on collaborating to learn, many teachers ignore that students need to *learn to collaborate*. They have to learn skills such as: *how to listen*, where they will take seriously other's ideas and how they relate to their own; *to take turns*, such that the resulting sequence of interactions is smooth and one turn relates to the next (This idea comes from conversational analysis where there is a flow from one turn to the next and it appears to be part of a conversation and not each person talking out loud to themselves.); *to make decisions* when there is no consensus, rather than one person dominating all decisions or simple voting without resolving disagreements. Murphy and Hennessy put forward some elements that support and constrain collaboration, as follows:

Supporting collaboration

- teacher commitment to collaboration;
- authentic activity;
- a strategy for students to be involved in establishing the problem context;
- the teacher supports student autonomy and decision making in the task;
- the use of tools to support the development of shared references (e.g. use drawing to think with, not as formal communication).

Constraining collaboration

- lack of links to the wider D&T community;
- limited opportunities for students to explore the problem through considering problem solutions;
- teacher does not monitor student understanding of the design needs to be met;
- restricted responses allowed to the activity that undermines authenticity (not just a constrained design specification, which is the norm in professional design and is authentic).

D&T usually involves design and making a product for a need and, when this is authentically done, this can be a real need for an actual customer or client. Murphy and Hennessy (2001) found that this meant that the teachers were inclined to push the production of this product, even at the expense of the students' learning, in an effort to finish making it (and satisfy the students' desire for success) and satisfy a customer (the tyranny of product outcomes; McCormick & Davidson 1996). A task that involves the production of a drawing could lead to such problems, because the drawing becomes a product in itself, especially when it part of a design portfolio and separately assessed.

Thus we have clear pedagogic guidance to implement collaborative activity in the D&T classroom, with guidance on what to aim for (learning to collaborate and collaborating to learn), requirements for collaborative tasks, and supporting and constraining conditions in the classroom. Along with what we know about collaboration and ICT (my next section), we have a good basis for joint designing using ICT.

Collaboration and ICT

Work on collaborative tasks with joint products (as indicated in the previous section), is still uncommon in the literature, despite the early grounding of socio-cultural theorists like Crook (1994) or those who have really tried to engage with the idea of collaboration through technology (e.g. Schrage 1990). Schrage discussed joint writing to record thinking at meetings and, despite him not being a learning theorist, his ideas are very powerful in the educational context.

Teasley and Roschelle (1993), who dealt with students trying to reconcile a real world of bouncing balls with a vector model (represented in software) by using the latter to predict the former, present ideas that relate to the D&T activity. Their concern is with synchronous collaborative activity and they are concerned to understand the language and action used by collaborators to establish shared knowledge, while recognising differences and rectifying misunderstandings. At the heart of collaboration they see the need to create and maintain a *joint problem space*. The software they used allowed students to establish *fidelity* (the match of their mental model and an external display) and *mediation* (the use of the external display as a tool to negotiate meaning). They identify several features of collaborative discourse:

- *turn taking* – sequences that indicate the degree of sharing of problem representations;
- *socially-distributed productions* – collaborative completion, where, for example, one student starts a sentence and the other finishes it;
- *repairs* – that are required because even in collaborative activity there is individual activity that can lead to conflict, a difference of view that needs to be negotiated;
- *narratives* – verbal strategy to monitor each others' actions and interpretations (e.g. explicitly talk about computer mouse movements and the intentions behind them);
- *language and actions* – the importance of gestures, e.g. in accepting something or demonstrating an idea.

They argue that the computer forced students to spend considerable time developing their joint understanding because it helped to make language less ambiguous (students can see the result), allows non-linguistic conversational turn taking, and helps resolve impasses by allowing ideas to be tried out.

The importance of context, which has a socio-cultural history, leads to a need not to see students working at the machine isolated from the classroom (Crook & Light 1999), when they are collaborating at or through the computer. This means that students bring with them an experience of collaborating (or not) from their normal classroom work. In addition, the substance of the work they do at the computer relates to other work in the classroom (even self-contained software such as Integrated Learning Systems depend for success upon how the work relates to other classroom activity; Wood 1998). This idea leads to a stress on the importance of looking at the culture of collaboration that normally exists in a classroom without the use of the computer (i.e. the classroom discourse; Littleton 1999). In addition it is important to be aware of the culture of the subject (represented in the worlds outside and inside the classroom), both in relation to the collaborative norms but also the tasks that include collaboration.

Most of this work on collaboration has a focus on 'collaborating to learn', but ICT gives unique conditions to allow students to 'learn to collaborate'. Schrage (1990) gives a powerful example of the effect of the technology on human interaction, when he points out the effect on long-distance telephone calls that have a significant delay in the voice travelling between the two speakers. Each has to wait a little longer than normal and hence this stresses the importance of listening to the other person. Translating this idea into the situation of remote students jointly designing, they automatically adopt collaborative approaches not usually found if they were working side by side at the same computer. Rather than just take the mouse out of the hand of the other student when they want to draw something, they have to ask the other student if they want to take control of the mouse or ask if they can take control back. It also requires more explicit language that contributes to the collaborative process; the Teasley and Roschelle (1993) 'narratives'. These aspects of collaboration will be shown in the example I analyse in the next section.

The most common work on collaboration in D&T using ICT involves video conferencing. For example, students can design a product and produce a drawing using CAD, then send this drawing electronically to a remote site for manufacture and use video conferencing to communicate with the manufacturer and watch the process. There are a number of centres that provide remote manufacturing services to UK schools as well as equipment manufacturers, such as Denford (http://www.denford.co.uk/). Another example would be students consulting with a remote expert about their work (e.g. Open University 2000). Currently the technology for any of this work is still not routinely available nor is it easy to use. But, even where it is in extensive use, the amount of discussion of the learning issues in a related publication is small (e.g. Arnold 2002). (Even BECTa, the main agency that promotes ICT in England, devotes all of its web site area on video conferencing to technical issues http://www.becta.org.uk/technology/desktopvc/desktop_vc/vcresrc.html).

Of course while there remain many technical issues to be overcome before such collaborative technologies become common place, it is inevitable that the concern of teachers, and those who support them, will be on the technology rather than the teaching and learning. The example I give in the next section is presented in the spirit of putting the emphasis on teaching and learning at a time when it is difficult to implement any such collaborative technologies in schools.

An example of collaboration

The example that I will analyse involves two students from different schools who remotely collaborate on the design of a pen that can be manufactured from a series of plastic tubes (Open University 2001). They are using standard drawing and communications software (Micrographifx *Windows Draw* and *NetMeeting*). This allows them to have on screen the same view of the drawing and for them to each take control of the mouse in turn to work on the drawing. As they work they can also see a video picture of each other, along with an audio link through headphones and microphone (see Figure 1). They are therefore able to talk to each other as they jointly work, with each student able to contribute.

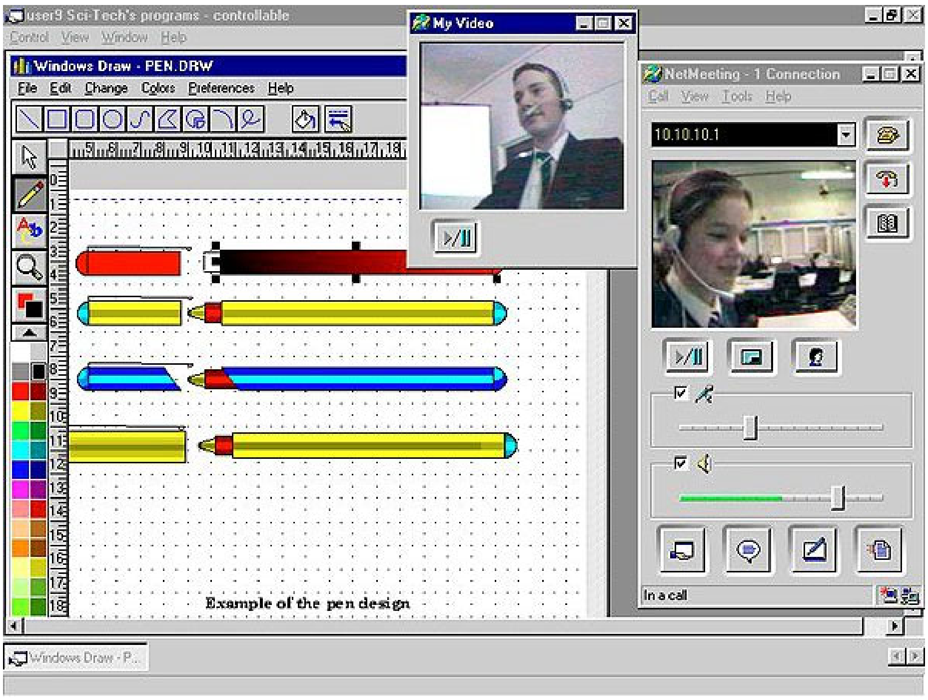

Figure 1

Students working on a pen design, showing the video link in small windows on screen

This is an example of desktop video conferencing, with the addition of a shared common workspace. The students had been working on this project prior to the lesson in which they collaborated. They had already developed the skill of using the drawing software and had ideas about what pen they would design. This was the first time they had ever used this communications software, and prior to the lesson they had not communicated about what they would do (their teachers of course had). They started with a simple tube as the body of the pen, decided who would draw it, what colour, then worked on the shape of the nib, and the pen top (shape and colour).

As this was their first time, inevitably the collaboration was at a primitive level, and simple decisions were taken with little discussion, but with a regard for the other person. In addition the collaboration shows unequal participation by the students, with one student 'taking charge', but in a collaborative spirit. It illustrates some important issues, and points to the potential of this collaborative environment, which I will draw attention to below in terms of both 'collaborating to learn' and 'learning to collaborate'.

Although this was an example of video conferencing, with the students able to see each other, the important medium of communication was the audio link (when combined with viewing and working on the shared workspace). Given the high premium on the video in terms of the bandwidth for the network linking the computers, it would have been as well to dispense with the video of each student. Where students can show each other objects or drawings then the video may be useful, though full-screen video would be more appropriate.

Collaborating to learn in the example

During the interaction a number of statements were made by the students indicating collaborative thinking and hence collaborating to learn. The first concern *design decisions*:

> You're going to have the nib yellow? [*indicating an implicit decision made by the other student*]
>
> It doesn't have to be round it can be square. [*the student is checking that the other has considered this choice*]
>
> I'll do the clip red? [*checking that this is ok*]
>
> Is that ok there, or is it a bit too big? [*checking this size decision*]

There were also statements that indicate students *making thinking explicit*, for example:

> I'm just going to draw it [*the pen top*] on it [*the body of the pen*] and then take it off.

This procedural knowledge, illustrates both the use of the software (to draw the pen in situ and then to move it to create it as a separate component) and the procedures involved. By its nature collaborative activity lends itself to making thinking explicit, because the students have to explain their thinking to each other (this is its 'mediation' role). Where such explicitness does not occur, it may be that students need to learn to collaborate, to ensure they create the intersubjectivity that is essential for collaboration.

Some of the elements on 'deciding what to work on' (under 'learning to collaborate' below) can be seen as making thinking explicit.

Collaborative moves in the example

These moves are important in learning to collaborate and are often not explicit nor negotiated between collaborators; for example, one student taking the mouse out of the hand of the other to carry out an operation, without asking or ensuring that the other student is happy to relinquish control. These moves become more evident in the situation where students are working remotely, because of the structuring given by the technology (in the way Schrage 1990, describes for the long-distance telephone call). Examples of these moves evident in the example are those associated with:

- taking control [*facilitating turn taking*]

  You want to control it [the mouse] and colour it [the pen] in?

- deciding what to work on ['*self*' regulation, where '*self*' is not an individual that is being regulated, but the collective, the pair]

  Do you want to draw the rest of the pen, the tip of the pen?
  I've just drawn the lid now you can colour it.

As noted earlier, some of these moves will concern the process of collaborative thinking, and will overlap with that category. This overlap is more likely when the collaboration is extensive, indeed the fact that this is a relatively primitive level of collaboration may mask the potential of this example. I will examine this potential to illustrate how collaboration can be more sophisticated.

Potential of this example

I will examine this potential, firstly through the nature of the task, and then by exploring what aspects of collaborating to learn and learning to collaborate could be developed.

a. Nature of the task

To take up the idea of peers acting in a guided participant role, it is possible to have one student who might be experienced at some aspect of the design, working with another student whose expertise is different.

To link students to the community of practice of designers, the collaboration could also involve an expert designer in industry to:

- jointly design a product;
- to present a design proposal, or completed design, for a consultation.

For this situation the relationships are different from those of peer collaboration. There have been many initiatives over the years to involve outside technology experts in work in schools. This approach using ICT can overcome the difficulty of such experts being released from the workplace to visit schools, which would allow the use of the limited number of such experts who are able to bridge the gap between professional and school situations. More elaborate collaborative designing is possible if the student is working on industrial problems giving them a participatory role in the community of practice (and hence various levels of legitimate peripheral participation).

It is also possible to jointly design a product with a client, and this is particularly important when students must appreciate the needs of the client. For example, in designing with the disabled there is a need to appreciate the needs and to discuss with them the possible designs. It would be possible to actually include the disabled person in the design process, thus emulating one of the situations seen as important in the 'co-designing' movement noted earlier in relation to design outside schools.

b. Collaborating to learn

The example did not involve the students in establishing the purpose and need for the object being designed, one of the elements of intersubjectivity. Possible approaches to establishing this element of intersubjectivity include:

- investigating and deciding upon pens to be used in students' own schools (e.g. defining the sizes, colours and shapes required), for example through a user survey (they might decide to try to produce a pen that serves their two different sets of users);
- reconciling different needs within a jointly agreed design.

The example had little scope for students exploring each other's mental state to reach agreement on, for example, how to satisfy the needs and how this might be done through alternative designs. This agreement could generate a range of products or a single product that can satisfy the needs across the two situations (schools).

If the object being designed was different then cultural differences may become important; for example, a toy for a child, where different child care arrangements or education may result in different needs. Alternatively a bicycle lamp could be designed that needed to comply with different legal requirements (where, say, the students are in different countries).

c. Learning to collaborate

Deciding on steps in the process ['self' regulation]. The talk, taken from the example above, indicated 'self' regulation at the level within a particular step in the process of design (in this case detailed designing). It may be that this regulation could be at a higher level; for example, deciding if user needs had to be examined or whether a detailed design specification was necessary.

Resolving difficulties [repair]. The flow of actions and decisions in the example indicated no difference in opinion at any level (partly because one student dominated). When contentious issues are at stake then students need to learn how to resolve these and, in particular, how to repair differences in perception of what the issues are (to explore each other's mental state).

Decision taking. In any group activity different roles can lead to individuals taking some decisions on their own and some collectively. Students need to learn which are appropriate to be done individually and which collectively. This would become evident with a project lasting a number of weeks and a limited number of remote links being made by the students.

Will the potential be realised?

It would not be unreasonable to take a sceptical note in viewing the potential of this form of design activity. First, as noted earlier, the promise of ICT has not been realised, not least because the access to sufficient high quality ICT hardware and software has been limited. Second, the potential to transform teaching and learning has been oversold, and in some cases ICT adds very little. I would argue that the latter problem is more to do with the difficulties of the former (lack of access to ICT), consequently people have been pre-occupied with the technology. Experience from video conferencing indicates that such network technologies will take time to become easy to use and to be robust enough to guarantee a smooth-running lesson. In that time the preoccupation is with the technology, as it is the most immediate problem. This in turn leads to insufficient thought to the educational benefits. Collaborative technologies offer the transformation of teaching and learning to take us into new situations for which we do not have the pedagogic techniques. For example, if we are to help students to collaborate to learn and to learn to collaborate, how are we to intervene in an interaction to support it? The means of interaction exclude the teacher, and interventions are intrusive in the task of designing, making it difficult to help students. Similarly, assessment of joint work is problematic in a tradition that favours individual assessment.

Nevertheless it would be a pity to wait until the technology is better to think about collaboration; it would be better to have developed ideas, ready for the day when they can be implemented routinely. Some of the research from the world of design outside schools, discussed earlier, offers help in some areas. For example, Garner and Hodgson (2002) found that student designers in higher education found video conferencing ineffective for joint designing, and were happy to use mobile telephones (not unrealistic in schools and universities, given the ownership of these among young people!) to supplement meetings, individual CAD working and file sharing. This reinforces the point I made earlier about dispensing with the video image in favour of the audio link alone. As noted earlier, some of the approaches adopted in universities in the past may use technologies that are now available to schools. Wojtowicz, Davidson and Nagakura (1995) explore three kinds of environments that were used in a Virtual Village Studio project. The first, *design correspondence*, resembles the desktop earlier example, where two workstations read and write (electronically) to each other (synchronously or asynchronously). The second is a *digital pinup board*, where many workstations can read and write to a pinup board so that they can all share the same documents (asynchronously). The third environment was *distanced collaboration*; in effect two pinup boards linked so that two sets of collaborators (each set linked to one of the boards) could work together. While these particular models may not apply to school projects, they provide ways of thinking about the collaboration rather than the limitations of existing school ICT. As web-based technology reaches schools, more flexible approaches that resemble current professional design will become possible, and hence can be used in schools (just as professional CAD software is now available to them).

The particular needs of schools, and the importance of clear teaching and learning goals and approaches, call for research and development activity in this field, for the potential of collaborative ICT-based design to be realised.

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"It's Just Computers and Electrical Stuff…": Changes in Students' Views of Technology in a Year 7 Classroom

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Previous research in technology education has shown that primary school students often possess limited views of technology, which are centred on the products of technology, such as computers and electrical appliances. In this study four Year 7 classes were involved in a design and technology unit of work structured to present a holistic view of technology that integrated the various components of technological design. Data sources included student interviews, survey instrument results, audio- and video-recordings of classroom interactions, students' written reflections, and student-produced artefacts. Findings indicated that the majority of students possessed narrow views of technology at the commencement of the study, which were consistent with previous research. Data analysis conducted during the intervention and at the conclusion of the study indicated that the majority of students had developed more integrated views of technology, which were no longer only focused on the products of technology. Further, there were changes in the source of ideas and explanations given by students in the final design activity when compared to the initial design activity.

Introduction

While craft oriented curricula for specific groups have been in existence for many decades, technology studies within general education is comparatively recent both internationally, and in particular in Australia (Eggleston 1992; Layton 1993). While considerable diversity exists internationally in technology education, the predominant thrust is towards a broad view including a design and problem solving approach (Layton 1993; McCormick 1997) rather than the more narrow craft/vocational view, the former view being consistent with the thrust of A Statement on Technology for Australian Schools (Australian Education Council 1994).

Ideally, students should use design processes and undertake the construction of artefacts in learning environments that resemble the everyday environments that designers and engineers work in (Roth 1998), that is, what are often called 'authentic contexts.' Authentic contexts are real life contexts that provide the basis for rich and purposeful experiences in design tasks (Davies 1996; Kimbell, Stables, & Green 1996; Roth 1998). Significant outcomes have been claimed for students experiencing authentic activities in the design technology context (Hill 1998; Ritchie & Hampson 1996). Authentic, open-ended approaches to teaching technological concepts provide students with ownership over tasks they undertake during technological activities, which has been shown to be important for student learning (Fleer 1999; Solomon & Hall 1996).

In Queensland, Technology is now a Key Learning Area implemented across the curriculum, especially in the primary school. The Queensland Technology syllabus (Queensland Schools Curriculum Council (QSCC) 2002, p.1) recognises that:

> technology involves envisioning and developing products that meet human needs and wants, capitalise on opportunities and extend human capabilities. Products of technology include artefacts, processes, systems, services and environments. These products make up the designed world. Products of technology have impacts and consequences on individuals, local and global communities, and environments.

The syllabus uses the term 'working technologically' to describe a way of working that interweaves technology practice, information, materials and systems with considerations of appropriateness, contexts and management. The implicit purpose of 'working technologically' is the design and development of products that enable people to meet their needs and to capitalise on opportunities. It is therefore important that teachers employ authentic activities in design and technology classrooms to develop the expressed intentions of the syllabus and enhance design and technology education.

Many studies have investigated student and teacher views about technology and their influence on technology education. In a series of studies Rennie and Jarvis have investigated student and teacher views of technology in Australia and the UK (Jarvis & Rennie 1996; Rennie & Jarvis 1996) reporting the limited views held by both teachers and students and a high degree of commonality between student views of technology in those countries.

Considerable debate is also present in the literature about the nature of technology, technology concepts and processes with general conclusions being that technology concepts are not well defined in the literature, that by its nature technology is multidimensional and draws on a wide range of concepts, that concepts and processes need to be developed in conjunction, and that the design process is not simply a sequential series of steps (Johnsey 1995; Jones 1997; McCormick 1997). The classroom culture, including the openness and "authenticity" of activities has also been shown to strongly influence the manner in which students operationalised their technological activities (e.g. Jones 1994; Murphy & McCormick 1997).

In our previous research (McRobbie, Stein, & Ginns 2001; Ginns, Stein, McRobbie, & Swales 2000) with teachers inexperienced in design and technology studies as they began to introduce those studies into their classrooms, we have reported that there was little evidence of student discussion of scientific or technological principles relating to student artefact construction or operation. Further, these teachers, because of their limited knowledge of both science and technology were unable to capitalise on the opportunities inherent in the artefacts to introduce discussion along those lines. In this study we investigate whether providing teachers and students with support relating to the development of some of the scientific and technology principles related to their design activity results in changes in the way students undertake and discuss their design activities.

The aim of the study was to investigate whether an intervention designed to increase student and teacher knowledge of science principles and related properties of materials resulted in:

- changes in students' views about technology, and
- changes in the source of ideas and explanations students employ in a design and make activity.

Research design

The study was conducted in four year 7 classrooms (approximately 100 students) in a Brisbane primary school. These classes were organised so that they operated as two combined class groups of two classes each. Four groups of three students were selected from each of the combined groups for intensive study. These students were selected from their responses to initial surveys to obtain variation in those responses. Each combined classroom engaged in a series of design activities on a theme (about 15–20 hrs over about 5 weeks), which were sequenced to develop student tool and discursive practices. The study sought to implement design activities that encompassed the following features (Crismond 2001, pp.792–794):

- Good design challenges involve authentic hands-on tasks…
- …made from familiar and easy-to-work materials using known fabrication skills…
- …and possessing clearly defined outcomes that allow for multiple solution pathways.
- Good design tasks promote student-centred, collaborative work and higher-order thinking
- …and allow for multiple design iterations to improve the product…
- …with clear links to limited number of science and engineering concepts.

This paper will report on a section of the unit in which students initially designed and constructed an iceblock container that would prevent an iceblock from melting over a one hour period. At the conclusion of this activity two of the researchers engaged the students in a sequence of science activities designed to provide them and their teachers with conceptual knowledge of the principles of heat transfer and related properties of materials. These activities included hands-on demonstrations and activities in which conduction, convection, radiation, and the insulation properties of materials were investigated. The students then designed and constructed a hot food container that would keep a food item and drink warm for a period of two hours.

Data were derived from; field notes and analytic memoranda based on observations of the classrooms, with a particular focus on the four selected groups of students; classroom documents and artefacts; surveys relating to prior views (all students in the selected classes completed; the Attitudes and Perceptions about Technology survey (Rennie & Jarvis 1996), an open-ended writing/drawing task on "What technology means to me," and a picture quiz as used by Rennie and Jarvis (1996) with primary children); student logbooks; initial and final interviews with students; and video and audio recordings of classroom transactions and student actions. Classroom transactions and interviews were transcribed for analysis.

Results and discussion

The results of the study will be discussed under the following three assertions that were drawn from analysis of the multiple sources of data.

Assertion 1 – Students views of the nature of technology changed from being narrowly focused on the products of technology at the commencement of the study to more informed views in the majority of cases at the conclusion of the study.

Pre-intervention

Results from data analysis of interviews and survey instruments completed at the commencement of the study indicated that the majority of students held narrow views of the nature of technology that were typically focussed on the products of technological innovation. These limited views of technology were evident in responses to the question, "What does technology mean to you?" posed in the initial interviews and survey instruments. Example responses were:

- big appliances that normally run off electricity
- a lot of new things invented, computers and things that can help people to do things
- technology would have some sort of source of power to make it run …
- its just computers and electrical stuff.

Students also exhibited narrow views of the possible technological activities involved in design and technology. They assumed that the types of activities they would be engaged in during the unit would involve working with electricity, batteries and computers:

- working on the computer
- creating your own machine using electricity, batteries …
- you might have to construct like a Lego ™ model that actually moves parts.

Post-intervention

At the conclusion of the study the majority of students expressed more informed views of technology that extended beyond commenting mainly on the products of technological innovation to present views that could be described as being more highly integrated. Students' responses from final interviews included:

- designing your own things and seeing if they work and testing…
- Technology is like new design and new products and stuff to be tested and new ideas to see if they work and to improve new things and if they do work, why do they work.
- making something better and working out what its kinks are, or problems, and trying to fix those problems to make it better.
- I thought technology was computers and everything but it's more designing. It's just not computers. It's designing and making stuff.

This last comment in particular shows changes to students' thinking about what technology means to them.

Assertion 2 – The intervention changed the students' views about heat transfer and the properties of materials involved in heat transfer.

Initial design activity

The majority of students held alternate conceptions of principles of heat transfer during the designing and construction of the first authentic artefact, the iceblock container. For example, students expressed confusion over whether immersing the iceblock in water would help or hinder the preserving process. Although some students were able to use appropriate language such as 'insulation' they were unable to articulate a scientifically acceptable meaning of the term.

- but something can't melt if there's no water around it to make it melt…can it?
- water is what makes something melt so if we make sure there is no place for water to go, how will it melt…
- aluminium has to be on the very outside
- aluminium can be on the inside too because around the ice block will make it cold cause whatever is there is going to be cold, right. Aluminium will get cold and it will be like an insulator.

Many students chose appropriate materials, such as Styrofoam, when constructing the iceblock container, but were not able to express why these materials would be effective in terms of their heat transfer properties, as is evident in the following statements:

- But doesn't that (alfoil) generate heat?
- Yeah generates heat on the outside so then the heat goes through the alfoil and makes it warm.
- We need something like to keep the coldness in and then it's got like a barrier there to the hotness and then a space between it and it's got like not wool but something thinner but not touching it…It can't be wool cause that's too hot.

Post-intervention

Alternate conceptions of heat transfer were also evident in students' responses during activities developing the science principles and properties of materials relating to heat transfer, although many students appeared to accommodate more informed views at the end of the activities. For example, many students thought an insulator "kept the heat out" at the beginning of the session, but after engaging in the activities, students' responses typically reflected more scientifically appropriate explanations, for example, "because insulation is insulation, it will still do the same thing whether you're keeping something hot or keeping something cold".

A shift in students' views of the nature of heat transfer and related properties of materials was evident during the planning and construction of their second authentic artefact, the hot food container. Students were able to not only select more appropriate materials for the artefact, but explain why these materials were appropriate based on their properties and the students' evolving ideas about insulation and heat transfer.

- Inside the box I was thinking we could make a platform up the top cause hot air will rise to the top and that's where it (the hot food) will be and keep it a bit hotter.

Assertion 3 – There were changes in the source and explanation of ideas that students drew on in the initial design activity when compared to the final design activity.

Pre-intervention

Students drew extensively on everyday, out-of-school experiences as the sources of their technology knowledge at the commencement of the study and during the design and construction of the iceblock container. Very few students cited in-school experiences that had helped them to make or explain decisions during technological activities.

- Think about it if your Mum wraps a doughnut or something in your lunchbox and your bag is in the sun all day, your doughnut doesn't get hot because it's in the gladwrap.
- We wrapped the block up in newspaper because my Dad said they used to wrap meat up in newspaper to keep it cool.
- Mirrors reflect heat and they've got metal at the back of them
- Does wood keep in heat?…Yes wood (does), oh you know saunas they're lined with wood…

Post-intervention

During the set of science activities conducted by the researchers, students participated in many activities including a convection current activity (hot air rises), radiation with different coloured papers (black absorbs heat, white reflects heat, shiny side of alfoil reflects heat, matt side of alfoil absorbs heat), and an activity using different materials to insulate cans of hot water. Students' artefacts were observed to incorporate many of these concepts, for example, most artefacts were painted black or covered in black paper and almost all designs used the principle of hot air rising in the positioning of their food/drink items.

- Why are you painting it black?
- So that it conducts heat, cause black was the highest temperature.
- Which side of the alfoil will you use…?
- Shiny side reflects…the non-shiny side absorbs.

Further, many students appeared able to select and justify appropriate materials as a result of their intervention experiences and incorporated scientifically acceptable views of heat transfer and insulation in their designs. Students were also observed to connect and/or modify their ideas from the initial design activity (the iceblock container) to incorporate and/or modify them for the final design activity (the hot food container). When asked whether the hot food container was different from the iceblock container, one replied: "We actually should have done it the same because it would have kept the heat in. …because Stryofoam keeps the heat in." When asked further if it keeps things at the same temperature, she replied in the affirmative.

Conclusion

This study was designed to incorporate a unit of work on design and technology into a primary school classroom that was centred on the design, evaluation and production of authentic artefacts. Previous studies with elementary teachers with limited science backgrounds have shown that students or teachers in design and technology classrooms seldom discuss science or technology related principles in the design or evaluation phases of their activities. This study showed that initially, the students drew predominantly on out of school experiences to inform their views of technology and their design activities. It further showed that when teachers are aware of appropriate science and technology principles and provide appropriate learning experience for students to experience and discuss those principles, students will attempt to draw on, apply and discuss those principles in addition to drawing on their previous out of school experiences.

These findings have clear implications for the professional development of teachers, especially those who are inexperienced in science and or technology principles. It shows that if teachers are to capitalise on the opportunities for development of science and technology principles in students through design and technology activities, it is important to ensure that they are provided with opportunities to develop their own knowledge.

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The Model of Situated Cognition: Lessons for Technology Education

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The intention behind the new learning area known as technology education has been to move away from the old paradigm of technical or vocational training to a new paradigm of critical technological literacy. Teachers have moved from craft-based technology teaching into a new curriculum that presumes they can establish the type of authentic situated cognitive settings that will allow their students to develop the cognitive skills required. Lacking the skills to make the transition, they tend to fall back on their traditional modes of teaching, which means that the type of intellectual skills that students need in today's rapidly changing, technological society are not being met. The model of learning known as situated cognition offers one possible solution by giving teachers a means not only of understanding what is meant by technology in general and the technology curriculum in particular, but also of ensuring that their students engage in total technological practice.

Introduction

As the world entered the new millennium, many educators and policy-makers realised that students needed to be equipped to live in a world that was rapidly changing. Educational reforms were essential so that students could be educated to face the challenges of the new century. One such reform involved the emergence in many countries of a new discipline, technology education, designed to replace the skills-orientated, technical subjects of the past, such as metal work, typing, and clothing. The intention behind this new learning area has been to move away from the old paradigm of technical or vocational training to a new paradigm of critical technological literacy. A technologically literate person, it is deemed, has the power and the freedom to examine and question issues of importance in a technological society.

Teachers' concepts of technology and technology education have a direct bearing on how students perceive the subject (Jones 1997). It is therefore of concern that, in New Zealand, many teachers' concepts of technology are still craft based and that teachers are guiding their students' concepts of technology accordingly. Blame should not be laid entirely at the feet of our teachers, however. Teachers of technology frequently have been required to take on the challenge of this new subject without being given the opportunity to build their own technology knowledge and practice. Novices, themselves, they have not yet attained the conceptual knowledge and process they need to guide their students to undertake technological practice in its broadest sense (Jones 1997).

Anecdotal evidence and my own experience as a teacher educator in the area of technology indicates that this situation is particularly apparent in secondary schools, where teachers of technology tend to rely on their backgrounds in the former craft-based subjects when setting the content and structure of their technology lessons. This 'fall back' stance also reflects the fact that teachers often return to the 'comfort zone' of their usual mode of teaching and/or subject sub-culture when required to move from the certain to the unknown. The danger, of course, is that the students become confined to the same narrow sub-culture view. As Jones concludes from his review of student learning in the area of technology education, 'When students' concepts of technology . . . are narrow[ed]. . . this constrain[s] their technological practice and limit[s] the potential for learning technological concepts and process' (1997, p.90).

How can this situation be arrested? I believe that the model of learning known as situated cognition offers one possible solution. The use of this model would give teachers a means not only of getting to grips themselves with what is meant by technology in general and the technology curriculum in particular, but also of ensuring that their students engage in total technological practice and become technologically literate. My purpose in this article is twofold. My first aim is to examine the model of situated cognition with references to those researchers who have contributed to its development. My second is to suggest, where appropriate, how the principles and practices implicit in situated cognition can be employed to enhance the teaching and learning of technology in our schools.

Situated cognition

Situated cognition is perhaps best described as the learning that occurs in the situation where the learning takes place. It operates on the premise that the acquisition of knowledge (the cognitive process) is situated in activity, and that this knowledge is then used and made sense of within specific contexts and cultures. Social interaction is a critical component of situated learning because the learning takes place in a community of practice that embodies certain beliefs and behaviours. The community of practice in which an architect, for example, is engaged, is likely to have some similarities to that of a mechanical engineer, but the two are likely to consider quite different social and cultural issues in their everyday practice.

Brown, Collins and Duguid (1989) encapsulate these premises with their claim that *what* is learned cannot be separated from *how* it is learned and used. The *activity* of learning is thus integral to what is learnt. For them, the activity and the situation are integral to cognition, and so 'support learning in a domain [subject area] by enabling students to acquire, develop and use cognitive tools in authentic domain activity. Learning, both outside and inside school, advances through collaborative social interaction and the social construction of knowledge' (p.32). If educators ignore the situated nature of cognition, say Brown et al, they defeat their goal of providing relevant and useful knowledge.

Knowledge also needs to be presented in a manner that allows learners to draw on their existing knowledge. This ability to call on accessible and useable knowledge is a strategic process in that it gives learners the cognitive tools to decide *how* to decide and *what* to do and *when* to do it. Such tools are vital to the type of learning that the technology curriculum encourages.

That an individual possesses this strategic (or, as it is also known, procedural) knowledge should not be assumed, however. Nor should it be assumed that an individual knows how to draw upon that knowledge even when he or she does possess it. Furthermore, in the school situation, in general, and in the manner in which technology, in particular, is (mis-)taught, students frequently are asked to use a cognitive tool (e.g. problem solving) without effort being made to ensure that this tool (or set of tools) has relevance to both their existing conceptual strategies and culture. As Hennessy (1993) concludes from her studies on the use of situated cognition in the classroom, 'the failure to build upon children's informal knowledge impedes acquisition of the formal calculation methods and precludes children from bringing their implicit conceptual understanding to bear. The teacher's job accordingly becomes one of trying to reconnect principled conceptual knowledge with procedural knowledge' (p.10). In short, if schools (and teachers of technology) are to provide their students with the types of 'authentic' learning outlined here, it is imperative that they are given the understandings and opportunities required to link together existing and new conceptual knowledge, cultures, activities and cognitive tools.

Authentic learning and the notions of cognitive/craft apprenticeship

Students regularly encounter difficulties in learning in a school culture because it is far removed from the real situation of their every-day lives and cultures. The context of their learning is therefore not authentic. Too often, it seems, school students are denied access to the lore and practices of the cultures implicit in a subject area. Authentic activity, as an essential aspect of the practices associated with situated learning, allows students to experience the real practice of a subject area. Authentic activity can be achieved by inviting into the school practitioners of specific tasks and occupations or, conversely, taking the students out to the real world of the practitioner. Authentic activity also involves, to the extent that circumstances allow, students seeing teachers genuinely engaging in and reflecting upon authentic exploration of the subject matter at hand; of seeing teachers acting as practitioners and using these cognitive tools to wrestle with the problems of the world.

The type of authentic learning expounded here involves, as Brown et al (1989) suggest, an apprenticeship model. As they observe, the very word 'apprentice' implies that the core of learning is inherently situated in authenticity. The teacher promotes learning by making explicit his or her own tacit knowledge and by modelling strategies for the learners in authentic situations. The learners eventually are empowered to continue independently.

> To learn to use tools as practitioners use them, a student, like an apprentice, must enter that community and its culture. Thus, in a significant way, learning is, we believe, a process of enculturation. . . . Many of the activities students undertake are simply not the activities of practitioners and would not make sense or be endorsed by the cultures to which they are attributed (Brown et al 1989, pp.33–34).

New Zealand's technology curriculum lends itself well to the authentic learning premises just described, as these statements from the curriculum document (Ministry of

Education 1995) indicate:

> . . . students are motivated to participate in purposeful activities, enabling them to apply and integrate their knowledge and skills from many learning areas in real and practical ways. Technology education offers authentic opportunities for community interactions and for linking school activities with the wider world of enterprise and the community (p.7).
>
> Learning activities in technology provide natural, regular, and authentic opportunities for students to relate to others and work co-operatively. Many problem-solving tasks demand a high level of negotiation, collaboration, and respect for others (p.19).

In essence, situated cognition involves enculturating learners into authentic practice through authentic activity and social interaction. To illustrate how this model can work in practice, Brown et al (1989) refer to teaching practices developed by Schoenfeld. Although mathematically based, Schoenfeld's practices have relevance for any learning area, including, of course, technology. When teaching mathematics, Schoenfeld encouraged his students not to use problem solving as an isolated tool but to view mathematical problems with a mathematician's eye and to use a mathematician's tools. By setting the solving of mathematical problems within an authentic context, Schoenfeld enriched his students' conceptual learning because that learning went well beyond reliance on an abstract conceptual tool and related to practice.

Situated social practice and its implications for schools

Situated social practice emphasises the inherently socially negotiated quality of meaning and the interested, concerned character of the thought and action of persons engaged in activity. For Lave (1991, p.67), whose work in the early 1990's on situated learning on communities of practice contributed significantly to the development of situated cognition, 'learning, thinking and knowing are relations among people engaged in activity in, with, and arising from the socially and culturally structured world.' In other words, the world itself is socially constructed.

Lave uses the analogy of 'oldtimers and newcomers' to illustrate this process. Within any community, newcomers enter at its periphery, but as they become active and engaged within the culture of the community, they move steadily to its centre, eventually assuming the role of oldtimer. Lave's conception of oldtimers/newcomers accords with the technology curriculum's encouragement of teachers to invite experienced technologists into their classrooms. These people (oldtimers) bring with them expert conceptual and procedural knowledge of their practice, and they are able to identify for students (newcomers) issues and problems associated with their practice in a societal context. By offering concrete examples of practice and giving students opportunity to engage with the real world, these people help students appreciate how they can use (independently in time) cognitive tools such as problem solving to enhance their understanding and knowledge of technological processes and issues.

Lave's views have a direct parallel with the apprenticeship model. She believes that newcomers must be given a good view of what is to be learnt from the very beginning. Goals must be made clear for the newcomers so they know where they are heading. This endorses Brown et al's (1989) view that cognitive learning must be explicit for learners. It also brings to mind Hennessy's (1993) discussion, within the context of situated cognition, of 'novices and experts'. Experts, says Hennessy, have at hand the intuitive specialist knowledge of their particular domain that comes from years of engagement in that area (p.1). Novices, of course, do not have this benefit. Unless the expert knows how to make his or her knowledge explicit and grounded within the novices' existing knowledge and experience, the required cognitive learning may not take place.

The implications for using experts within the technology classroom are obvious. Technology teachers must take care to brief fully these visitors on the students' levels of understanding of a domain, their ability to use certain cognitive tools, and the required learning outcomes. This point is given extra credence from studies conducted at Vanderbilt University in the early 1990s (see, for example, The Cognition & Technology Group at Vanderbilt 1990). Here, the researchers found that students' learning outcomes as a result of experiencing a type of situated learning the researchers termed 'anchored instruction' were best realised when the students received clear explanation of the goals and purposes of the instructional tasks in which they were engaged.

Broadening the scope of her discussion, Hennessy (1993) argues that knowledge is not readily transferred from one situation to another. With her colleagues McCormick and Murphy, she observes that 'Practitioners rarely find it useful to draw upon knowledge or skills attained during schooling. This is because schooling does not prepare pupils for later life or for problem solving in the work place; it can be viewed as a unique culture, a specialist practice with its own conventions, organisations and concerns, which are of little value to society outside' (Hennessy, McCormick & Murphy 1993, p.75). They actually give as an example the subject-matter of technology, noting that teaching which does not reflect the real world of technological activity is unlikely to develop successfully students' awareness and appropriate use of technology thinking. Research carried out by McCormick et al (cited in Jones 1997) also indicates that students have difficulty translating knowledge taught in alternative subject areas to technological problems. Conversely, the aforementioned research carried out by the Cognition and Technology Group of Vanderbilt University within the area of technology education revealed that teachers needed to make it clear to students that the tools and knowledge they gained in their technology tasks could be employed in other subject areas and contexts. This process of 'transference' is an important aim of the New Zealand technology curriculum.

In line with one of the basic premises of situated cognition theory, Hennessy (1993) highlights the importance of situating learning in social settings. She observes that although 'knowledge moves from being private to being shared through engagement in socially shared activity and discourse' (p.3), our education system still favours individual success. Furthermore, despite many teachers advocating group work, students still work as individuals within the group, frequently because the group work is not set up with correct procedures and clear roles and expectations. The technology curriculum attempts to address these issues by stating that students should be encouraged to work cooperatively and collaboratively with each other, their teachers and other adults (Ministry of Education 1997, p.19).

In the real world, Hennessy (1993) continues, problems are seldom as clearly defined as they are in schools. We solve them by actively seeking information that is relevant to the problem. In the school situation, problems typically are pre-formulated and not situated in reality. For example, the maths taught in schools has very little relevance to the way that maths is used in every day life. Hennessy cites two studies on adult numeracy that found formal teaching of mathematics to have little relationship with the mathematics commonly practised on a daily basis. Again, the relevance of such considerations to the technology curriculum is obvious.

According to Hennessy (1993), children are capable of participating productively in activities involving mathematical and scientific (read also technological) thinking. They have at hand an implicit understanding of many concepts and principles before encountering the instruction that enables these to be made explicit. Yet progress is slow because teachers and curriculum developers tend to ignore children's existing knowledge and experience. They have difficulty bridging the gap between school-taught procedures and every-day practice and thinking. This concern is supported by Simpson, cited in Hennessy (1993, p.9), who observed frequent mismatches between students' actual learning experiences and outcomes and teacher-intended learning outcomes. An astonishingly high proportion of the tasks presented by the teachers were not matched to children's level of attainment, and teachers remained unaware of the cases where they had underestimated the children's actual abilities. Such concerns are fundamental to the need to situate new learning experiences for students within their existing knowledge and practice.

For Hennessy (1993), the ultimate aim of the apprenticeship model of learning is to give learners control over their own learning processes and the confidence to engage in critical analysis. Tutors make their tacit knowledge explicit by modelling through authentic activity effective strategies and by demonstrating desirable ways of problem solving. The process continues with the learners' knowledge increasing through the social sharing of tasks. Eventually, 'fading' occurs. Tutors gradually withdraw their help as the learners develop the ability to think independently and acquire the practical skills to solve the problem. Under the apprenticeship model of learning, tutors must have some understanding of each learner's needs, knowledge structure and how he or she processes knowledge. They must also ensure that the learning is embedded in authentic and meaningful activity, and that it makes deliberate use of both physical and social contexts.

Lave, cited in Resnick (1991, p.6), argues that if we are to understand what is learned, we must understand how it is learned in the context of the social structures, both formal and informal, within the learning institution or school. She disputes the view that we can treat schools as neutral environments that have no social or cultural features of their own, yet where students can acquire competencies to be used in a range of situations. Resnick (1991, p.4) similarly challenges the view that the social and the cognitive can be addressed independently: 'the social context in which cognitive activity takes place is an integral part of that activity, not just the surrounding text for it.' For Lave and Resnick, every cognitive act must be seen as a response to a specific set of circumstances. In short, we can only fully understand the cognitive process by allowing for the situation in which that learning occurs.

What is important about Lave's and Resnick's views is that they challenge us to identify and think about the social structures, often invisible, that affect how learning occurs, particularly within the school. These structures can be at variance with the culture of the wider community, which makes it all the more important in terms of the principles of the technology curriculum for teachers to ensure that their students have access to the community beyond the school gates. Again, this can be achieved by bringing technologists into the school or by visiting these experts within their actual communities.

Even the tools we use within schools to process information bring with them cultural and social histories and conventions that constrain and limit what can be taught. These tools can be both cognitive—forms of reasoning and debate as well as theories and models—and 'concrete', such as maps, dictionaries, calculators and computers. We are rarely aware of the cognitive restraints associated with these tools, given that they are, as Resnick (1991, p.8) points out, products of our inherent social influences and knowledge.

Brown et al (1989, p.33) concur, arguing that conceptual knowledge should be considered as being similar to a set of tools. They state that using these tools actively rather than passively results in a rich understanding of the tools themselves and of the world in which they are used. Learning and activity are thus interwoven and cannot be separated. These views call on those of us who teach the technology curriculum to encourage students to examine critically the very tools, whether a computer or a theory, that they use in this area of learning. Such tools can provide the focus of a lesson—for example, the impact of the computer on society or how we now acquire information—or be used to further develop cognitive skills (for example, critical examination of a theory or model).

Information that I have gained from speaking with teachers indicates that a number of schools in New Zealand, intermediate particularly, are beginning to embrace these considerations when delivering the technology curriculum. For example, Mary Mason, a teacher at Remuera Intermediate School, recently delivered a unit called 'Gastronomical Delights for Golden Years' to her class. The unit engaged the students in all aspects of good technological practice as identified by the technology curriculum and including those that are characteristic of situated cognition theory.

During the unit, the students visited a home for elderly people and conducted research with the residents on their culinary likes and dislikes. The students looked at the residents' tastes in yogurt, bread and ginger beer. They created their products, took them back to the residents for evaluation and testing (including a tasting session), and then adjusted the products to meet the needs of the residents. The unit allowed students to learn new technological concepts and practices from experts/technologists (such as the chef) and to situate that learning, and the cognitive tools they used to conduct their research, within an authentic setting/culture. It also gave them experience of a section of society (that is, the elderly) that they might not otherwise have encountered, so enhancing their understanding of the some of the social and physical issues confronting these members of our community.

Summary and conclusions

Throughout this paper I have given a broad overview of the model of situated cognition and its development by various researchers. I believe, and have attempted to demonstrate in the article, that the instructional practices and learning outcomes implicit in this model sit very comfortably with the New Zealand Technology Curriculum's intent 'to develop technology literacy through integrating the learning strands to enable students to participate fully in the technology society in which they live and work' (Ministry of Education 1995, p.5). More specifically, the examples of learning and assessment practices given in the curriculum document encourage teachers to take students to authentic settings, engage in dialogue with technologists, and take cognisance of the impact of technologies on society. In this regard, the technology curriculum adheres very closely to the precepts of situated cognition.

Constructivist theory, which underpins the model of situated cognition, holds that forms and content of knowledge are constructed through active interaction with the environment. Most educators would agree that constructivism is now an accepted part of pedagogical theory and practice. I would argue, however, that very few of today's classrooms actively or correctly employ constructivist practices, such as those that are characteristic of situated cognition, and, if they do, the students do not perceive that what they are doing is constructing knowledge. This is a particular concern in the technology area, given that the curriculum objectives require students to construct knowledge in authentic, situated settings and then to transfer (build upon) what they have learned—whether it be new understandings about an issue or the use of new cognitive tools—to other situations, settings and subject domains.

But before we can expect students to achieve such learning outcomes, we must first ensure that teachers themselves have embraced the theory and been given opportunities to develop expertise both in specific technological domains and in the pedagogical practices mandated by the technology curriculum. Technology education in many of our secondary schools continues to be delivered by teachers who are not accustomed to facilitating constructed knowledge. They have moved from craft-based technology teaching into a new curriculum that presumes they can establish the type of authentic situated cognitive settings that will allow their students to develop the cognitive skills required. Lacking the skills to make the transition, they have tended to fall back on their traditional modes of teaching, which means that the intellectual skills that students need in today's rapidly changing, technological society are not being met.

In their 1989 paper on situated cognition, Brown et al (p.41) argue that the development of an epistemology informed by situated cognition in our schools requires the active support of interest groups. If we accept that such an epistemology has merit and that it is still not sufficiently apparent in schools, we must challenge the Minister of Education to acknowledge that simply familiarising technology teachers with the subject matter content of the technology curriculum, as appears to be happening with the National Certificate of Educational Achievement, is not sufficient. Technology teachers need both financial and professional support to undertake study that will develop their ability to deliver the technology curriculum in a manner that is congruent with its intent. Like the students they teach, they would be well served in this learning by the lessons implicit in constructivism in general and situated cognition and practice in particular. Such support would take our technology teachers from novice to expert, so allowing them to facilitate their students in their journey from apprentices to experts.

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Working Together To Improve Practice: The Intad Project

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This paper describes an action research project undertaken in seven Queensland high schools during 2002. The aim of the project was to examine the implementation of units of work based on the recently developed subject syllabus in Industrial Technology and Design. The project involved state and independent schools in both regional and metropolitan locations and covered a period of seven months. The project represents a new development in research in that the project was funded by the Industrial Technology and Design Teachers Association of Queensland (INTAD). At the time of writing this paper, the project was not completed so this paper represents a "work in progress".

Introduction

Professional development and research are important components of the introduction of new work programs. During 2001 the Industrial Technology and Design Syllabus (QSCC 2001) in Queensland was developed and approved by the Queensland School Curriculum Council (QSCC). In early 2002 Industrial Technology and Design Teachers Association of Queensland (INTAD) decided that the best way for the association to support the implementation of the new syllabus was to provide professional development to a select group of Industrial Technology and Design (ITD) teachers. Because the new syllabus involved a change from teacher-directed to more student-centred teaching strategies, INTAD believed that teachers would benefit from a more hands-on, and more intensive and sustained approach to professional development that more traditional approaches based on half or one day in-service programs. In addition, INTAD was keen to monitor the project in order to use the experience developed during the project to provide advice to teachers who subsequently implemented the new syllabus. The Centre for Technology Education Research (CETER) at Griffith University was commissioned to monitor the implementation using an action research methodology.

Background

In 1994 the national technology statement and profiles documents (Curriculum Development Corporation 1994a & b) were released. These outlined the nature of technology education as one of the eight key learning areas proclaimed as part of the Hobart Declaration (1989). However, progress in implementing the technology key learning area has been slow. The slowness has been a result of at least three features. Firstly, the Hobart declaration mandated revisions to all KLA's. The result of this is that state departments of education established schedules for the development and implementation of KLA's and in most cases the Technology KLA was not first in the schedule. Secondly, the Technology KLA encompassed a range of existing subjects that were seen to have conceptual links to the Technology KLA. However, they had traditionally had no or little relationship with each other. The result was some competition as teachers and associations attempted to maximise their influence on the shape and direction of the new KLA. Thirdly, The Hobart Declaration mandated that KLA's be introduced into schooling from years one or kindergarten to ten. This meant that a new curriculum area with new challenges was introduced into primary schools staffed by teachers who generally had no relevant training or experience and as a group were not favourably disposed to technology. In Queensland the QSCC took the decision that, in addition to the development of a Technology KLA, it was necessary to develop what it describes as subject syllabuses. Subject syllabuses have been developed for Industrial Technology and Design, Home Economics, Agriculture, Computing and Multi-Media. The project described in this paper concerns the implementation of the Industrial Technology and Design subject syllabus.

Methodology

The overarching methodology was action research. The reason for selecting this method was based on concerns for the effectiveness of professional development and a determination to research the project in ways that supported the professional development. The success of the professional development and subject implementation exercise that was the subject of the research was regarded as problematic. That is, the implementation was seen as representing a significant change in pedagogy and there was a question mark over whether teachers would be able to make the change. Given this, it was felt that a more sustained professional development program was required and that it would be useful to monitor this in some way, both to refine the process as it went along, and to provide a refined and well-documented model for future in-service programs. For these reasons a modified action research methodology was selected. That is, action research is designed to be undertaken by teachers for the purpose of professional development. However, for this study, while teachers identified themselves as being involved in the professional development and the associated research, external researchers were involved. However, the research was consistent with action research principles (Gay & Airasian 2000) in that teachers provided feedback on their developments and the study was based on teachers examining their own practice in the setting in which it takes place. The use of an external researcher is consistent with action research principles where the researcher provides: *External or peer observation involves having a peer or colleague observe, assess, and provide suggestions about an aspect of the teacher's practice such as questioning behaviour, lesson organisation, or feedback to students* (Gay & Airasian 2000, p.597).

Instruments

Data collection instruments consisted of classroom observations, interviews, teacher reflective journals of day-to-day progress and developments, and a monthly teleconference (six in all), where all teachers engaged in a feedback discussion with the external research assistant acting as facilitator. All tele-conferences were audio-recorded. Seven schools were involved in the study. Five were within the greater Brisbane metropolitan region and two were located in the country.

Table 1

Demographic details of participating schools

NUMBER	LOCATION	SYSTEM	NUMBER OF STAFF INVOLVED	LEVEL OF SUPPORT
A	Brisbane	State	2	$1000
B	Outer Brisbane	Independent, Church	1	$700
C	Regional	State	2	$800
D	Regional	State	2	$1000
E	Regional	State	2	0
F	Brisbane	State	2	$1000
G	Outer Brisbane	State	2	$1200

Results

Process & Observations

The project began with representatives from all seven schools attending an initial professional development (PD) day. The day occurred during school time and was intended to give all schools the benefit of an equal and progressive start. The PD program involved presentations from INTAD, the Queensland School Curriculum Council (QSCC – now part of Queensland Studies Authority, QSA), Education Queensland, and the researchers from Griffith.

Content of the PD included curriculum understanding, methods of unit planning, issues of delivery in school, assessment procedures, the role of the researchers, and description of action research and the data collection methods proposed for the study. While the day was considered successful many participants considered it a case of "information overload".

The visiting intentions for each school were negotiated, as follows. Each school would have an initial visit during the time when they were planning the unit that would be their trial. A second visit was organised to view an example of classroom delivery and discuss how well the teachers considered their planned projects had now been transferred to the classroom. At the conclusion of this visit, a short interview was held with each of the teachers directly involved.

The intention of the first visit was to observe their planning process and format. It was not the researcher's intention to discuss or offer opinion, even when these were asked for. Often the researcher had to make it clear that he was there to observe and report what he saw, without influence or bias, to the extent that this was possible. With many of the schools the first visit by the researcher was accompanied or preceded by a visit from a representative of the QSCC. This was not part of the initial plan but was useful in separating the roles of professional developer and researcher, with the researcher there simply to observe and record, and the QSCC representative to discuss and assist. This format was used with six of the seven schools. The more remote country school was visited by the researcher only.

Efforts were made to visit the schools at a time and date that was appropriate in terms of the timing of their project. Some schools had planned and started to deliver their trial projects prior to the initial visits by the researcher. It did not appear to hinder the continuity of the projects in any of the schools.

As the project continued, regular tele-conferences were held and recorded. The intention of the tele-conferences was to have regular contact with all participants and for each of them to offer updates on their own projects as well as to discuss and develop a better understanding of the developments in other schools. The tele-conferences were also used to provide running PD by INTAD executive members about issues of planning and delivery for student-centered learning approaches in Secondary Schools.

The second round of visits was scheduled to coincide with classroom delivery of the planned project. Considerable rearrangement occurred in the timing of these visits. All schools were visited with the exception of the more remote country school. A visit to this school was planned but was later cancelled due to another commitment. The continual rearranging of visit times and dates did highlight how busy these teachers were. In many cases there was only one class on at any one time that was involved in the trial. This made the timing of visits and then time afterwards to discuss and record the events difficult.

At the conclusion of the second visit a short interview was held (and audio taped) with the participating teachers. The intention of the interview was to record the teachers' responses to the use and implementation of the subject area syllabus and to consider how this might influence their use of this syllabus in the future. They were also asked to comment on what they considered was the greatest success and any concerns they had at the time of the interview.

The project concluded with another professional development day. The intention of this day was to provide a vehicle for the participants to display student work and discuss their projects, and to offer constructive feedback on the projects. To offer expert advice on issued raised by the participants and consider where their efforts might now be focused. Staff from QSA, INTAD and Education Queensland attended the final PD day to contribute to the feedback and evaluation of the projects.

Case Studies

School A

Two teachers are involved in the trial with one being the HOD. This school focused on the use and development of a trial unit using the 'Electroflash' kits that were promoted at the INTAD professional development conference. The use of the kits and the intention to have students engage in 'discovery learning' were a focus for the HOD. Considerable background knowledge of electronics on the part of staff was required. The project was trialed with year 9. While there was interest in the project from the students, the initial trial did not provide the focus for students that might be achieved with a real application of the electronics knowledge they were learning. In addition, some students displayed reluctance to doing something different from what they expected to be doing. However, these problems were soon overcome.

The HOD commented that with five subjects coming under the label of technology in this Secondary School the Industrial Technology and Design teachers don't see the students until year 9 and then only for one semester. Considerable concern that developmental time is not available to all students. The planning wizard available at the first conference was considered but not used in unit planning. Considerable time was spent in the planning stage, with a definite emphasis on wanting to 'get it right'. Considerable debate about what needed to be included in a well-planned unit of work.

One concern expressed by the HOD was that historically, teachers have not had to spend so much time planning a unit of work. Most of the staff in the department are in their 50's and are reluctant to consider the new syllabus. The focus on design-based and student-centered learning was not met with support from the majority of the department.

School B

There was considerable interest in the project from the HOD at school B and he was interested in including another teacher in the trial. The HOD has had some experience and interest in incorporating design into workshop projects over the past years. He is aware that this could be developed further and wants to convince other staff that design should be a central part to all projects.

A design brief was written around a simple, relevant idea that would relate to most students. While firm controls were kept on the variety of projects outcomes, students showed considerable improvement in design processes and a willingness to sketch and explore many possibilities. Freehand drawing skills were developed and used by all students. The teacher's willingness to accept ideas that he (the teacher) hadn't thought of, appeared to encourage more students to think creatively.

The issues of planning formats and then assessment and reporting were evident. The trial highlighted to the staff involved that projects at all levels needed to be either altered or re-written. This was an example of a good but small staff in curriculum development, making the teachers aware that they still had a long way to go. The expectation was that programs would be developed over time, rather the 'throw the baby out with the bath water'.

School C

This school is three years old. Two teachers are involved in the trial. Both KLA and subject area syllabus are used within this area of the school. Two teachers were involved in the trial project. Both are very familiar with current curriculum developments. The school has an individual approach to project planning and delivery. Considerable time is invested in planning each new unit to included outcomes from all subject areas. It has taken the teachers time to adapt to this expectation in the school.

Some classes included aspects of design in the trial projects, while others 'designed on the run'. One of the trial teachers focused on developing a manufacturing system to a preset project. Both teachers considered they had varying degrees of success. In one case teachers felt that students had developed considerable knowledge of the topic. This was done in both written and practical forms. This new knowledge did not transfer into a design-based project of any particular meaning. The new and 'exciting stuff' did not appear to be linked to any particular purpose or relevant design. The use of specialist and non-specialist teachers being used to teach technology was an issue in this school. This school also has the expectation that other teachers will deliver projects that will include ITD outcomes. These may, or may not be achieved. No transparent process of checking or moderating assessments was apparent.

School D

Two teachers are involved in the trial and there is a high level of support from the HOD. The school has a significant background of incorporating design into their workshop-based classes. However, this was evident in some classes but not in others. Knowledge of the subject area syllabus is very apparent. One of the teachers used the same trial project with two very different classes. A major success for this teacher was to 'unpack' and explain the learning outcomes being focused on in the project, so that the students could identify and realise when they were being achieved. The project involved new knowledge but not significant individual design.

The second teacher also included significant 'new knowledge'. Equipment and machinery was being used that was not evident in most other classes. The focus was on manufacturing systems. Considerable emphasis on communication and cooperation was involved. In this school the Technology KLA was far more in evidence and considered more 'important' than the ITD syllabus.

Of significant interest to all teachers in this school are the issues of assessment, recording and reporting. The realistic expectations of assessment to outcomes (when they are only beginning to understand and plan to outcomes) was evident**.** Many issues were raised and answers hoped for. How will parents understand and react to terminology in a report that is significantly different? How does a student rank compared to another? Etc. etc.

School E

There was great enthusiasm from the HOD in terms of understanding the new syllabus and then providing the leadership for his department to embrace and use it in their classes. The HOD and one other teacher are involved in the trial. The HOD researched and studied relevant research and the new syllabus at length. At the heart of the understanding was the belief that the HOD wanted to encourage the students to be 'designers' and 'technologists'. Considerable emphasis was placed in understanding and interpreting level 4 of the ITD syllabus.

The planning of the unit involved a set project and range of practical skills to begin with, then a design challenge to incorporate the set project. Investigation and research was an expected part of the design component only. The nature of the trial class involved two distinct age groups in the one class. The project chosen did not appeal to the older students until the design component was undertaken.

This was an example of a mature teacher making some changes to a project to incorporate design but still keeping aspects of a project under tight control with no opportunity for multiple outcomes. The teacher involved is a strong advocate of the new subject area syllabus and shows signs of developing more student projects in future endeavours.

School F

Two teachers are involved in the trial project in this school. This has come at a time when the HOD is absent from the school and there are significant interruptions to teachers within the department. Electronics was the focus of one of the two trial projects. It is hoped that this will 'update' the subject and attract a bigger range of students. Kitsets are used to build up knowledge and become familiar with components and circuits. A preset circuit is built for a predetermined function. The students have input into the design and manufacture of the case to house the circuit. The second project included a greater emphasis on design into a project that was already being undertaken by the students.

During the trial the first teacher realised that considerably more time was needed than was first thought. The trial group was a year 9 class. Consideration was given to putting the project into year 10 in future. The issues of when students come to the workshop classes, for how long and whether it would be compulsory for all students, came up often.

The teachers involved were often searching for answers and confirmation that they were doing well. The areas of planning for outcomes and assessment of these were two of the most obvious areas for questions. They put considerable effort into trying to 'get it right' and often needed a sounding board. As yet, there is little consideration that the KLA and ITD syllabus will have major impacts on what and how they teach.

School G

There are two teachers involved in the trial and there is a definite confidence within this school. They also have a trial underway for New Basics. A new HOD and teachers with training completed in the past few years. The trial project focused on Electronics and built up background knowledge in the year 9 class using preset examples in kit form. The students then had to construct a product that used a predetermined circuit but were expected to design and construct the body and look of the product. An in-class visit showed a strong approach to centre on the students and they all worked on individual projects. Many students commented that they had enjoyed the difference compared to other projects and had especially enjoyed the success with electronics.

New Basics and KLA documents appeared to have a greater influence than the ITD syllabus. The planning wizard from the INTAD conference was used. Again, another example of every student doing a pre-set component. This dominates what can be done afterwards with the project. Considerable variety in the look of students' end products. Students appear confident enough to put their individual stamp on the project.

Considerable effort is being made by trial participants to support each other and take what they have learned and expand it into this growing part of the school. There is considerable support from the principal to develop this area of the school and development plans for implementation over the next three years have been created.

Preliminary observations

A fuller analysis is still to be undertaken, however, some general observations can be made.

1. The process seemed to work. That is, action research, tied to professional development, appeared to provide the kind of support and feedback to help teachers implement curriculum changes that has some realistic chance of being sustained.
2. The tele-conferences appeared to work and at a variety of levels. At one level they provided information. This ranged from information about curriculum and teaching from Education Queensland officers to information about the researchers' requirements. On another level, it provided a gentle stimulus for teachers to keep on track with the project. This is probably important, given the many pressing calls on teachers' time and the tendency to run out of time before completing tasks that may not be seen of immediate priority. On still another level, the teleconferences seemed to work to bind the participants together in a shared enterprise and provide a sense of community. This seemed to evolve over the course of the six tele-conferences. Teachers moved from a more formal, and sometimes defensive approach to the conferences to a more collaborative, sharing approach, further into the project.
3. The changes achieved were nevertheless, reasonably modest, and highlight the need for on-going professional development and monitoring.

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Application of an Analytical Framework to Describe Young Students' Learning in Technology

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This paper discusses a framework for describing and analysing how young students (5–6 years) learn in technology with a view towards enhancing teaching and learning practice in technology. Examples of student work which demonstrate the complexity of learning in technology, and what young children can achieve with appropriate teaching strategies are presented. Holistic aspects as well as associated variables are highlighted.

Introduction

There are several aspects of technology which can present a challenge for the young learner, for example, maintaining a focus on the end point of the technological activity, transferring information from one technological task to another, understanding the purpose of the various design stages, to name a few. A considered approach by teachers, taking in such aspects as appropriate task selection, clearly defined learning goals, scaffolding and linking, appropriate student teacher interactions and keeping the end goal in focus during learning, can overcome many of the challenges and assist young children to achieve beyond current expectations in technology. Using a case study approach the teachers featured in this paper used a holistic approach to planning and assessing technology education, such as the one shown to be successful for teachers involved in the LITE (Assessment) project (Moreland, Jones & Northover 2001).

The LITE (Assessment) project

Learning in Technology Education or LITE (Assessment) was a three year project which first investigated and later enhanced primary teachers' ideas and practices regarding teaching and assessing in technology education. It was noted that although teachers demonstrated knowledge of technology education in terms of technological strands and areas, and appropriate activities for technology, this knowledge lacked depth and detail. They compensated by confining their teaching to activity based technology, rather than focusing on technological concepts and outcomes. This in turn affected their assessment practices because, lacking robust technological concepts, they based their formative interactions and summative practice upon factors such as general and social aspects. It became clear to the researchers that in order to address their primary aim of enhancing assessment practices in technology education; they must first address the technological knowledge of the teachers. The LITE (Assessment) intervention stage (Moreland et al 2001) began in the second year. It involved fifteen teachers (all of whom demonstrated a sound general teaching pedagogy) including two teachers of five-year-olds, or Year One students. The primary focus was to target the teachers' formative interactions with their students by ensuring the interactions assisted their students to move forward technologically. In order to achieve this it was important to assist teachers to enhance their own knowledge of technology and how to teach it. One strategy was the development of a framework.

This framework which describes the categories for learning in technology, allowed teachers to specify concise intended learning outcomes as they planned their technology, and to keep these learning outcomes foremost as they interacted with their students throughout the technology process. The framework became the focal point for planning and for guiding formative interactions and analysing student learning. The framework successfully assisted teachers to clarify concepts in technology, and identify and address their own knowledge gaps prior to teaching. They could ensure that their learning outcomes reflected a balance across conceptual, procedural, societal and technical aspects, while understanding the yielding nature of the barriers between. This in turn impacted upon formative interactions with their students, which became increasingly technological (and useful) because the process of planning had clarified the teachers' ideas about learning intentions and the technology within the task. Better understanding of technology allowed them to be discerning but flexible, and able to deal with unexpected technological learning that arose during the learning process. Very apparent was an enhancement of student performance in technology education resulting from these improved interactions.

The third year saw a widening of focus to include targeting teachers' summative strategies (Moreland et al 2000). It was important to ensure that the teachers and researchers had a shared understanding of summative assessment, which went beyond an overview of previous learning. Not only should summative assessment involve accumulation of evidence collected over time, and coverage of previous learning, but should also suggest where future directions for learning lay. Summative assessment practices by LITE teachers needed to be meaningful to a wider audience than the classroom teacher and student, such as school and outside management, parents, successive teachers and other relevant parties, although the focus was in classrooms.

Related to this was the accumulation of student work gathered, throughout the technology learning process, which was given sharper focus during 2000. Considered portfolios of work in technology, with accompanying commentary and analysis, were found to be a powerful tool in assisting teachers to enhance summative assessment understandings and practices. A significant development during 2000, was a profile for recording summative data about individual students, which was closely linked to the planning framework shown in Figure 1, and included holistic statements about learning in technology. At the end of the three-year project, the teacher participants were enthusiastic about their progress. This was reflected in the following comments which teachers made as they looked back over their three-year involvement in the research project.

> My planning, and formative and summative assessment practices have made huge strides. I am able to take some of these ideas and adapt them into other curriculum areas.
>
> My interactions with the students are more detailed, focused and far more specific. My children have knowledge of where they are going.

The LITE (Assessment) project met its main goal of enhancing the teaching, learning and assessment practice of primary school technology teachers (Moreland et al 2000), affirming the desirability of an integrated approach to planning teaching and assessment (Harlen 1994). This paper presents some specific strategies used to teach technology in classrooms with young learners by technology teachers. An example is presented demonstrating the successful use of strategies and includes selected student work.

Strategies for teaching technology with young children

The New Entrant room is a unique point of transition between Pre-school Education and formal schooling, and as such has a learning focus which can probably not be found else where in the school. One of the difficulties for technology is that language development; both oral and visual is central to all curricular covered. This means that technology receives minimal attention. A further complexity is that the level of performance of New Entrant students is hugely variable, as are their interests, their rate of learning and their competence socially. This in itself can be problematic, and in terms of assessment and evaluation there is the challenge of attempting to analyse their understandings without being restricted by limited or non-existent writing skills. Effective teaching strategies and management are all important in identifying the conceptual and procedural understandings that these children have achieved. With these complexities in mind several strategies need to undertaken to enhance student learning.

Enhancing the performance of young students in technology education

Increasing numbers of studies in recent times have attempted to analyse the designerly thinking and design capabilities of these young students and to identify strategies which will enhance learning in technology at this early level. To find these studies we need to search broadly into the areas of Technology Education, Art and Craft, and the cognitive development of pre-school and school age children. As a result of data analysis of the LITE project, the New Zealand National Exemplar Project in Technology Education, and an ever-increasing range of international writers, valuable teaching strategies for technology teachers working with young students has become apparent.

Task selection

Young students engaging in technological activity need to be working within a known environment, and carrying out real and familiar tasks. Designerly thinking in young students begins as designerly play in which children interact with their environment, playing, making and exploring ideas. Design occurs as part of the unfolding drama created by the children and may or may not result in a tangible outcome (Coghill 1989). In school based design activity where there is an expectation for a design solution or artefact, working within a context in which students feel confident and already knowledgeable, will ultimately enhance their ability to engage in tasks and their overall performance. Carr (2000) refers to the importance of anchoring tasks to everyday meaning to improve achievement.

Student drawing

Similarly with the drawing and design work of young students, children prefer to draw what is familiar, what gives them pleasure, and what they have drawn or experienced before (Thomas & Silk 1990). Drawings tend to be representations rather than an accurate reproduction of the topic or object depicted (Thomas & Silk 1990), and children also tend to draw what they know rather than what they see (Freeman 1980). This obviously has implications for the accuracy and the usefulness of the images children produce in their technology planning.

End point focus

Strategies for maintaining a focus on the end point of the technological activity is another ongoing challenge for junior room teachers. Stages within the design process tend to become end points in themselves, i.e. a design drawing becomes a colourful representation of a design solution but without intentionally informing its construction. The reasons for this are varied but one solution is to make very clear to students the purpose of the activity they are involved in (Anning 1992; Fleer 2000). For example, if they are drawing a plan of a kite they are about to make, they need to understand why they are drawing it, i.e. it could be to help them decide what their solution will be, to list materials they will require, to decide on joins and construction methods, or to provide a basis for formative interactions with their teacher. The drawing activity must have a clear purpose to make it meaningful for students and then inform their final solution. As Matthews (1994) states, it is never too early to discuss with children how their images work: it is just that one has to vary one's use of words according to the child's age.

Mismatch between planning and construction

Linked to this feature of young children's design work is that final solutions often do not resemble plans or design drawings (Rogers & Wallace 1998). When teachers employ strategies which keep the final solution and the eventual product user central to the technological development, children seem more likely to maintain their focus on developing useful solutions (Kimbell et al 1996). At the beginning of each session, for example, it is useful to review previous work and refocus students on the task ahead of them, providing them with reminders of early discussions, decisions made, and referring them to wall displays, pictures or charts which summarised previous sessions.

Modelling and planning

Closely aligned with this discussion is the 2D versus 3D debate in early design work. Stables supports the idea of 'hands on exploration' and in particular that which provides a basis for ensuing design work. The advantages of young children 'playing around' with materials and then constructing their ideas through 3D models circumvents the difficulty of trying to translate 2D flat images into a 3D prototype or model (Stables 1997). In a study in which children's ability to model clay was compared with their 2D design work, it was shown that their competence improved when working with clay. Their models showed side and frontal perspectives, unlike their 2D drawings, and most attempted to achieve verticality or stand-up models. The mix of views that are often seen in children's drawings are thought, as a result of this study, to be a consequence of the problems set by the 2D medium rather than students' lack of understanding of the relationship between these views (Golombe 1997). Giving students the opportunity to handle materials that are available for them to use, and to construct prototypes through trial and error, would appear to be a more useful design sequence for young students (Stables 1997; Anning 1992). In addition, providing time and materials for undirected playing and making during the daily programme, will further enhance students knowledge and capabilities

Information transfer

Transferring information from one technological task to another, and from one stage within a design process to another is also problematic for young students. Crisafi and Brown (1986) investigated analogical transfer with two and three year old students and found that young children were able to transfer learning from one situation to another in certain circumstances. One of these circumstances was to ensure that children recognised the similarities of the tasks previously carried out. Learners need to "notice" similarity and "apply" the rule (Crisafi & Brown 1968). In the classroom it is a matter of making links for students, e.g. "Remember when we talked about", or "Remember when we saw".

Consideration of variables

The final point worth particular mention is young students' inability to consider more than one or two variables at any one time. Siegler (1996) discusses the unidimensional and multidimensional thinking of young school age students and believes that five year old students tend to reason unidimensionally and that there are conditions that seem to promote this level of thinking. For example, (i) unfamiliar tasks; (ii) tasks which require a quantitative comparison–more, less; (iii) tasks which require a discrete choice between two or three alternatives–red, yellow, blue, or (iv) tasks which include a single dominant dimension which can lead children towards specific incorrect answers (Seigler 1996). This suggests again, that task selection for young students is critical and should be chosen from a familiar context and involve the development of a familiar artefact or device as its solution. Tasks should be sufficiently challenging and open ended to allow for multiple solutions, but should only include a small number of unrelated variables.

It is clear that working with five-year-old students offers challenges to technology education that are not as apparent with older age groups. It is also clear that successful and meaningful technology activities can be achieved with these students if the process they are working through is carefully managed, tasks are appropriate, formative interactions and considered methods of gathering and analysing their work are employed. Regular undirected opportunities to practice and refine their skills should be an on-going part of every classroom programme and strong links to the integrated approaches of Early Childhood programmes will allow students to work in a preferred multi-curricular way (Lambert 2000). Technology Education is a natural flow-on from the imaginative and designerly play observed in any Early Childhood environment.

Example to demonstrate successful technology teaching

Example 1: Developing a photo frame with a standing or hanging device

This discussion is based around a technology unit taught by an experienced teacher in technology, with a group of twenty-two New Entrant students. The technological area in which this unit was situated is Structures and Mechanisms. The New Zealand curriculum defines this as including a wide variety of technologies, from simple structures, such as a monument, or mechanical devices, such as a mousetrap, to large, complex structures such as a high-rise office block, or mechanical devices such as a motor car (Ministry of Education 1995).

As part of the New Entrant students' initiation into their new classroom, the teacher took digital photographs of each of the students to display on the classroom wall. The technology unit linked into this activity. Students were invited to make hanging or standing photo frames in which they could take their photographs home when the display was changed. The primary focus of the unit was the selection, design and construction of the hanging or standing device of the photo frame, with the design and construction of the frame being of secondary importance. The task selection was all important. In this case an interest in the photographs had already been created and the desire to take them home was unquestioned. The idea of developing a photo frame with a hanging or standing device so that the photos could be safely transported and displayed at home was a task within the grasp and interest of the students. Photo frames were a familiar artefact in their lives, and the students already had an understanding of their purpose and function. The teacher's planning was detailed and identified student learning in terms of the LITE framework mentioned previously, i.e. conceptual, procedural, societal and technical knowledge.

The first stage of the unit involved several sessions where students shared and built upon existing knowledge. They looked at a range of commercially produced photo frames, identified appropriate materials which they could work with, and discussed the concept of "frameness"–what is a frame, what is it's purpose and how does it function?

The following work samples were selected from a range of students participating in this unit and were analysed according to the framework described previously. It also includes a teacher scribed summary of students' prior knowledge. Each sample selected shows a stage that is of significant in the technological process.

1. Conceptual Development

As an introduction to this unit, the teacher took time to discuss the idea of making a photo frame for their class photo. She also spent several session discussing children's existing understandings of a photo frame, how a photo frame functions and identifying some of its most import features. The students were generally immersed in the topic, with discussions, collections of frames, books showing how to make frames, and then beginning the focus onto the criteria for making their own frame and support device. These charts summarise students' prior knowledge and their ideas about the selection of appropriate materials to make their photo frame and support structure. This gives a useful overview of the understandings and ideas these students have without being restricted by their limited writing abilities or having to take time to record individual responses. The conceptual understandings of these students are quite clear: They are beginning to use appropriate descriptive language, (plastic, protection, wiggly lines), and they have a beginning understanding of some technological principles, i.e. aesthetics, (decorations to make [the frame] look good); stability, (not floppy) and rigidity, (not bendy or twisty). They are able to identify appropriate materials and they have an understanding of the function of the frame, i.e. the photo goes behind the glass, [the frame] goes around the photo, and [the frame] covers the white bit on the photo.

2. Initial Planning

The next stage of the unit involved re-focussing students on the development of their own photo frames and support devices. Firstly the task was clearly defined and then students and teacher listed what they considered they must include when making the frames. This established the criteria which students needed to consider in their design work. The next session involved identifying materials that the students had available to them and which would be easy for them to manage. A final chart centred on the decoration of their photo frames. Whilst this was not a focus of the technology, it was something the children were expecting to do. The work shown demonstrates procedural and conceptual understandings. Students were able to use the appropriate technological language, e.g. corflute, plastic, and tin foil. They understood the purpose and function of the photo frame, i.e. it was to display a photograph, to protect the photograph and to look attractive. They began to talk about two methods of displaying the photo frame, and were able to select appropriate materials for the construction of their own frame and support structure. They were also beginning to express understandings of technological principles and were able to relate conceptual understandings of existing frames to the design of their own photo frame.

3. Children's Frame Designs

This was a critical session in terms of management strategies to support these very young students. The session began with a recap of the previous discussion on materials for photo frames, followed by the introductions of the day's task, i.e. to draw a plan for their own photo frame. The purpose of the plan was discussed and links made to other plans they had seen, e.g. the plan to make a small sailing boat in one of their shared books. They discussed how a plan was different from a drawing and how you should draw a plan, i.e. pencil drawing with labels. They also recapped on the criteria for their constructions. Two pieces of student work examined, showed that the children have an understanding of the whole task, i.e. one student had included the cardboard piece from which the frame is going to be made, a plan of the front and a plan of the back. Both of the plans showed an understanding of the purpose to which the frame will be put, e.g.

the inclusion of the rectangular or oval window in the middle of the frame through which the photograph will show. The children had a beginning understanding of how to draw a plan, i.e. it is to tell other people your ideas so needs to have labels. They understood the function of the frame and how it relates to the support structure, i.e. the inclusion of the standing mechanism in each of the drawings. The plans were drawn in 2 dimensions and the children were able to select appropriate materials for the task, i.e. cardboard, thread, paper, ice cream lid or corflute.

4. Support Mechanism Plans

In this session students were to make a plan of the support mechanism for their photo frame. They had previously looked at a collection of frames that included a wide variety of hanging and standing mechanisms. Students recapped on the discussion of how to better display the photos, they considered where the photo frames were going to be displayed and they thought about the concept of stability, or not wobbly, in terms of their standers or hangers. They recapped again on things to consider when drawing the plan. Two examples examined were of a hanger and a stander. The children had a clear understanding of the task. Some of them were able to select a solution for a particular purpose, e.g. Jack said, "I am making a hanger so my baby brother wont get it" [the photo frame]. They were able to communicate their ideas with a 2D drawing and were able to select appropriate materials for the task, i.e. cardboard and string. They were able to transfer ideas from a previous session and apply them to their designs, e.g. metal clips to hold the back of the frame on, cardboard hooks, and parcel tape to hold the frame together.

5. Frame Construction

Translating 2D design drawings into a 3D structure was the focus for this session. This is considered to be a very challenging task for young children, but in this case, the image drawn, although 3D as a construction, was relatively flat, with only a front and back view to consider. The teacher carefully stepped her students through the following stages: a recap of the previous discussion about materials which the children could use, a close look at the inside shape of their photo frames, i.e. where the photo would go and how it needed to be slightly smaller than their photo. They also looked at the selection of pre-cut cardboard, corflute and plastic and then teacher demonstrated how to draw around a photo to determine the correct size for the inside shape. The children worked on this task in groups of five or six whilst other class members were occupied with another activity. Most wanted to work independently but a teacher aid was available to help with difficult cutting and the use of the glue gun.

The finished examples demonstrated students' procedural and technical knowledge. They were able to select appropriate materials for the task, and they understood the purpose of their design drawings in terms of guiding their final construction work. They demonstrated the use of basic technical skills, i.e. the use of scissors, making straight cuts, and following a pattern. They were also able to consider, and later talk about, the criteria selected earlier, i.e. protect the photo, the frame to go all around the photo, have decorations, look good, be strong and include a photo winder smaller than the photo. As is frequently observed with young children, their design ideas for decorations were mostly abandoned. The teacher in an earlier session had invited children to bring along decorations to use on the construction day. Sadly the carefully drawn rockets, dogs and patterns were exchanged for stick on silver stars, shiny stones and golden bows brought along to school by enthusiastic parents.

6. Support Mechanism Construction

The purpose of this session was for students to translate their 2D drawings into a 3D structure for supporting their photo frame. The final constructions demonstrated learning similar to that shown in the previous session. A significant difference was in the way students kept to their plan. There were no distractions of glitter or silver paint, just a stander or a hanger that needed to work. There was an air of diligence and determination to successfully complete this part of the job.

7. Teacher Summative Assessment

The photo frames were finished and the children presented them to the rest of the class. They had an opportunity to share interesting details and the teacher encouraged the children to ask questions of each other. She also talked about the process they had worked through and how it was a technological process. Her final task was to record summative statements about each child's practice and the progress that had been made throughout the unit. She had kept all student work including their initial ideas, homework investigations, annotated plans, and photographs of their final solutions. She also spoke individually with each child throughout the unit and used prepared templates to focus her discussions. These doubled as a record of their understandings, as well as a place to record anecdotal teacher notes. Summative statements were written based on the key learning outcomes identified in the unit plan, the criteria set by the children and their teacher, and how this was reflected in their final construction. The finished photo frames were greatly prized by children and parents alike, and now reside proudly on top of various pianos, bedside tables, and sideboards.

Conclusion

To enhance and sustain learning in technology there needs to be a focus on teacher knowledge of specific and technological learning outcomes in conjunction with appropriate pedagogical approaches. These pedagogical approaches must take account of beginning school children and the particular strategies that are need with this group of students.

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Learning in and Through Technology: Modes of Engagement

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As more of our daily activities become electronically mediated our increasing connectedness to the computer has come under close investigation, not only in terms of social, cultural and philosophic effects, but also in terms of psychodynamic effects. Of particular importance to educators and researchers of new technology is the convincing argument by theorists such as Turkle (1984), Idhe (1990) and Sofia (1993) that all of these aspects of our relations with this tool-object-idea should be considered in any analysis of human-technology-world relations. This paper will profile an analytical model that responds to this argument that was used in a recently completed ARC Discovery Research Project which inquired into the applicability of new information and communication technologies and systems (NICTS) to the assessment and evaluation of learning in a tertiary setting.

Introduction

This paper profiles the Visual Arts/Media component of the first phase of an Australian Research Council funded cross-discipline, cross-institution research project entitled "Constructing a new conceptual framework for using digital technologies in achieving better arts assessment". The research project brought together five Chief Investigators—Steve Dillon (Music Education, QUT) Glenda Nalder (Visual Arts/Media Education, Griffith University) Andrew Brown (Digital Music, QUT) Jude Smith (Dance, QUT) and Judith McLean (Drama, QUT). The research aimed to address a significant problem identified by arts educators—that the contribution of arts learning in education is often overlooked and undervalued because its emphasis on intuitive/creative (non-rational) ways of knowing is commonly perceived to be unable to be adequately documented and/or measured. Whilst within the arts we have developed effective textual and numerical means of evaluating arts products and processes, these means are frequently criticised by arts educators because they fail to capture the essence of artistic knowledge or the ephemeral qualities of arts making. Innovations in digital recording and information management systems present the opportunity to capture, store and manage multiple forms of evidence about artistic product and processes.

Research objectives

The objectives of the 2001 ARC Discovery proposal were:

- to identify the qualities of artistic knowing across arts disciplines; to identify gaps in the present approaches to the assessment and evaluation of arts learning and teaching; and,

- to discover ways that digital technologies might be used to improve the scope, depth, relevance and frequency of feedback.

The proposed outcomes of the first phase, "Digital Media Assessment Portfolio" (DMAP) action research project, in which we applied digital technologies to the collection of evidence of student learning in our own courses in semester one 2002, were:

- a theoretical framework for a feedback system, and
- a model for the use of digital media in arts learning assessment that can be applied to the later development of new learning and teaching support software tools with industry partners.

Data Forms in Phase 1 comprised:

- Student portfolios which include: DVD shots of work and processes, Arts products, marks and critical/reflective comments that show evidence of changes in thinking.
- Teacher's Reflective comments from the organisational and working point of view as well as personal feelings about student's progress and observations.
- Students marks.
- Purposively selected interviews with students with the portfolios i.e. talk aloud with portfolio.

Data Analysis for Phase 2, to date, has involved collating and coding the interview material collected by a research assistant. A focus group session was convened with all CIs and the research assistant to draw some conclusions from the data. Each CI presented a summary of their discipline's perspective, and pertinent themes were examined across disciplines. This session was summarised by a research assistant and the recommendations and results will be written up in 6 papers—one for each discipline and one cross discipline paper. In the paragraphs that follow, I have teased out some preliminary findings that will be presented for feedback to *Evaluations 2002* (a National education evaluations conference convened in Brisbane by the Australian Technology Network Universities) on November 14.

DMAP research questions—visual arts/media

- What are the grounds for recognition of an artwork, as such, in an educational context (whether a school, community or TAFE, university creative arts faculty, or a production studio)?
- What are the current assessment and evaluation practices (A&EP) in the Arts?
- What are the specificities of new information and communication technologies and systems (NICTS) that could be advantageous to A&EP?

Research context

My research subjects were volunteers from among the 100 second-year, generalist primary education students of the Visual Arts Education course 2124VTA at the Logan campus of Griffith University. The education context was their preparation to implement the new (2002) 1–10 Arts Key Learning Area (KLA) Syllabus—specifically the Visual Arts and Media strands covered in the course 2124VTA Arts 2 (Visual Arts.) That is, to make and teach art within the range of acceptable performance for a tertiary student, taking into account the fact that they are education students undertaking *one* visual arts-media hybrid course in their degree program.

Professional context

On graduation the research subjects will teach an outcomes-based curriculum to students in years 1–10 that is organised around 8 Key Learning Areas. In the Visual Arts/Media strands of the Arts KLA they will assess the student's ability to demonstrate the learning outcomes that are set for the various levels (1–6) identified in the Queensland Studies Authority (QSA) syllabus. Overlaying this outcomes-based approach is a *New Basics Framework* (NBF) for 1–10 curriculum based on the development of repertoires of practice that draw on clusters of discipline specific knowledge. The aim of the NBF is to achieve quality student learning outcomes and prepare students for 'new times' through the provision of 'rich tasks' that encourage knowledge transfer to contexts beyond the classroom, by providing 'real world' ('authentic') learning experiences that relate to students' lives. This new framework was an outcome of the *Queensland Schools Reform Longitudinal Study* (QSRLS 1998–2000) which examined and reported on the key educational issues of productive pedagogies; productive assessment; professional development; productive leadership; and system alignment and support. The QSRLS identified a practical misalignment between pedagogies and assessment tasks. It found that assessment tasks that teachers set were often low in intellectual demand, disconnected to the world, and intellectually unchallenging. To address this problem, Education Queensland proposed a 'productive assessment' strategy where teachers in the middle years of schooling would engage in 'moderation' meetings on setting and grading assessment tasks across and within schools, and reflective dialogue between the primary and secondary sectors on assessment would be encouraged.

In the professional context, the NBF rich tasks are described as outcomes that are transformational (enable students to function in real-life roles). The KLA outcomes are used in planning to ensure that the full intent of the KLA is realised. The KLA learning outcomes are seen as traditional when they refer to the content and skills of a learning area as demonstrated in everyday classroom situations, and transitional when they refer to the higher-order competencies and performances in tasks at a (comparatively) macro level. Because these 1–10 frameworks are new, reporting devices and assessment practices are still evolving. The feedback and reports published during the pilot phase of the NBF rich tasks suggest that the social moderation of evidence of learning—which has been a key assessment strategy in the Visual Arts, and Film and Television in senior secondary education in Queensland for at least 20 years—may be the preferred strategy for the 1–10 sector. In Senior Secondary Art, matrices are used that describe the standard for each grade (A to E) for both making and appraising artworks. As well, many secondary educators would maintain that the tertiary arts education sector has much to learn from them in this regard. Having taught in both sectors, I would concur with this perception.

Learning context

Students research, and critically analyse artworks and media images, and study the art-making trajectories of children. They explore concepts, receive technical instruction in art media and techniques, participating in interactive, guided, and shared learning in small groups to develop visual literacy by making and reflecting on art in terms of the objectives for each workshop. They study art education theory and design curriculum and plan lessons for the 1–10 sector. Learning experiences are based on 'real world' contexts for art-making. The studio is noisy as learning takes place in conversations between students about what is being made—whether an individual or collaborative work. The art-making experiments culminate in one fully developed artwork for display. The students write a statement of intention for this artwork (informed by their study of the discipline) that responds to the learning objectives, and meets the specific task and overall course criteria. They study the standards statements and give feedback to each other on the standard of the evidence each has collected for submission. They are required to indicate what they believe is the standard at which they (themselves) are working. Assessment is embedded and the process is transparent. Assignments are designed to encourage transformational learning, and objectives, criteria, and grading standards are explained in detail. Students monitor their progress by cross checking the evidence they are providing of their learning with the learning objectives, and the criteria and standards for the learning context.

Discipline knowledge ('artistic knowing')

It is important to stress that in my research setting the students are not being trained as artists, but as educators who may be having their first experience of art-making. Less than 30% of students have formally studied art beyond one semester in year 8. Their portfolios contain experiments, only one of which is developed into a completed art-work for exhibition at the University open day. I guess the experiments would equate with performing art "rehearsals", and completed works with the public performance.

The regular (non-digital) portfolio assessment item is formative, and provides evidence of:

- research into art and visual culture from past and present contexts and non-western cultures
- understanding of the qualities of the medium used
- understanding of the making techniques
- awareness of resource, management and safety requirements
- understanding of the technical and symbolic codes and conventions of visual communication/expression (applies elements and principles of design)
- insightful reflection on processes and success or otherwise of achievement in terms of objectives for each workshop
- effective management of information and resources.

Embedded within the above list are references to the elemental, procedural, technical and conceptual aspects of art-making. The portfolio collects together the results of the students' engagements with the concepts explored in each workshop. Students reflect on their achievements in terms of the objectives set for each workshop. The workshop objectives are based on the knowledge demands of the discipline (or key learning area) syllabus that the students will be required to implement. These include: a critical awareness of art's philosophic tradition (aesthetics), recognition and use of technical and symbolic codes of visual communication (including the elements and principles of design and awareness of intended audience), expressivity, and creativity.

The finished artwork is a summative assessment piece. Students select a portfolio experiment for development into a completed work, providing evidence of

- *the intention for the artwork* (a statement indicating the concept and art function (i.e. substitution, personal expression, narrative, embellishment, persuasion) they wish the work to communicate and perform)
- *conceptual development* (development of the original idea is evident in the record of planning and in the work as it evolves toward completion)
- *creative development* (experimentation leads to novelty in the resolution of the art work)
- *visual literacy* (effective use of elements, principles and concepts of design, and technical and symbolic codes and conventions of the visual arts)
- *presentation and display* (the integrity of the work is preserved and/or enhanced in its completion and display)
- *peer and self review* (an appropriate model for appraising and evaluating artworks in the course context is applied, with reference to the intended function of the artwork).

In the above list are features that I would argue need to be present for the work to be recognised as 'artwork' within the course context.

Going digital—choices

Constructing a digital media portfolio could involve (1) using the computer to generate experiments and subsequent artworks (2) translating evidence into digital media by scanning and video recording (3) adopting a hybrid approach that provides options for computer mediation in the art-making process. Choice was influenced by several factors which could be categorised as pedagogical, logistical and ethical, such as

- prior knowledge of the medium (teacher and students)
- the scope for the use of the medium (NICTS) in the art-form
- technology resourcing (teacher and student access to technology)
- support for the use of NICTS in the learning context
- impact on the learning process.

The scope for the use of the medium in the art-form in any learning context will be constrained by lack of prior student knowledge and digital technology resources. In this context, limitations were that a majority of students had little prior knowledge apart from one semester of art in year 8. The studio has one PC and one Macintosh computer, one scanner, one still digital camera and a digital video camera and tripod shared between 25 students in any one session. Options for the type of portfolio were limited to translating (option 2, above) in the research context, because of the demands of the course for a broad range of art-making techniques, and time constraints. In any context there will be ethical constraints. In the research context, a social justice consideration meant ensuring that the research project did not disadvantage students. Disadvantage was avoided by refraining from using the video camera to monitor the learning that took place through peer discussions of works-in-progress during art-making. Instead, a more ethical approach was taken whereby volunteer students used the video camera to record their own artworks and their reflections on the artworks outside of class time. Only one student among the volunteers had prior knowledge of media production, having studied the board subject Film and Television to year 12, and this proved to be advantageous as a more extensive analysis of the technological encounter could be undertaken.

Some reflections on the technological encounter in the visual arts/media strand

Research data relating to the Visual Arts and Media experience will contribute to the overall analysis of the research data, for which the Multiple Perception Analysis (MPA) method (Ecker et al 1984) has been adopted. MPA involves capturing the observations and reflections of the research subjects and researchers during the study. The theoretical perspective underpinning my analysis is derived from a framework devised by Sofia (1993) which built on Idhe's (1990) phenomenology of technics (the human use of technology in the world.) Sofia demonstrated that adding semiotic and psychoanalytic perspectives extended the vocabulary through which human-technology-world relations might be examined. A semiotic analysis focuses on significations, tropes, forms, and processes. Psychoanalytic theory focuses our attention on the irrational tendencies in human-technology-world relations, highlighting the bias inherent in assumed intentionality.

It is important to acknowledge at the outset that Visual Art and Media productions, like the other art-forms under investigation in this project, are, in any case, technologically-based. Historically, visual artistic practice has involved technological innovation that requires a more than passing knowledge of the physical sciences. We only need think of the technological and scientific knowledge underpinning ceramics, bronze sculpture, brass instruments, photography, print-making, lighting and mechanical stage machinery, experimental video and computer graphics. While computer mediation of art's processes is growing, computers still do not displace 'hand-work', or 'craft' or 'artistry', or 'ideas.' Rather, our art-forms are evolving conceptually through computer mediation, for example, the genre of netArt, the conceptual basis for which is the informational mode. Our first year students take a compulsory course in IT. Their success or otherwise in this course tends to set the tone for how they relate to computers for a while after that.

I noted, for example, that during a routine scanning task that I embedded in the course to encourage all students to consider using the computer as an imaging tool that some students claimed they were 'technophobic'. They found their engagements with the computer disempowering and alienating. Anecdotally, this attitude appears to be connected to prior experience of 'the hand is faster than the eye' regime of 'expert' tutors with whom most of us would be familiar. I discovered, through implementing a simple management technique, that there can be advantages attached to lack of resources that help to eliminate techno-fear. Students can be empowered by a simple 'domino' peer tutoring process using a single computer in a large class. Students indicate when they wish to receive instruction in a procedure, and gather around the computer in 'threes.' First in the queue is shown the procedure, observed by the tutor whilst executing the task, and then goes on to teach the procedure to the next in line. Less confident students can watch for a while before taking their turn. Our etiquette is that a 'novice' learner of a concept or technique is not 'told' what to do during his or her execution of the task after receiving instruction, but given time to think through the process, asking for further guidance when necessary. New knowledge is reinforced, and a sense of satisfaction gained through teaching the process to the next 'novice' in the queue. A recommendation arising from this experience is that it remains important for teachers to demythologise and demystify new technologies, and to develop strategies to empower students by making computer-mediated tasks non-threatening and the computer as user-friendly as a pair of scissors, a notepad or a whiteboard.

As Sofia (1993) noted, Idhe (1987, 1990) gave us a very useful model for distinguishing between different kinds of technologies in terms of the kinds of experiences, knowledge, and human-world relationships they enable and constrain. Idhe's "Genres of Technics" are organised around four categories of relationships between humans technology and world: Embodiment, Hermeneutic, Alterity and Background. All of these generic relationships are identifiable in our technological encounters. But I would argue, like Sofia, that the specificities of the computer have, over and above those of other technologies, not only heightened these generic relationships *and* made them much more obvious, but elicited more intense feelings. This intensity may be attributable to the sense of alienation described above, compounded by the computer's (irrational) mythologisation as a rational 'thinking machine.' Over time, this phenomenological relationship of alterity—the distinction between self and object—begins to break down, and the computer becomes a second self. An important understanding to be reached here is that computers are machines programmed by humans, despite appearing to have minds of their own, but that they might also make us think and do things differently.

In our art studio, the networked computer, scanner, printer and digital still camera take their place as mere tools among the many that we use. The video camera, however, does not. When the camera is around, we feel threatened by its 'eye' and 'ear' and its 'memory' which we (somewhat irrationally) believe will steal our image, voice, and our personal moments or interactions, turning them back at us in ways that do not correlate with our own perceptions of events. The video camera halts our conversation mid-sentence. This phenomenological response signals that the sudden introduction of the video camera—particularly by the researcher—can be a threatening intervention. This outcome has implications for the researcher/teacher to be aware of the impossibility of objectivity in this kind of research. Idhe would describe this phenomenological relationship as one of embodiment (where technology operates as body/prothesis). In Sofia's psychoanalysis, pathologic tendencies would be voyeurism or narcissism where the boundary between the body and the machine breaks down, and the body incorporates the machine. The impact of invasive technologies on the student, the creative process, and its evaluation, must not be underestimated. Video documentation has cultural, moral and ethical implications. Students should be allowed to negotiate an acceptable alternative to video documentation. They need to be given time to become comfortable with the presence of the camera at the very least. At best, s/he needs to be in absolute control—preferably behind the lens or at least directing and/or editing what the camera sees and captures of her/him self or work. Students should also have final approval of the recording, and copyright clearance should be obtained for its subsequent use.

Conclusion

To return to the research questions outlined above, the digital encounter has resulted in an extended vocabulary through which the specificities of artistic knowing, and evidence of artistic learning, can be articulated. The research process has emphasised that a conceptual framework for assessment in the arts in the tertiary and 1–10 sectors needs to be underpinned by clear statements of the qualities that allow a work of art to be recognised as such in each learning context. A model for the use of digital media in assessment portfolios must be based on a critical awareness of the specificities of NICTS. This includes the recognition that technological reproduction of an artwork subsequent to its creation is not the artwork itself but a representation of the artwork. Furthermore, in translation into digital format, features of an artwork—such as scale and colour—can be easily distorted. An artwork produced in minute dimensions can be reproduced and projected in a significantly enlarged version. In some cases this enhances the artwork, in others, it may diminish the artwork. As well, artworks translated into informational mode can be easily decontextualised and recontextualised. There are specificities of the informational mode that make digitally generated artworks replicable, rather than merely reproducible, without degeneration. (Nalder 2001). Each replicant is indistinguishable from the original. A model for digital documentation of artworks must take into account the specificities of technology and technique. For example, there are differences between digitising an artwork with a scanner, photographing it with a still digital camera, and recording it with a moving digital video camera with audio that have implications for equity in the assessment process. While tele-mediation may not suit all learning styles, there are specificities of the informational mode that have implications for extending both the conceptual and creative processes. Both the scope and the grounds for such extension must be well understood by participating students. A semiotic understanding (Sofia 1993) of the significations, tropes, forms, and processes of the informational mode is crucial to aesthetic decision-making. Finally, a clear message emerging from a preliminary analysis of the perceptions of both the researcher and the research subjects is that opportunities provided for additional reflection by students and teachers through the introduction of new processes within a critical inquiry context leads to deeper learning. Having student generated and managed evidence in digital format and information mode (databased, retrievable, with feedback loops) would support and facilitate reflective learning and flexible learning while furthering the new media skills development demanded by the professions.

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Developing Professional Designers in Information Environments: A Problem-oriented Case Study Approach in Technology Education

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The development of students' professional identity and orientation within their field is a key issue for any undergraduate course. For courses in new areas of technology this is especially the case, particularly as their applications are drawn from an ever-increasing range of disciplines and abilities. Information Environments is a studio-based multidisciplinary program within the School of Information Technology and Electrical Engineering, at the University of Queensland. The program infuses traditional IT subjects with design skills and a people-centred focus. These graduates must attain a suite of competencies that include technological skill, multidisciplinary understandings, design expertise and a collaborative approach to problem solving and creative solutions.

How can these aims be effectively integrated within a course that seeks to bridge the procedural and propositional 'gap' for technology students? How can such courses provide opportunities for students to understand and influence their emerging roles as professional designers of Information Environments, and within the broader technology and design industries? In seeking to facilitate an integrated approach to exploring design contexts, and an in-depth understanding of the range of analytical imperatives within the design process, the third year course 'Advanced Information Environments' adopted a problem-oriented case study approach both as a model of professional orientation for its students, and as a guide to educational design.

This paper briefly outlines the process of course design, curriculum design, and conceptualisation of learning experiences and assessment within this approach, and the intended implications for students' professional understandings. We review an action research project in the course 'Advanced Information Environments' in which students' professional understandings and orientations are explored. We then discuss these outcomes and their implications for models of learning within design and technology education.

The emerging interdisciplinary field of designing information environments

In the domain of design and technology many exciting and innovative directions continue to emerge, particularly its various fields of application and practice (Ozcan & Akarun 2002). The Bachelor of Information Environments at the University of Queensland is a studio-based multidisciplinary program within the School of Information Technology and Electrical Engineering. In response to the increasingly hybrid nature of design and technology, this program infuses traditional IT subjects with design skills and a people-centred focus. Graduates must attain a suite of competencies that include technological skill, multidisciplinary understandings, design expertise and a collaborative approach to problem solving and creative solutions.

The Advanced Information Environments course (IENV 3201) aims to broaden third year students' understanding of the diversity of issues from numerous perspectives that underlie and inform the design of information environments. In emphasising the need for a thorough and critical approach to arriving at design decisions, it is hoped that students will develop an understanding of the breadth of analysis required in developing a holistic view of the information environments context, as well as an experiential appreciation for the nature of themselves as professional practitioners in the field. Students are required to demonstrate their learning through:

- Engaging in multidisciplinary research using a variety of sources;
- Selecting appropriate approaches to analyse a given context, and understanding the requirements for technology to support it;
- Considering the implications of social and ethical issues for their designs;
- Selecting and justify appropriate methods of inquiry in relation to a problem or context;
- Critically assessing and rationalising findings from their research;
- Reporting on their outcomes in a manner appropriate to this field, in written and oral form.

Designing information environments involves analysing a domain from a broad range of perspectives that include the technical, social, ethical, aesthetic and safety issues from within a multidisciplinary framework of informing understandings about people and their behaviour (including strands of psychology, sociology, ethnography). Problematically, designing has been shown to be a highly complex, situated, and distributed process (Kuhn 2001; Roth 2001; Stein, Docherty & Hannam, forthcoming), involving the intersection of up to 14 different areas of specialisation (Ozcan & Akarun 2002) in which effective learning experiences must take into account a complex array of imperatives (Stein, Ginns, & McRobbie 2002). As such, it is argued by some that whilst the practice of interactive design has a well-established pedigree within the various domains of art and design (Ozan & Akarun 2002), current IT oriented interactive design practices constitute a unique (albeit, a recently formed) field of professional practice, and a formalised discipline of its own accord (Mok 1996 in Ozan & Akarun 2002).

Facilitating an understanding of the field and the profession

With this in mind, we set out to develop an educational design that would facilitate indepth understandings of information environments as an emerging interdisciplinary field of practice, as well as accommodate the 'new vocationalism' that commonly frames student and industry expectations of higher education (Symes & McIntyre 2000). While the former goal is not unusual in today's universities, the latter reflected our concern for the integration and foregrounding of the complexities involved within professional practice as essential components of these students' educational experiences (Denning 2000; Fenwick 2002; Kuhn 2000; Ozcan & Akarun 2002). Therefore, our primary aim was to provide opportunities for the development of expertise in which the 'expertise' reflected the actual practice of information environments designers within authentic contexts of design problems. Concurring with Billet's notion of 'knowing in practice' (2001), we sought to account for expertise as "a product of interdependence between the individual acting and the social practice in which they act" (2001, p.449).

In sum, we identified two overarching aims for this course. The first was the provision of scaffolded opportunities for students to integrate and enact their understandings of informing disciplines within a contextually authentic way. The second was to foster sophisticated epistemological and professional understandings about the nature of designing for information environments as integral dimensions of students' evolving self-knowledge and emerging identities as designers.

These concerns acted as imperatives guiding our curriculum development, which implied interrelatedness to the following approaches to educational design:

- Experiential learning–Kolb's (1984) experiential learning theory is grounded in the position that true education must be embedded within experience and complemented by reflection. For Kolb, learning is seen as the process whereby knowledge is created through the transformation of experience through the engagement and reflection of the learner.
- Case Studies–Prominent arguments for case based learning include the facilitation of student learning towards greater expertise, the contextualisation of learning in ways that connect content and action, and the transfer of knowledge from previous experiences to new situations (Bennett, Harper & Hedberg 2002; Sykes & Bird 1992).
- Problem oriented curriculum–Learning through solving or managing problems has emerged as a specific pedagogy for the development of professional identity (MacDonald & Isaacs 2001), reflective practice in the iterative processes of critical design (Kuhn 2000), greater self-knowledge as a professional and enhanced professional practice (Fenwick 2002), as well as epistemological competence, interdisciplinary understandings and transdisciplinary learning (Savin-Baden 2000).

A literature search revealed that discussion of the theories, frameworks and implementation of each of these approaches is extensive. Much has been reviewed on the nature of problem-based learning for a range of professional areas, and in particular the multi-factorial nature of its effectiveness for higher education (Norman & Schmidt 2000; Savin-Baden 2000). Kolb's experiential learning theory has been thoroughly documented and empirically examined (Kolb 1984; Svinicki & Dixon 1987). Similarly, the rising popularity of case study pedagogy is reflected in the literature, particularly in the areas of medicine, law and business (Gross Davis 1993; Sykes & Bird 1992). However less has been said on the potential for complementarity across these three pedagogical themes, and in particular, of the application and relevance to the interdisciplinary imperatives of design and technology education.

In a recent analytical paper, Kreber (2001) proposed that a case study approach to teaching in higher education provided an effective means by which students may encounter all phases of Kolb's experiential learning model. In doing so, Kreber points out the potential for integrating both a case study method (Gross Davis 1993) and problem-based approach (Knoop 1984) to educational design. The paper proposes that this approach may have the potential to foster higher order learning "such as critical thinking ability" (p.218) and to cultivate "self direction in learning" (p.218). In acknowledging the limitations of this conceptual analysis, Kreber calls for further discussion and empirical testing of this integrated approach and its pedagogical potential.

Given our concerns for the development of professional understandings and identity, and our interest in weaving the strands of experiential learning, case study and problem oriented curriculum together as an integrated curriculum for design and technology students, we found Kreber's conceptual analysis (2001) to be compelling and worthy of empirical review. The aim of this action research project was to investigate the students' professional understandings and sense of professional identities, and how they developed over the period of two semesters, as they engaged in a design studio course. In this paper we have report on the following key questions:

- Are there changes in students' professional understandings and sense of professional identities?
- What are the empirical outcomes of Kreber's (2001) conceptual model? Specifically:
    - Does the model foster critical thinking and self-direction in learning?
    - Does the model enhance students' professional understandings and identities as designers of information environments?

Our research approach and the learning context

Following an applied action research approach (Carr & Kemmis 1986; Neuman 1997), the planning, structure and progress of the course were monitored across the semester with the course co-ordinator (Viller, co-author) acting as the primary teacher/researcher. With the permission of students, data were collected in form of the student assignments, student online discussions, and a survey administered at the beginning of semester, and again at the end of semester. The survey comprised four open-ended questions thematically related to students' perceptions of their role as a professional designer in information environments, the qualities, skills and abilities they understood to be most imperative, and their perceptions of what informs their design work. The co-ordinator’s journal also provided another source of data.

As a 'work-in-progress', this project is currently limited to an analysis of participant observation and selective coding of data sources (Neuman 1997). This has permitted the development and testing of key themes as guides, which will be re-evaluated during the second stage of the project.

This honours level course was structured to allow for a weekly pattern of lectures, tutorials and seminars in which the 'teaching mode' was described as a problem-based approach characterised by a sequence of steps (Savin-Baden 2000). Students completed this cyclic process three times engaging in three new case studies each time. Students formed groups of 4–5 for the first case study, 2–3 for the second case study, and worked independently on a third case study (in which they defined the study themselves). Each study was assessed by a seminar presentation and written report.

Findings – Learning about learning in information environments

Are there changes in students' professional understandings and sense of professional identities?

The focus on developing students' identity as professionals was initially opportunistic, an outcome we assumed would result from the adoption of a problem-based, case studies approach. As these student reflections demonstrate, it is the process of research of the problem and potential design that appears to have been the most salient aspect of some students' learning experiences:

> The process undertaken for this [final] Case Study has been different from the previous in a number of ways. The main difference was primarily in the way in which I approached the task. A conscious effort was made to follow the recommended process within the Course handout. Whilst the recommended process required a little more work on my behalf, I believe I've learnt more about academic research and writing from Case Study 3 than from the previous two Case Studies combined.
>
> I found that by spending a little more time planning how to do it i.e. structuring the research paper in the recommended manner e.g. analyse the problem, what do we already know etc, the process of actually doing it i.e. creating a well structured research paper, became a great deal clearer.

As these student comments indicate, the sequential and cyclic steps of the problem-based learning approach emerged as an important element of their learning experiences. The problem-based approach embedded important processes into their engagement with the case studies, including the analysis of the problem, the investigation and generation of multiple perspectives on the problem, and the explicit identification and use of strategies for gathering and critically analysing appropriate information to inform their decision-making, designing and reporting. This process is central to the learning objectives for the course, and are essential understandings within design and technology practice (Kuhn 2001; Ozcan & Akarun 2002; Stein, Docherty, & Hannam forthcoming).

The educative value of this understanding is illustrated in the following comment, which provides a conceptual link to the first of our broad educational aims (for students to integrate and enact their understandings of informing disciplines within a contextually authentic way):

> Whilst I found researching the topic straightforward, I found that I initially struggled to identify the research topic for the Case Study. This was in primarily due to the lack of any knowledge of the topic area. I also found the task of researching an area where I had little knowledge was both difficult and frustrating until a basic understanding of the research topic is gained. After I developed an understanding of the topic, I found that the use of accurate keywords and descriptors revealed a wealth of valuable research papers, which in turn were used to complete the Case Study.
>
> I found myself refining the direction of the Case Study as I progressed further into the topic. I found that the direction of the Case Study changed as I gained a better understanding of the topic area. This was in part due to my clearer understanding of the key issues relating to

> the topic and also due to my ability to accurate locate research papers that provided fascinating tangents to explore.

The second student comment above captures the heart of our intentions for Advanced Information Environments, that is, the open and inquisitive orientation a designer must achieve towards the ill-defined and ambiguous problems most often found in design contexts. A designer's capacity to remain open-minded and sensitive to the range of issues any problem presents is central in the effectiveness of the final outcome (Denning 2000; Kuhn 2001). We feel that the interweaving of problem-based learning within case studies enabled students to assimilate effective tools with which to attend to the heterogeneity of issues they are likely to experience in the world of design. In the words of the co-ordinator's journal:

> At the beginning of the advanced information environments course, I sensed a lot of 'not air traffic control again' from a large number of the students (it is a popular subject matter). But by the end there was a common assumption that there was more than meets the eye with the subject matter (i.e. they were much more receptive to the fact that there was almost always an alternative perspective on the problem being addressed). This was reinforced throughout the course as every piece of assessed work required them to address multiple perspectives, take a holistic view, and use the literature critically….I think the clearest evidence that they learned something and are still thinking this way is looking at the comments they provide each other about their presentations in [the following course] Studio 6 ("have you thought about...?").

The second aim of the design of this course was to foster sophisticated epistemological and professional understandings about the nature of designing for information environments as integral dimensions of students' evolving self-knowledge and emerging identities as designers. Originating from the course co-ordinator's observations of student predispositions and assumptions about designing information environments, and how their work will be informed (often limited conceptions about web-design or programming related tasks), this aim was important in facilitating a shift in students' understandings about the complex and transdisciplinary nature of their role in information designing, and their perceptions of themselves as designers.

Student responses to the survey implemented at the beginning of semester indicated simplistic and impoverished views of their role in information environments, how their work as a designer will be informed, and the qualities, skills and abilities they may require for effective practice. Survey responses at the end of semester appeared to be more detailed and articulate, indicating some development in:

- students' perceptions of the field and themselves as professionals

> IE will develop into an area where information systems can be changed from pragmatics & difficult usage to user focused meaningful uses...Range of activities:-web dev. system design consultancy, helping users use current systems (tutorial style??) etc.

- students' understandings about what will/should inform their work

> user consultation--Ethnographic study, etc. (incl. feedback from user reviews of systems); previous/current systems; research areas already/currently undertaken

- students' perceptions of valuable qualities for information environments design

  Open minded, being prepared to listen to other's ideas. Getting to know the user and design for them. Knowledge of design theory and practices

  Flexibility; Active; Enthusiastic; Quick thinking

- skills, abilities and competencies perceived as imperative for designers

  Ability to liase between user & developer; Able to create a discourse that all sides of a design team would be able to understand-remove the gulf between user, developer, designer, etc. Exposure to up-to-date development software & be able to use them successfully to convey ideas/proposals/concepts to other people.

Perhaps the most interesting demonstration of students' emerging sense of professional 'self' is inherent within their final case studies. The topics for these case studies were open for self-selection, in which students were required to identify and research a topic of choice in the manner identical to the previous case studies. It was hoped that the student selection would reflect a growing awareness of the breadth and multidisciplinary and diverse epistemological nature of information environments. The varying degree to which this aim was achieved can be adequately reflected for this paper via a brief selection of topics presented:

- Alternative interfaces for computer-based musical composition and performance, utilising gestures, media spaces, and wearable technology;
- Technology and Phobias: Furthering the Treatment;
- Awareness in the Workplace: Interactions between non co-located Groups;
- Night Driving: How well can you see at night?

What are the empirical outcomes of Kreber's (2001) conceptual model?

This action research project remains current, precluding our comments here from representing completed empirical findings. However, at present, there seems to be preliminary evidence to indicate that Kreber's conceptual model aimed at "fostering experiential learning through case studies" (2001, p.223, figure 2) has been adequate in describing some potential learning for students in higher education. The data collected thus far indicates that students become engaged in case studies in an experiential manner through the processes of the problem-based cycle. Our findings also indicate qualitative development in critical reasoning (both written and oral) both as a competency and an orientation, and a gradually increased propensity for self-direction and autonomous thinking in relation to the case studies.

However, it is the positioning of Savin-Badin's PBL framework (2001) within Kolb's experiential learning theory (in Kreber 2001) that makes Kreber's conceptual analysis most salient to understanding the potential for case studies in professional design education. Earlier we discussed the centrality of professional understandings and identities as a vital aim of the course, and an influential component of information environments as an emerging discipline itself. We hypothesised that an educational design that incorporated aspects of problem-based learning as tools within a case study approach would facilitate the experience of designing for information environments. While Kreber (2001) has chosen to focus largely on critical thinking and self-directed learning as outcomes of the transformative nature of this model, our findings indicate that this conceptual model could be further elaborated.

Savin-Baden (2000) offers multiple models of problem-based learning, covering a range of educational intentions: epistemological competence, professional action, interdisciplinary understanding, transdisciplinary learning, and critical contestability (pp.126–127). This course sought to involve students in as many of these learning experiences as possible, by way of progression from epistemological competence to transdisciplinary learning. The interwoven strands of problem-based learning, case studies and experiential learning theory appear to have provided an effective educational design from which to begin to attend to these concerns. In which case, a conceptual analysis of the model's potential (Kreber 2001) may be enhanced by the inclusion of the epistemological nature of transformational learning, and the critical, transdisciplinary orientation to professional domains (such as design and technology) that a revised model may attend to. In doing so, Dewey's notions of transformational learning (in Kreber 2001) will be comprehensively attended to.

Implications – Empirical research and conceptual development

Our study is incomplete, yet preliminary empirical findings indicate that a conceptual model in which the case study approach effectively facilitates Kolb's experiential learning phases (through infusing a problem-based approach to learning) has potential for the development of critical thinking and self-directed learning. Additionally, the outcomes of this action research project indicate the model's potential for the transformation of learner's understandings about the nature of knowledge in the discipline, and understandings about their role as a practitioner in design and technology.

We put forward the suggestion that a comprehensive model of transformational learning through case studies and problem-based learning would include dimensions in relation to the learner's epistemological orientations and transdisciplinary understandings of the nature of the field of practice, and themselves as a practitioner. Further work in this regard should include both a revised conceptual analysis for the potential integration of Savin-Baden's (2000) framework, and the empirical testing of the framework in higher education.

Finally, as the nature of the design and technology field continues to change and evolve, our task in higher education includes the development and implementation of effective, relevant and cogent educational experiences. We see the ongoing examination, development and documentation of this integrated model as one with potential to enhance the learning of design and technology students, and contribute to future understandings about the fields within which they will practice.

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Primary Teacher Beliefs and Practices in Working and Thinking Scientifically and Technologically

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What are primary teachers' beliefs about thinking and working scientifically and technologically in the context of their classrooms? How do the teachers' beliefs manifest in classroom practice? What differences do the teachers see between thinking and working scientifically and technologically in the context of their classrooms? These questions were the central themes of my recently completed doctoral research. Three experienced primary teachers were the participants in the case studies. Interviews and classroom observation were the techniques used to identify how the teacher beliefs about thinking and working technologically and scientifically were manifested in their classroom practice. Key findings from the research revealed that these teachers had consistent, coherent beliefs about how children learn based on valuing students as individuals, a focus on relationships and developing autonomous learners. Their strong pedagogical knowledge ensured that they provided challenging learning experiences in science and design and technology. In curriculum planning they all focused on the processes involved in thinking and working scientifically and technologically. The findings from this research have significant implications for professional development and undergraduate pre-service education programs.

Introduction and background

My previous experience over two decades in both science and design and technology curriculum in the primary school, has led to the recognition of the problematic nature of the processes involved in science and design and technology education in primary schools. Common perceptions amongst teachers are that working and thinking scientifically is equivalent to "hands on", and working and thinking technologically is "design, make and appraise". However, in the South Australian curriculum documents these terms mean considerably more than that. Thinking and working scientifically and thinking and working technologically became the focus of the research because they are seen to be the essence of the scientific and technological processes respectively.

The research aimed at ascertaining primary teachers' beliefs about the processes involved in thinking and working scientifically and thinking and working technologically as it impacts on their classroom practice. Literature in areas such as Systems Theory (Laszlo 1996) Integrated Curriculum (Hattam 1994; Dufty & Dufty 1988; Johnsey 1999) and recent curriculum documents from various states in Australia (DETE 2001) have demonstrated the importance of schools providing connected learning experiences across disciplines. Advantages of integrating subjects include enabling children to study the same concept or skill from differing view points and reinforcing understanding. Children do not perceive the world in subject compartments as much as teachers do, and so it is more natural for them to study skills and concepts rather than curriculum subjects (Johnsey 1999). Although this current era in curriculum reform is a time of integration of the various ways of knowing (i.e. multidisciplinary), there is a view that integration cannot occur effectively until differentiation has been identified. It is therefore essential that teachers and students be introduced to the various disciplines but that the relationships between them are also established. Many curriculum systems (e.g. UK National Curriculum) have done well with the differentiation (Johnsey 1999) but are yet to use structures that show the relationships between ways of knowing.

Underpinning my research was the premise that in order to provide a rigorous curriculum primary teachers need to analyse both the science and design and technology learning areas and be able to identify the characteristics of the specific ways of knowing involved in thinking and working scientifically and technology before they can start to make connections and prepare holistic learning experiences for students.

Research method

The research method involved two key stages. Stage one of the study involved thirteen primary teachers completing a questionnaire and participating in a follow-up interview regarding their views about thinking and working technologically and scientifically. Subsequently, stage two involved three in-depth case studies where a unit of work in design and technology and a unit of work in science were observed and documented to identify how these teachers' views about working technologically and scientifically were reflected in their classroom practice. The key elements of the case study research involved:

(1) selection of 3 teachers from the original group of 13 volunteers
(2) structured interviews with the teachers to discuss their science and design and technology program, characteristics of their classroom climate and their understanding of what it means to work and think scientifically and work and think technologically
(3) classroom visits so that the children become acclimatised to a visitor and for me to observe the classroom climate
(4) observation of a unit of work in design and technology and a unit of work in science
(5) structured interviews at the end of each lesson and the unit of work
(6) analysis of data
(7) reflecting and attempting to draw conclusions.

Using a case study method within a qualitative research paradigm has offered, through the richness of the individual teacher's experiences, opportunities to consider the complexities of teaching and learning in science and design and technology by embedding them within details of everyday life in primary classrooms. Triangulation of data to enhance its validity has been implemented by using questionnaire, interview and classroom observation. This paper focuses primarily on the second stage of research, the three classroom case studies.

Findings

Whilst each of the case studies is unique, some useful comparisons can be made between factors within each case study, and across all three cases. The key questions that were the focus of the study and form the framework for reporting the findings include:

- What are the teachers' beliefs about thinking and working scientifically and technologically in the context of their classrooms?
- How do the teachers' beliefs manifest in classroom practice?
- What differences do the teachers see between thinking and working scientifically and technologically in the context of their classrooms?

What are the teachers' beliefs about thinking and working scientifically and technologically in the context of their classrooms?

These very experienced and highly regarded primary teachers each had clear and strongly held ideas about what were for them the essential elements involved in thinking and working scientifically and thinking and working technologically and also what they must do to bring this about in their classrooms. They regarded students planning their own investigations, using students' questions and providing practical learning experiences that focus on 'scientific' process skills, as the essential components of learning experiences that would assist students to think and work scientifically.

Similarly an emphasis on creative thinking, providing a range of tasks, tools and materials to investigate, and ensuring sufficient resources were available for their students to devise solutions to 'real world' problems were the essential components of learning experiences which would assist their students to think and work technologically.

Beliefs they shared about thinking and working scientifically and technologically included, valuing students' ideas, making connections via holistic planning, focusing on the processes, providing active learning experiences, extending the classroom to include the outside environment and using secondary sources to support teaching and learning.

Whilst they all had an intuitive understanding of thinking and working scientifically and technologically none of the teachers had a strong background in science or design and technology content knowledge. They lacked confidence in their own science knowledge and recognised that there was a great deal that they did not know. However, they had all developed strategies to locate the knowledge required to teach each topic and had the confidence to access appropriate resources from outside organisations, collegial or parental expertise. Indications are that teachers are not interested in gaining more knowledge about a topic unless they are teaching it. This suggests that primary professional development programs in science and design and technology which aim to increase teachers' content knowledge should ensure that this 'content' is presented within the context of teaching it rather than as an end in itself.

The teachers were decidedly more confident in design and technology but were largely unaware of any need for content knowledge in this area. Design and technology is a learning area that has captured the imagination of many creative primary teachers. Past experience as well as the outcomes of the research suggests that many primary teachers are more comfortable teaching in this area than in science. Design and technology neatly matches these teachers' beliefs that teaching and learning is grounded in the students' experience. It fits well with existing learning structures, particularly creative play and making things in the early years, and hands-on activity and craft in the primary years. As a result I have found that these teachers feel confident to teach this new area of study but it is clear that they have not encountered the challenge to identify the technological content knowledge, to broaden their view beyond tool safety and use to include a socially critical perspective, and to provide sequential and developmental learning experiences for their learners.

How do the teachers' beliefs manifest in classroom practice?

All three primary teachers had consistent, coherent beliefs about teaching and learning. They valued students as individuals, were literacy-based, and focused on relationships, communication and developing autonomous learners. In curriculum planning and implementation they all focused on the processes involved in thinking and working scientifically and technologically. Two of the teachers were able to articulate their beliefs about what this entailed in the context of their current unit of work and although the third teacher had difficulty articulating her beliefs, she concurred with those I inferred from her classroom practice. All three teachers saw little relevance in exploring the links between science and design and technology. However, this did not impede their ability to provide challenging and motivational learning experiences in both subject areas.

Claims that teachers bring to the classroom a particular understanding about design and technology depending on the subculture to which they belong is an issue recognised by secondary educators. Teachers with a background in science, agricultural science, technical studies or information and communication technology bring that specific perspective or bias to design and technology. On the other side of the coin, it may also be argued that as primary teachers are generalists they bring no such subject-specific subculture to design and technology. What the teachers in this research did bring is a subculture of strong pedagogy in primary practice which fostered gender-inclusive, learner autonomous, student-focussed classrooms and resulted in dynamic and action packed learning communities. It was exciting to see the evidence that despite their limited views of technology and lack of confidence in their scientific knowledge they provided wonderfully rich environments in which to learn science and design and technology.

The findings of this study fit well with the view that primary teachers tend to treat subject boundaries as artificial and at times inimical to effective primary practice. This overarching idea fits well with the five Essential Learnings namely Futures, Communications, Identity, Interdependence and Thinking that have become a focal point of the new South Australian curriculum material (DETE 2001). There has been a shift in the curriculum emphasis from the traditional subject areas to the attitudes and dispositions deemed necessary for students to adapt to the rapidly changing world in which they live. My case study observations occurred before the Essential Learnings had been distributed to all schools but they were evident in these teachers' classrooms as the teachers provided connected learning experiences in the context of science and design and technology. This is a striking and welcome example of effective intuitive practice being incorporated into curriculum changes.

What differences do the teachers see between thinking and working scientifically and technologically in the context of their classroom?

These three teachers could talk about specific characteristics of thinking and working scientifically and technologically in the context of their classroom. However, they all found it difficult to respond to questions about the similarities and differences between thinking and working scientifically and technologically in any general or abstract sense. Teachers' responses were inconsistent and seemed dependent on the context of their current teaching program.

By not having a clear idea about the distinction and relation between working and thinking scientifically and technologically the teachers missed the opportunities to follow through learning experiences incorporating both perspectives. The lack of content knowledge in science and the narrow linear view of design, make and appraise in design and technology resulted in them not having the flexibility to encourage and support students as they explored links between these ways of knowing.

Implications for professional development

Throughout the study I consistently examined the two key areas of learning separately, and so the implications for professional development are presented in Table 1 in two columns. The themes which emerged are the basis of the implications for professional development for primary teachers. A third column has been added as there are also implications for undergraduate programs and the outcomes of this research should inform forthcoming Education Reviews into primary teacher education.

Suggestions for future research in the fields of science and design and technology education

In order to progress the field of design and technology education further it would be useful for research focusing on:

- primary teachers' understanding of design and how their views are manifested in their classroom;
- the technological content knowledge that is needed by primary teachers;
- how teachers use drawings in design and technology tasks.

In order to take the field of science education further it would be useful for research to focus on

- the relative benefits of using a Non Instructional Time approach using specialist teachers versus having programs offered by classrooms teachers.
- the effect on students' learning as they switch from integrating areas of study in years R-7 to a subject based structure in years 8–12.

Table 1

Topics identified and implications for professional development and undergraduate education programs

THEMES	IMPLICATIONS FOR PROFESSIONAL DEVELOPMENT FOR SCIENCE	IMPLICATIONS FOR PROFESSIONAL DEVELOPMENT FOR DESIGN AND TECHNOLOGY	IMPLICATIONS FOR UNDERGRADUATE EDUCATION PROGRAMS
Primary teachers' scientific and technological content knowledge.	• Provide access to useable sources of scientific knowledge and set them within a classroom context.	• Explore current curriculum documents to broaden their understanding beyond tool use and safety, of what contributes to technological content knowledge.	• Ensure that undergraduate programs provide rigorous and challenging programs and access to useable resources for all students.
Socially critical focus.	• Challenge teachers to raise socially critical perspectives in the scientific investigations they are carrying out.	• Encourage and challenge teachers to construct their design and technology tasks to have a socially critical focus.	• Ensure undergraduates are exposed to a range of literature and assignment tasks that challenge the status quo.
Thinking and working.	• Show teachers how to focus on both components of thinking and doing and provide a 'hands-on, minds-on' program in science.	• Show teachers how to focus on both components of thinking and doing and provide a 'hands-on, minds-on' program in design and technology.	• Provide science and D&T courses that model effective classroom practice and require undergraduate students to think about what they are doing and what they expect to learn from it.
Using drawings with young children.	• Develop teachers' confidence to use children's labeled drawings as an effective assessment tool for students to communicate scientific conceptual understandings.	• Explore the current research that challenges the practice of asking young children to draw their ideas prior to solving problems in design and technology tasks. • Undertake classroom-based action research.	• Invite art/design education lecturers to present in technology and science education programs.
Exploring the integration between science and design and technology	• Provide primary teachers with the opportunity to theorise about what it means for their students to think and work scientifically. • Explore teaching models that help teachers maintain the discrete characteristics of each area whilst making connections for students. • Use Essential Learnings as a basis to explore interactions between different ways of knowing.	• Give primary teachers the opportunity to theorise about what it means for their students to think and work technologically. • Encourage professional associations to work more closely together to provide professional development programs for teachers. • Use Essential Learnings as a basis to explore interactions between different ways of knowing.	• In the first two years of an undergraduate teaching program set up courses to ensure students have sound understanding of each area. • In latter years, set up courses which focus on different ways of knowing to integrate subject areas and so encourage undergraduates to develop a holistic and connected approach to programming.

THEMES	IMPLICATIONS FOR PROFESSIONAL DEVELOPMENT FOR SCIENCE	IMPLICATIONS FOR PROFESSIONAL DEVELOPMENT FOR DESIGN AND TECHNOLOGY	IMPLICATIONS FOR UNDERGRADUATE EDUCATION PROGRAMS
School structures	• Explore school structures that support teachers to teach students science in different levels of schooling, early, primary and middle. • Explore the appropriateness of science specialists in primary school.	• Explore school structures that support teachers to teach students design and technology in different levels of schooling, early, primary and middle. • Explore the appropriateness of design and technology specialists in primary school.	• Ensure undergraduate students are exposed to the philosophy of the middle school.

The advantages and disadvantages of integrated teaching practice and the consequence in terms of student learning is under researched and as such provides many opportunities for future studies (Goodrum, Hackling & Rennie 2001). The findings from this study showed that experienced teachers who did not have a clear view of the ways of knowing for each subject had difficulty identifying working and thinking scientifically and technologically when teaching an integrated topic. Having a view of working scientifically and technologically as outlined by the curriculum frameworks did not appear sufficient for successful integration. Investigating the advantages for student learning in science and design and technology using a multi-disciplinary approach as suggested by Johnsey (1999) and Roth, Tobin and Ritchie (2001) has the potential to be very fruitful.

Conclusion

This research has taken me to the realisation that the findings from the case studies and the ideas in the literature fit comfortably with my experience of 17 years as a primary classroom teacher followed by providing professional development then supporting undergraduates as they learn the trade. Focusing on teachers' beliefs about the discrete characteristics of what it means to think and work technologically and what it means to think and work scientifically proved even more productive than my original intention to explore the complex area where they intersect.

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"Teaching" Values in Technology Education: A Critical Approach for the Theoretical Framework

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This paper discusses the issues of values in technology education in the context of a critical review of the literature. It presents the findings of this analysis and argues that the typology of values developed in technology education does not adequately represent the nature of values in this area and it is not helpful in terms of guiding teachers' practice. Thus, in terms of a typology, it is proposed that a distinction between intrinsic and instrumental values would be beneficial for developing an understanding of values in the area. In relation to the second area of concern, the paper suggests that in order to provide adequate learning experiences to students, teachers need to consider the relationship between the two concepts of teaching effectiveness and moral responsibility as a starting point for approaching value analysis. The regulative model of professional morality, which argues that all aspects of teaching needs to be moderated by social, ecological and cultural responsibility, is proposed as a framework for the development of an appropriate classroom learning environment in technology education. The place of moral values is highlighted in the argument.

Introduction

This paper contributes to the aim of this conference which is to explore learning in technology education by expanding on a discussion of values in technology education. Questions related to values in technology education highlight the importance of a technology curriculum that enriches students' awareness and appreciation of their responsibility as members of a technological society. The necessity of exploring values in technology education has been argued by a number of authors (Layton 1991; Barlex 1993; Prime 1993; McLaren 1997; Breckon 1998; Holdsworth & Conway 1999) as a vital aspect of a comprehensive technology curriculum. However, the typology of values developed in technology education does not represent to the full extent the nature of values in this area and it is not helpful in terms of guiding teachers' practice.

This paper critically reviews the approaches proposed by those authors and makes some suggestions on how to develop them differently. The paper suggests that in order to provide adequate learning experiences to students, teachers need to consider the relationship between effectiveness and responsibility as a starting point for approaching value analysis. The regulative model of professional morality, which 'limiting the aspects of effectiveness by the aspect of responsibility', is proposed as a framework for development a classroom environment in technology education. The importance of moral values is highlighted in the argument.

The starting point

From the early stages of the introduction and development of technology education as a compulsory learning area throughout the world, values have been acknowledged as an important part of the curriculum. In the English Interim Report (DES/WO 1988) the distinction was made between "intrinsic values – considerations such as efficiency of resource use, value for money; and contextually related values – considerations such as health and safety, user preferences and ecological benignity (1.32 to 1.34)" (DES/WO 1988, p.76). It is also specified that Design and Technology activity

> involves pupils in making judgements of any kinds – technical, economic, social, aesthetic and others. As pupils' capabilities increase, there should be progressive refinement in the art of making these judgements (DES/WO 1988, p.76).

These two areas of concern: the typology of values used and the reasons why these values are important, provide the initial basis for the following discussion.

Typology of values in technology education

The distinction between intrinsic and contextually related values in technology education is an issue that has not been addressed by researchers. Instead, the majority of authors have classified values in technology education under headings related to the proposed areas of judgement making: "economic, aesthetic, moral, environmental, technical, spiritual and so on" (Layton 1991, p.6).

A justification of this typology was proposed by Prime (1993) on the basis of categories developed by Schwartz and Bilsky (1987, 1990). Those categories include a) values that relate to the biological needs of individuals; b) values as 'requisites of co-ordinated social interaction'; c) 'survival and welfare needs of groups'. As a result six sub-categories of values in technology education were identified by Prime (1993): **personal, social, economic, political, cultural, environmental**. Other researchers (Breckon 1998; Holdsworth & Conway 1999) added moral, technical and aesthetic values to the list.

Thus, the main theoretical assumption for categorising values is that values in technology education are related to human needs. All values identified are treated equally; no hierarchy is proposed. However, on the practical level, teachers put the following priorities on teaching values, with the first being the most important: technical, aesthetical, economic, environmental, social, cultural, moral, political (Holdsworth & Conway 1999). The conclusion drawn by Holdsworth and Conway (1999) is "that there are some teachers who just do not view certain values as relevant" (p.213) to technology education.

Value judgements

The main argument supporting the importance of value education in technology relates to the provision of a basis for "value-based decision in the designing, implementing and evaluating of technology, in situations that are ethically complex" (Prime 1993, p.34). Value judgements are considered as "the individual decisions or choices which make the values of people explicit" (Holdsworth & Conway 1999, p.206) and which are "closely connected to personal integrity and personal identity" (Halstead 1996, p.5). Values provide a basis for choice, decision making and action in a wider context.

Value judgements are considered as relative to a particular situation. For example, Prime (1993) argues that technology "often poses real ethical dilemmas in which there are no obvious right answers or altogether satisfactory solutions. In such cases the challenge is to weigh all relevant contextual factors and to be guided by the values deemed to be more important in that situation" (p.32). Thus a relativistic approach to the nature of all decisions is acknowledged and no general guidelines for decision making are given to teachers or to students.

How to deal with values

Another important area of concern, which is not directly related to the quote from the Interim Report, is what teachers can do in relation to values? The most frequently found answer is to make students think about values. As summarised by McLaren (1997):

> Teachers have a responsibility to raise awareness and increase understanding of social, ethical, environmental, economic values and issues involved in design in order that pupils can attempt to make informed, considered and sensitive value judgements (p.259).

Another position balances the cognitive component of values by an affective one. Prime (1993) on the basis of Schwartz's (1992) interpretation of values argues that values have both cognitive and affective components: "developing values through technology education must … address the cognitive component, by exposing children to all the relevant knowledge, as well as engaging their feelings by placing technology in a human or social context that is meaningful and real" (p.32). The cognitive component is the underlying beliefs in which values are grounded. The affective component relates to the feelings and attitudes towards the object of value. This affective component distinguishes values from beliefs.

The third component of values, a behavioural one, is not explicitly presented in technology education literature. However, it is analysed in the psychological research as an important component of values that may lead to action (Rokeach 1973).

Intrinsic - non-intrinsic nature of values

The argument presented in this paper is that the interpretation of values in technology education presented above is not sufficient for improving teachers' understanding in this area, nor does it present clear guidelines for the development of their practice. Several issues following from the analysis will be explored below. The first one relates to the intrinsic - non-intrinsic nature of values.

This distinction has been made by a number of authors, for example *intrinsic* (good in itself) and *instrumental* (a means towards the end) kinds of value (Jarrett 1991); or *terminal* (referring to 'end-states of existence') and *instrumental* (referring to 'modes of conduct') values (Rokeach 1973). According to Rokeach (1973) terminal values include such concepts as a comfortable, exciting life, a sense of accomplishment, a world of beauty and equality, freedom and happiness, inner harmony, self-respect and social recognition, true friendship and wisdom. Instrumental values encompass such concepts as ambitious, open-minded, capable, helpful, honest, imaginative, intellectual, logical, responsible, self-controlled.

The examples of intrinsic values presented through the *Interim Report* do not correlate with theoretical interpretations of intrinsic values. They can be defined as instrumental in their nature.

Although most researchers acknowledge a functional relationship between instrumental and non-instrumental values, they see a conceptual advantage of this distinction. This is also true and for technology education. The distinction between two kinds of values provides a broad framework for thinking about values. All categories from Prime's typology can be interpreted differently on the basis of this distinction. For example, personal values can be intrinsic or instrumental, social values can be intrinsic or instrumental and so on. In technology education we are dealing mostly with instrumental values. Thus, it is important to understand the nature of *instrumental values* and to recognise the importance of the development and careful consideration of them in reaching the aims of technological activity. As stated by Jarrett (1991) "in education the means one uses to reach one's ends are themselves going in some measure to determine the nature of those ends" (p.9).

Two major kinds of instrumental values, according to Rokeach (1973) are those that have a moral focus and those related to *competence or self-actualisation.* According to Rokeach (1973) moral values refer to those "that have an interpersonal focus which, when violated, arouse pangs of conscience or feeling of guilt for wrongdoing" (p.8). They refer mainly to modes of behaviour and "do not necessarily include values that concern end-states of existence" (p.8). Competence or self-actualisation values refer to personal focus, for behaving logically and intellectually.

For most people values are ordered hierarchically in terms of their relative importance (Schwartz 1992 cited in Prime 1993; Rokeach 1973). As demonstrated above, among technology teachers, values related to competence (technical, aesthetical, economic) have a priority compared to moral values (Holdsworth & Conway 1999). In this paper it is argued that moral values should be a priority in the teacher's and student's hierarchy of values.

Moral values

A dichotomy between reason and commitment has been analysed from different perspectives. Habermas (1974/1963) argues that rationality (defined as efficiency and economy) "cannot itself be placed on the same level with all the other values" (p.259) or prevail above them. He cited Hans Albert who made the suggestion:

> to place in the foreground … in the establishment of a criterion for the validity of ethical systems, the satisfaction of human needs, the fulfilment of human desires, the avoidance of unnecessary human suffering. Such a criterion would have to be discovered and established, just as this is true for the criteria of scientific thought (Habermas 1974/1963, p.280).

Thus, rationality, effectiveness must be framed by the moral considerations. Moral values constitute a part of the person's value system. The approach used by Jarrett (1991) gives a useful definition of moral values contrasting them with ethics. For him the moral (morality) is considered as

> an aspect of the ethical, namely that which particularly concentrates on obligation, the ought and ought-not, on duty and conscience and human virtues, where the ethical will also include consideration of the good life, happiness, well-being, admirable conduct over and above the call of duty, and the place in life for such kinds of value as the aesthetic, cognitive, et al … We must add …some such modification of the ought, to indicate its moral nature, as "with respect to our consideration for the welfare of others, or requirements of our duty" (Jarrett 1991, p.14).

Where should the moral values be placed in technology education? Two areas of application for moral values have been identified by this research: professional morality of technology teacher and moral judgements of students in relation to the products they develop.

Professional morality

In relation to the professional morality of the teacher a concern similar to that expressed by Habermas provides a basis for the theory that starts from the assumption that no professional action should be guided only by "functional criteria of means and end relations under the perspective of functional success" (Oser 1994, p.60). As argued by Oser (1994)

> A responsible professional action must be informed by a structure of moral values that enables the actor to estimate positive and negative consequences that concern human beings immediately or indirectly. The relationship between success and care in regard to consequences is the core criterion of this theory (p.60).

Oser (1994) provides a useful model for conceptualising different approaches to teaching on the basis of the relationship between effective and responsible teaching. He proposed four types of possible connections: (a) interpretive; (b) additive; (c) complementary, and (d) correlation or regulative. These models are seen as a useful way of thinking about teaching practice in technology education. They constitute a hierarchical structure of increasing knowledge of how to solve the conflict between aspects of effectiveness and responsibility.

The interpretive model starts with the assumption that good intention is implicitly a moral aspect. "The danger of this model is that people view *effectiveness* [italic added] as a moral good in itself" (Oser 1994, p.62). Training to the test, technical function and economic success of the product are important. According to **the additive model**, one should, in general, be success oriented, but in some cases reflections on ethical issues are required. "The danger of the additive model is the absolute separation of two realms [ethical and instrumental] that are, in fact, dependent on each other" (Oser 1994, p.62).

In **the complementary model**, responsibility and effectiveness are seen as interdependent. In this context, to be responsible means "to measure effectiveness from the point of view of good intentions, estimated consequences, and experienced needs" (*ibid,* p.62). Each technical act must be reflected. However, this reflection is not structured. "There is not yet a communicative technique for having a professional moral knowledge systematically related to successful professional actions" (*ibid,* p.62).

The regulative model is based on the idea of limiting the aspects of effectiveness by the aspect of responsibility. In this view, professionals have to know "how to solve problems involving effectiveness conflicts and how to estimate outcomes by balancing important moral issues" (Oser 1994, p.63). Any teaching act has a moral core. This approach is more time consuming, challenging and demanding, but it will result in feelings of "obligation, shared norms, and engagement" (Oser 1994, p.63).

A current approach to values in technology education that is presented in the literature correlates with the additive model (reflections during the product analysis, classroom discussions or case studies). In most publications it is assumed that teaching moral content (knowledge concerning norms, rules, justice matters, etc) is valuable in itself because it "helps students to develop a moral point of view and helps teachers themselves to understand what morality can contribute to interpersonal life" (Oser 1994, p.90). The complimentary model had been also identified as another model used by teachers (author's observations and interviews in Russia 1999–2001). Teachers believe that morality and responsibility are learnt more on the action level, through models such as teachers.

In this paper, it is argued that the regulative model should be used by technology teachers. They should view the classroom environment and the process of designing and making primarily as "a moral enterprise but as serving functional purposes" (Oser 1994, p.103). It is important that teachers' attention is been focused on moral values and on inclusion of students as real discourse partners in the ethically problematic situations.

Students' moral judgements

Classroom environments that cultivate responsibility will stimulate students to put moral values first. They will not be considered as one category of values among the others but as a reference point for all design decisions. On the basis of research Oser (1994) concludes that "seldom does a teacher state that he or she must set conditions that allow the students to take responsibility; to understand the meaning of being just, caring, and truthful themselves; and to show commitment for their schoolmates" (p.62). The nature of technology education provides a rich context that can be easily moved beyond the concept of effectiveness. Thus, the discussion of values that is presented in technology education literature at the moment, should be replaced by discussion of moral values as a starting point for making judgements made by the students.

Conclusion

In this paper, it is argued that the typology of values developed in technology education does not adequately represent the nature of values in this area nor present an approach teachers may use to guide their practice. It is proposed that in technology education teachers mainly deal with instrumental values that can be classified as moral and competence-based. Although competence values receives ultimate attention from technology teachers, it is argued that moral values have to provide a framework for all technological activities and should be at the top of the values hierarchy among technology teachers.

In addition, three components of values have to be taken into account, these are: cognitive, affective and behavioural. Cognitive component provides the awareness of different values and demonstrates the reasons to put moral values first. The affective component establishes links between the technological task and students feelings by putting technology into a meaningful context. The behavioural component gives students an opportunity to act in accordance to their moral values.

To deal with values effectively the teacher has to develop an appropriate classroom environment that will help students to recognise a situation as being ethically problematic; that will enable students to have a voice and express their feelings and thoughts and find a solution that serves the best interests of all parties involved. So students have to be aware of the effectiveness-responsibility framework and use it in their activities. Both objects and technological experiences have to be valued.

Further research is needed in identifying the list of instrumental values (moral and competence focus) that will provide a basis for the practical applications of the theoretical ideas presented in this paper.

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Values in Technology Education: A Two-Country Study

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Like science, technology, and by implication, technology education, was once thought to be value-neutral. Such propositions are now discredited, however, the question concerning the values that technology educators hold is still an open one. This paper reports on the findings of a pilot study into the values held by technology educators in a selection of high schools in Australia and the Russian Federation.

Introduction

Since the 1990's Technology education programs, curricula, standards or syllabi have been introduced in many countries including Australia, (Curriculum Corporation 1994a, 1994b; QSCC 2002) America (ITEA 2000) Russia (Lednev et al 1998) and Hong Kong (Curriculum Development Corporation 2000). The programs from which these technology education programs have grown have a history that is variously, craft, industrial arts or work skills oriented. The values within these courses reflected their history and nature.

Contemporary technology education programs represent a significant change from these earlier programs that had quite specific orientations, as they generally propose a wider concept of what technology education should be concerned about. One of the concerns that had been articulated in most technology curriculum documents is an explicit emphasis on values. That is, the values that students should explore, be exposed to and understand, as a result of involvement in a technology education course. However, implementation of any policy heavily depends on teachers understanding the policy and having strategies suitable for implementing it. Two assumptions underpin and provide part of the rationale for the study. The first is that teachers need to have an explicit understanding that values are involved in technology education. The second is that teachers need to understand and be able to use strategies aimed at the development of particular values among students.

Background

There is a substantial number of publications that argue for the inclusion of values in technology education (Barlex 1993; Breckon 1998; DES/WO 1988; Holdsworth & Conway 1999; Layton 1991; McLaren 1997; Prime 1993). A widely accepted approach to describing them is in terms of eight categories developed on the basis of theoretical analysis of human needs (technical, economic, aesthetic, social, moral, environmental, cultural and political) (Layton 1991; Prime 1993; McLaren 1997). However, very few studies focused on teachers' interpretation of values. As teachers' values influence the values of their students, an exploration of teachers' values was the central objective for this study. The study was considered important both in order to understand classroom practice, and to inform the process of developing the most effective ways of preparing teachers to deal with values in technology education.

> One factor which seems to be missing from the views of all individuals and organisations …[DATA, OFSTED, DfEE] are the views and opinions of those who deliver a values input to the students, the design and technology teachers themselves" (Holdsworth & Conway 1999, p.209)

Another objective of this study was to trial an instrument for data collection for the comparative study. No comparative studies examining the values held by technology teachers were located in a literature search. However, a number of comparative studies examining teacher values in general were reviewed (see for example, Stephenson, Ling, Burman & Cooper 1998; Steiner-Khamsi & Dawson 2000). Thus, comparative perspective for investigating the approaches to values taken by teachers was another type of literature that informed this study. Comparison between two countries made it possible to examine the issues related to the dimension of specific versus universal characteristics of values in technology education. These studies examined teachers' views on the kinds of values that should be taught in schools and the most effective ways to teach values in schools. The general conclusion was that:

> educators lack a discourse to express their ideas about values and to conceptualise the area of values in education. This stems, largely, from the lack of theoretical knowledge and experience educators possess in this area (Ling 1998, p.210).

All studies indicate the importance of establishing an appropriate analytical and interpretive framework for this type of study. Among the issues related to comparative research underlying the study were the following: The meanings ascribed to the issues within the two languages and the assumptions underlying the views of participants in the study.

Research question

What values do technology teachers express as values for technology education and how do they interpret their roles in dealing with values?

Methodology

The research described in this paper was a trial, with the intention that it would inform the development of a proposal for a larger, funded research project. Only limited University funding was available and the methodology was shaped, to some extent, by this factor. The methodology was qualitative and based on structured interviews with teachers, and a survey they filled out after the interview. The interviewees selected for the study were practicing technology teachers or heads of technology departments. In addition, teachers were selected on the basis that they could be considered to be competent professionals and to have a progressive outlook on technology education.

Five teachers were selected from Australia, these coming from government high schools in the greater Brisbane metropolitan area. Five teachers were selected from Russia from three regions: Nizhny Novgorod, St. Petersburg and Karelija. All were from state schools. As an exploratory study the study was as much concerned with ways to explore the issue, both in terms of the issue itself, and in terms of exploring it in a cross-cultural context

Instrument

The instruments for data collection consisted of two parts. The first one was a structured interview that explored: the values teachers expressed about technology education and the relationship between their views about values and effective teaching; values in technology education and values in other subject areas; teachers personal values; and the relationship between values and effective teaching. The second data collection instrument was a survey where teachers ranked their responses to a number of statements about professional values. The survey was designed to explore the degree to which teachers' values reflected an emphasis on functional success or moral values, and the relationship between these two values dimensions. Some demographic data were also collected. The interview contained six questions and the survey contained sixteen statements and two questions. One question asked teacher to indicate the proportions of their professional time spent on various aspects that related to values and the second question asked them to describe how they implemented their values in their classrooms. All interviews and surveys were conducted at the schools where the teachers worked, at a time convenient to each teacher.

As an interpretive framework, a model developed by Oser (1994) was used to both develop the interview and survey questions and as the basis for analysing the teachers' responses. That is, Oser provides a framework based on the analysis of the relationship between the concepts of effectiveness and responsibility in terms of teaching. Oser argues that teachers' professional action should not be guided only by: functional criteria of means and end relations under the perspective of functional success but that: A responsible professional action must be informed by a structure of moral values (Oser 1994, p.60). Oser describes two kinds of relations between functional success and moral values. The first Oser calls the regulative model which is described as the situation where teachers approaches to academic success are moderated by moral considerations. The second is called the additive model, which is described as the situation where moral considerations are seen as additional to functional success.

Analysis

The analysis of data consisted of transcribing each of the tapes of the interviews and sending the transcripts back to interviewees to verify the content. After establishing the final content of transcripts, the interview data were summarised and patterns of responses examined.

The survey data were compared and patterns established for those components of the survey where rankings were used. In this initial study trends and tendencies were analysed. A trend was defined as a set of responses to a statement where all responses were contained in two adjacent ratings. For example, in response to the statement The role of the teacher is to reconstruct the moral climate of school by transferring responsibilities to students, three Australian respondents ranked it as important and two as very important. A tendency was defined as a set of responses that while not in only two adjacent ratings, loaded to either left or right. For example, in the Russian response to the statement The most important goal for you is to establish interpersonal relationships with your students, three indicated that it was very important, one that it was quite important and one that it was less important. The responses are interpreted as a tendency to view the statement as being important.

As the survey covered material related to and overlapping the interview data, the two were examined separately initially, and then together to establish an overall picture, identify inconsistencies and to provide a small measure of triangulation for the data.

Results

The interview data for the teachers are summarised in Tables 1 and 2.

Analysis

Analysis of the interview data

Australia

Overall, there was a high degree of congruence in terms of the responses to the interview questions. Technology educators regarded the development of problem-solving skills, development of knowledge about safety, the hands-on nature and the ability to put theory into practice as the important values in technology education. When comparing the values in technology education to those of other subjects, all felt that most could be found in other subjects, but felt that the values were achieved in technology education because of the more authentic contexts. Technology teachers felt that learning values through practical application was the most appropriate approach to teaching values. The responses to the question about values they observed received a variety of responses which included egalitarianism, innovation, work ethic, quality, team problem-solving, lateral thinking and respect for other people's ideas. The variation in response seemed to be a reflection of different observations. That is, some appeared to be thinking of teaching values while others appeared to be thinking of the values observed among students.

The topic of professional morality appeared to elicit caution and vague responses along the lines of, it is important and there should be lots of it. However, apart from one respondent suggesting technology teachers' professional morality should be based on involving students in making the world a better place, no other specific responses were elicited. The question concerning the relationship between teaching effectiveness and moral considerations elicited a consistent response that the two should be integrated, and dealt with through project work.

Table 1

Summary of interview responses by Australian technology teachers

INVOLVE-MENT IN TE	ACTING HOD	HOD	HOD	HOD	HOD
LENGTH OF TIME IN TE	18 YEARS	15 YEARS	22 YEARS	6 YEARS	9 YEARS
What do you see as the values in TE?	Safety, Problem-solving, hands-on, practical application, creative thinking, promoting "smart state"	Problem-solving, understanding the world	Ability to put theory into practice, skills for work and life, safety	Thinking skills, creative thinking,	Development of the person, problem-solve and develop ideas, value for work and leisure
Are they similar or different to values in other subjects?	Different in being based in "real activities", similar to subjects like Art in the design aspect	Similar values to other subjects like Maths and English but TE can achieve them in practice	Similar to Home Economics, students regard TE as more enjoyable than English, Maths or Science	Different, more student-centered	Similar to other areas but TE provides the opportunity to relate to practical skills
How should teachers deal with values in TE?	Through practical application	By integrating them into the projects they give students	Integrated within the subject content	Not sure	By giving students the opportunity to make their own decision
What categories of values do you observe or recognise in TE?	Egalitarianism – kids don't observe a pecking order in TE. Innovation	Strong work ethic, value of quality work,	Safety, respect for other people's ideas, team problem-solving	Lateral thinking, creative thinking, engaging in authentic tasks	Appreciation of quality
What are your beliefs about professional morality?	Teachers should be of high moral character, Involve students in making the world a better place	Teachers should have high moral values (none stated)	Effective teachers should be able to include moral aspects within their teaching	A moral teacher is one who does it for the right reasons, to benefit students	Poor tape quality
What should be the relationship between effectiveness of teaching and moral considerations in TE?	Moral aspects should be integrated into the projects students do	The two need to be integrated, so they are meaningful for kids	An effective teacher should be a moral teacher, effectiveness should incorporate moral considerations	They should be complimentary	Needs a stronger relationship, more emphasis being put on content and its relation to prior knowledge

Table 2

Summary of interview responses, Russia

INTERVIEWEE	A	B	C	D	E
GENDER, LOCATION	MALE, N. NOVGO-ROD	FEMALE, N. NOVGO-ROD	MALE, N. NOVGO-ROD	FEMALE, ST.PETER S-BURG	MALE, PETRO-ZOVODSK
INVOLVEMENT IN TE	TEACHER, 28 YEARS	TEACHER, 6 YEARS	TEACHER 19 YEARS	TEACHER, 5 YEARS	TEACHER, 3 YEARS
What do you see as the values in TE?	Technology is the main subject. It provides a framework to link all subjects in terms of knowledge.	Development of problem solving skills and development of students as creators, not as a consumers	To educate a boy, a future head of the family, to teach those skills that he will require at the house to maintain, to fix, etc.	To develop the student and his qualities. It is general educational values as well	To develop the student – not to give him a specific knowledge
Are they similar or different to values in other subjects?	Similar, as moral values are general, but in TE this happened from the first hand experience	Similar, but the paths - how they are presented in the subjects are specific	Different, students learn skills that they do not receive through the other subjects	Similar, personality of the student is a holistic. Specific - possibility for the student to be more active	Similar, moral values can be developed by the other subjects
How should teachers deal with values in TE?	To approached moral issues through the real work, not through lecturing. React on the classroom situations; observe students and guide them in the right direction; involve the class tutors	It is not possible to teach about moral issues - cover issues during product analysis. Resolve all moral dilemmas in the classes + consult with the class tutor. You can teach how to get out from some situations	There is a relationship between technology and up-bringing and the teacher relates it to the students' family	Discuss moral issues through the projects, have some projects on ecological issues, (no time on social issues). React on what students did and on the situations from the real life. Deal with peoples needs	Depends on the situation and on the student - what values to touch. Discuss ecological issues, social (in the senior classes), regional specificity - traditions, economy profile; have a close link with a class tutor
What categories of values do you observe or recognise in TE?	Moral values relate to 'collective': team work, help, friendship, not to do bad things	Different qualities in the students and issues: ecology, spiritual-moral values, historical, nature-person relationships	Ecology, family values	"Did not think about classification"	Different qualities in the students

INTERVIEWEE	A	B	C	D	E
GENDER, LOCATION	MALE, N. NOVGO-ROD	FEMALE, N. NOVGO-ROD	MALE, N. NOVGO-ROD	FEMALE, ST.PETER S-BURG	MALE, PETRO-ZOVODSK
INVOLVEMENT IN TE	TEACHER, 28 YEARS	TEACHER, 6 YEARS	TEACHER 19 YEARS	TEACHER, 5 YEARS	TEACHER, 3 YEARS
What are your beliefs about professional morality?	You analyse the situation, the relationships with the students and try to avoid conflict moments. You should not press the child	To be a model, not to thrust on my opinion and to teach them to work for the well-being of the people. Morality - do not harm (as for doctors)	Help students to develop, to support different kids those who like to create and those who like to do the same	To be a model and to teach about values in the senior classes	To be a model and equal to the students but not to be a close friend. Teachers have to use different methods to develop student
What should be the relationship between effectiveness of teaching and moral considerations in TE?	Both are important and interrelated: good moral climate in the class help to learn better.	Teachers spend more time on the first one. In the program they do not touch a deep moral issues.	Without moral it is impossible to exist, but we spend almost all time on development of a technically literate person. Orientation should be on family, not society	Two should be in balance. However, high moral issues are considered by the other subjects. We do not have a chance to do this.	Should be both. The ratio should be 70%/30% (effectiveness/ responsibility)

Russia

Development of the person was seen as the major value of technology education as well as the possibility for technology education to provide a framework where all subjects can be linked was given as the initial response to the question of values. Subsequent responses regarded moral issues as values in technology education. A majority of teachers believe that values in technology education and other subjects are the same but they can be presented in technology education differently through practical experiences. Other subjects can spend more time on moral issues. Talking about values in TE teachers refer to moral values only. Technical, economic, aesthetic values were not considered as values. In Russia this relates to historical interpretation of values, where during the Soviet time there was one official view on values which gave the emphasis to spiritual, all-human, moral values. Technical and economic values were not discussed. Most mentioned ecological issues that they consider during their teaching, but they did not consider them as values unless the researcher asked them about it.

Many teachers indicated that in dealing with personal relationships among students and between the teacher and the students, a teacher can deal with values. Moral values closely relate to the person's relationships with the other people. These correlate with Rokeach's (1973) interpretation of moral values that refer to those: that have an interpersonal focus which, when violated, arouse pangs of conscience or feeling of guilt for wrongdoing (Rokeach 1973, p.8). They refer mainly to modes of behaviour and: do not necessarily include values that concern end-states of existence (Rokeach 1973, p.8). Thus, teachers can deal with moral values through the process of doing projects using the following ways: react to classroom situations and on the events in the outside world; observe and guide students; orient students' work on the well-being of the people. They believe that it is not possible and it is dangerous to explicitly teach about moral values. Teacher should be a model, thus moral values are implicitly included in the process of teaching (a complimentary model, according to Oser 1994). However, two of them mentioned that it is possible to teach about values in the senior classes, summarising what have been learnt in the other subjects.

Most teachers categorise values on the basis of students' characteristics. They all do something in their teaching using informal strategies. One teacher expressed the view that moral issues should not be included in the curriculum, otherwise all issues related to moral values will become formal and this would be non-productive. However, the teacher should pay attention to them. Another teacher believed that it is important to explicitly include values in curriculum, at the moment only some elements of etiquette and rules on how to behave in different situation are specified.

In responding to the question related to effectiveness versus moral considerations, all teachers agreed that both should be present, but acknowledged that they pay more attention and time to effectiveness (teaching the content and skills to the desired level of proficiency). The general request from the teachers' side was to have more time for the subject so teachers can pay more attention to values. However, this demonstrates an implicit value related to the interpretive model of teaching. That means that effectiveness (more knowledge, better quality of hand skills) is considered as morally good. This correlates with the survey results, where they demonstrated the belief that subject content knowledge is the most important quality of a good teacher and that during their teaching they give priorities to academic performance and competencies.

The teachers provided contradictory responses to the topic of values in technology education. Two female teachers believe that it should be a broader discussion and understanding of value issues in technology education. Another teacher stated that he is not interested in values, because it is difficult to conceptualise it and if you do so, it will become 'dry'. Values are incorporated in the people's relationships and because of that it is the best way to deal with them.

Analysis of the survey data

Australia

Trends were identified in responses to eight of the sixteen survey statements. In summary teachers believed that:

- Developing academic performance was a priority
- Moral content was a valuable aspect of technology education programs and should be developed gradually
- Morality is best developed through action and observing modelling of others
- Transferring responsibility to students is one way of reconstructing the moral climate of schools.

There was also a trend in the responses to the final question in the survey which asked them to indicate how they implemented their beliefs in practical teaching. All indicated they that addressed moral aspects of technology education by attempted to model appropriate behaviours. The interviews and surveys raised a number of issues to be addressed in future research. For example, there appeared to be a variety of understandings of the words value, moral and belief. There also appeared to be some inconsistencies in responses suggesting, possibly, particular interpretations. For example, all teachers indicated that their main emphasis was on academic performance but then indicated that subject content knowledge was not important for the teacher. It may be that technology teachers considered process to be the important factor in achieving high academic performance. Two survey statements elicited responses that could be considered as tendencies. One involved the importance of establishing interpersonal relations with students and the other concerned involving students in resolving ethically problematic situations. In both cases, the responses suggest a tendency to see both as important.

Russia

Teachers strongly supported statements that describe their teaching practice in terms of both effective and responsible types of teaching. Trends were identified in responses to four of sixteen statements. In summary teachers believe that the following are the most important and very important for their teaching:

- subject content knowledge is the most important quality of a good teacher
- the morale culture of school is established by each subject
- it is important to involve students in seeking solutions when a classroom situation is ethically problematic.

Another trend is that they do not believe strongly that:

- teaching moral content (knowledge concerning norms, rules, justice matters) is in itself a valuable enterprise because it helps students to develop a moral point of view.

These results correspond strongly with the interview results.

Three of these tendencies were quite opposite to the beliefs of the Australian teachers:

- importance of the subject content knowledge as an important quality of a good teacher (not important for Australians, a tendency);
- importance of teaching moral content (very important for Australian, a trend);

- the role all subjects should play in establishing a moral culture of a school (not important for Australian, a tendency).

Another two statements that had been interpreted differently by Australian and Russian participants were

- a tendency among the Russian teachers to believe that the moral quality of schooling is defined from the ends, not means
- a negative tendency among the Russian teachers towards the statement that students create the moral climate of the school by participating in its decision-making structure.

Conclusions

Theoretical models used as a framework for this research helped to identify that teachers pay a lot of attention to effectiveness in their teaching practice, however, they realise that moral issues are also important and should be in balance. It is possible to suggest that Russian teachers are moving closer towards the regulative model of teaching that is based on the involvement of students in discourse on the moral conflict solving. This can be explained by traditions of moral upbringing through all school subjects. All Russians refer to moral values when talking about values in technology education. Australian views correspond more with the additive model. They do not relate values in technology education to moral values, in the interview. Answering a survey question they expressed a belief that it is possible to teach moral content. However that may be related to the difference in the interpretation of moral values, that in Russian language relates to the spiritual, all-human values and in Australian has a close association with sexual behaviour. Technology education teachers in both countries did not express values in technology education in terms of technical, economic, aesthetic, social, etc.

In terms of the comparisons across the Australian and Russian teachers, certain patterns were observed. Firstly, there appeared to be a consistency of response between survey and interview data for both groups. That is, within both groups teachers' responses to the survey were consistent with their responses to the interview. In terms of the responses to the study the Russian responses are more spread out than the Australians.

Some different views were expressed by teachers in the two countries on how to deal with values. Australians believe that it is important to teach values and that they should be embedded in project work or modelled. Russians believe that it is not possible to teach values and there is no need to teach about values. They should be implicitly embedded into the teacher-student relationships. Teacher also should be a model for the students so that moral values are implicit in the work. This issue requires further investigation, as the interpretation of teaching values appeared to be different in two countries.

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How People Learn: Contributions to Framing a Research Agenda for Technology Education

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Introduction and overview

The past three decades has produced an extraordinary outpouring of scientific work on the processes of thinking and learning and on the development of competence. Much of this work has important implications for the design of learning environments and for the nature of instructional practices that maximise individual and group learning. Simultaneously, information technologies have advanced rapidly. They now render it possible to design much more complex, sophisticated, and potentially more powerful learning and instructional environments. While much is now possible given theoretical, empirical, and technological advances, many questions remain to be answered. What principles do we need to consider in connecting together learning theory, instructional practice, and information technologies? How can we do so in effective and powerful ways? What are the implications for research and development in the field of technology education.

This paper begins by considering general linkages among curriculum, instruction and assessment. With that as a context it moves to a consideration of some of the principal findings from research on learning that have clear implications for instructional practice. This brings us back to a consideration of the implications of knowledge about how people learn for some general issues of curriculum, instruction and assessment which is then followed by a more detailed discussion of important principles for the design of powerful learning and instructional environments. Throughout, attempts are made to draw out the implications of contemporary theories of learning and instructional design for question asking and the structuring of a research agenda in the field of technology education.

The curriculum-instruction-assessment triad

Whether recognised or not, three things are central to the educational enterprise – curriculum, instruction, and assessment. The three elements of this triad are linked, although the nature of their linkages and reciprocal influence is often less explicit than it should be. Furthermore, the separate pairs of connections are often inconsistent which can lead to an overall incoherence in educational systems.

Curriculum consists of the knowledge and skills in subject matter areas that teachers teach and students are supposed to learn. The curriculum generally consists of a scope or breadth of content in a given subject area and a sequence for learning. Standards, such as those developed in mathematics, science and technology, typically outline the goals of learning, whereas curriculum sets forth the more specific means to be used to achieve those ends. *Instruction* refers to methods of teaching and the learning activities used to help students master the content and objectives specified by a curriculum and attain the standards that have been prescribed. Instruction encompasses the activities of both teachers and students. It can be carried out by a variety of methods, sequences of activities, and topic orders. *Assessment* is the means used to measure the outcomes of education and the achievement of students with regard to important knowledge and competencies. Assessment may include both formal methods, such as large-scale state assessments, or less formal classroom-based procedures, such as quizzes, class projects, and teacher questioning.

A precept of educational practice is the need for alignment among curriculum, instruction, and assessment. Alignment, in this sense, means that the three functions are directed toward the same ends and reinforce each other rather than working at cross-purposes. Ideally, an assessment should measure what students are actually being taught, and what is actually being taught should parallel the curriculum one wants students to master. If any of the functions is not well synchronised, it will disrupt the balance and skew the educational process. Assessment results will be misleading, or instruction will be ineffective. Alignment is often difficult to achieve, however. Often what is lacking is a central theory about the nature of learning and knowing which guides the process and around which the three functions can be coordinated.

Most current approaches to curriculum, instruction, and assessment are based on theories and models that have not kept pace with modern knowledge of how people learn (Pellegrino, Chudowsky & Glaser 2001). They have been designed on the basis of implicit and highly limited conceptions of learning. Those conceptions tend to be fragmented, outdated, and poorly delineated for domains of subject matter knowledge. Alignment among curriculum, instruction, and assessment could be better achieved if all three are derived from a scientifically credible and shared knowledge base about cognition and learning in the subject matter domains. The model of learning would provide the central bonding principle, serving as a nucleus around which the three functions would revolve. Without such a central core, and under pressure to prepare students for high-stakes external accountability tests, teachers may feel compelled to move back and forth between instruction and external assessment and teach directly to the items on a high-stakes test. This approach can result in an undesirable narrowing of the curriculum and a limiting of learning outcomes. Such problems can be ameliorated if, instead, decisions about both instruction and assessment are guided by a model of learning in the domain that represents the best available scientific understanding of how people learn. This brings us to a consideration of what we actually know about the nature of learning and knowing.

Important principles about learning and teaching

Two recent National Academy of Sciences reports on "How People Learn" (Bransford, Brown & Cocking 1999; Donovan, Bransford & Pellegrino 1999), provide a broad overview of research on learners and learning and on teachers and teaching. While there are many important findings that bear on issues of learning and instruction, three of the findings described in those reports are highlighted in this paper. Each has a solid research base to support it, has strong implications for how we teach, and helps us think about how to frame questions for the domain of technology.

The first important principle about how people learn is that students come to the instructional setting with existing knowledge structures and schemata which include preconceptions about how the world works. If their initial understanding is not engaged, they may fail to grasp the new concepts, procedures and information that are taught, or they may learn them for purposes of an exercise or test but revert to their preconceptions outside the learning or occupational setting. Those initial understandings can have a powerful effect on the integration of new concepts and information. Sometimes those understandings are accurate, providing a foundation for building new knowledge. But sometimes they are inaccurate. In science, students often have misconceptions of physical properties that cannot be easily observed. In humanities, their preconceptions often include stereotypes or simplifications, as when history is understood as a struggle between "good guys" and "bad guys."

Drawing out and working with existing understandings is important for learners of all ages. Numerous research studies demonstrate the persistence of preexisting understandings even after a new model has been taught that contradicts the naïve understanding. For example, students at a variety of ages persist in their beliefs that seasons are caused by the earth's distance from the sun rather than by the tilt of the earth. They believe that an object that has been tossed in the air has both the force of gravity and the force of the hand that tossed it acting on it, despite training to the contrary. For the scientific understanding to replace the naïve understanding, students must reveal the latter and have the opportunity to see where it falls short.

The second important principle about how people learn is that to develop competence in an area of inquiry, students must: (a) have a deep foundation of factual and procedural knowledge, (b) understand facts, procedures and ideas in the context of a conceptual framework, and (c) organise knowledge in ways that facilitate retrieval and application. This principle emerges from research that compares the performance of experts and novices, and from research on learning and transfer. Experts, regardless of the field, always draw on a richly structured information base. They are not just "good thinkers" or "smart people." The ability to plan a task, to notice patterns, to generate reasonable arguments and explanations, and to draw analogies to other problems, are all more closely intertwined with factual and procedural knowledge than was once believed.

However, knowledge of a large set of disconnected facts or procedures is not sufficient. To develop competence in an area of inquiry, students must have opportunities to learn with understanding. Key to expertise is a deep understanding of the domain in which they are working that transforms factual and procedural information into "usable knowledge". A pronounced difference between experts and novices is that experts' command of concepts and procedures shapes their understanding of new information. It allows them to see patterns, relationships, or discrepancies that are not apparent to novices. They do not necessarily have better overall memories than other people. But their conceptual understanding allows them to extract a level of meaning from information that is not apparent to novices, and this helps them select, remember and apply relevant information. Experts are also able to fluently access relevant knowledge because their understanding of subject matter allows them to quickly identify what is relevant. Hence, their working memory and attentional capacity is not overtaxed by complex events.

A key finding in the learning and transfer literature is that organising information into a conceptual framework allows for greater "transfer." It allows the student to apply what was learned in new situations and to learn related information more quickly. The student who has learned geographical information for the Americas in a conceptual framework approaches the task of learning the geography of another part of the globe with questions, ideas, and expectations that help guide acquisition of the new information. Understanding the geographical importance of the Mississippi River sets the stage for the student's understanding of the geographical importance of the Rhine. And as concepts are reinforced, the student will transfer learning beyond the classroom, observing and inquiring about the geographic features of a visited city that help explain its location and size.

A third critical idea about how people learn is that a "metacognitive" approach to instruction can help students learn to take control of their own learning by defining learning goals and monitoring their progress in achieving them. In research with experts who were asked to verbalise their thinking as they worked, it has been revealed that they monitor their own understanding carefully. They make note of when additional information is required for understanding, whether new information is consistent with what they already know, and what analogies can be drawn that would advance their understanding. These metacognitive monitoring activities are an important component of what is called *adaptive expertise*

Because metacognition often takes the form of an internal conversation, it can easily be assumed that individuals will develop the internal dialogue on their own. Yet many of the strategies we use for thinking reflect cultural norms and methods of inquiry in a given domain of knowledge or work. Research has demonstrated that individuals can be taught these strategies, including the ability to predict outcomes, explain to oneself in order to improve understanding, and note failures to comprehend. They can learn to activate background knowledge, plan ahead, and apportion time and memory. However, the teaching of metacognitive activities must be incorporated into the subject matter and occupational skills that students are learning. These strategies are not generic across situations, and attempts to teach them as generic can lead to failure to transfer. Teaching metacognitive strategies in context has been shown to improve understanding and problem solving in physics and to facilitate heuristic methods for mathematical problem solving. And metacognitive practices have been shown to increase the degree to which students transfer to new settings and events.

The three core learning principles briefly described above, simple though they may seem, have profound implications for teaching and for the potential of technology to assist in that process. First, teachers must draw out and work with the preexisting understandings that their students bring with them. The teacher must actively inquire into students' thinking, creating classroom tasks and conditions under which student thinking can be revealed. Students' initial conceptions then provide the foundation on which the more formal understanding of the instructional content is built. The roles for assessment must be expanded beyond the traditional concept of "testing". The use of frequent formative assessment helps make students' thinking visible to themselves, their peers, and their teacher. This provides feedback that can guide modification and refinement in thinking. Given goals of learning with understanding, assessments must tap understanding rather than the mere ability to repeat facts or perform isolated skills.

Second, teachers must teach some subject matter in depth, providing many examples in which the same concept is at work and providing a firm foundation of factual and procedural knowledge. This requires that superficial coverage of all topics in a subject area must be replaced with in-depth coverage of fewer topics that allows key concepts and methods in that domain to be understood. The goal of coverage need not be abandoned entirely, of course. But there must be a sufficient number of cases of in-depth study to allow students to grasp the defining concepts in specific domains or areas of occupational skill.

Third, the teaching of metacognitive skills should be integrated into the curriculum in a variety of content areas. Because metacognition often takes the form of an internal dialogue, many students may be unaware of its importance unless the processes are explicitly emphasised by teachers. An emphasis on metacognition needs to accompany instruction in multiple areas of study because the type of monitoring required will vary. Integration of metacognitive instruction with discipline-based learning can enhance student achievement and develop in students the ability to learn independently.

Questions about learning and teaching in technology education

The preceding summary of what we know about learning and teaching, while stated in "generic" terms, can be applied specifically to any domain of education such as mathematics, science, or social science. The present context dictates that we try to apply it to technology education. Thus, an issue of central concern is the status of knowledge about how people learn and how we support such learning in the field of technology and technology education. One inference that might be drawn by one outside the field is that the technology education domain has a somewhat limited knowledge base. For example, relatively few research citations can be found in the AAAS benchmarks (1993) or in the AAAS science literacy maps (2001) for the area of technology. This contrasts with many of the other areas discussed in these documents. Such a finding is but one possible indication of the state of empirical knowledge about how people acquire the core concepts in the field of technology.

The following set of questions, derivable from the how people learn framework, can guide the compilation of research findings and/or the generation of a new and expanded research agenda:

- What defines the key conceptual knowledge structures and schemas for areas of technology and technology education? To what extent are the AAAS science literacy maps an adequate starting point for defining the structure of domain knowledge? How should they be expanded to capture core concepts?

- What constitutes expertise in the technology domain and what are its consequences? Can we define what expertise looks like? What is the relevance of doing so for how to design technology education? For example, what assumptions can be made about the conditions necessary to support acquiring expertise in specific areas of technology?
- What patterns exist in the growth of understanding and competency? For example, the AAAS literacy maps lay out various progressions but are they real? What do things really look like as students move along the developmental continuum and acquire competence and expertise? Are there micro-genetic studies of students' thinking as they acquire knowledge about certain parts of the curriculum? For what aspects of technology are data available?
- How does metacognition develop in specific areas of technology? What does metacognitive monitoring look like? What's specific about technology as a domain? Since we must acquire domain specific meta-cognitive rules and strategies, what strategies and knowledge are appropriate to areas of technology?
- What preconceptions and mental models apply to the domain of technology? For example, what do people believe about concepts such as constraints? What do people believe about systems or design, and to what extent are those ideas correct or incorrect? Do they hold beliefs or possess representations that we can build on? Must we systematically intervene and modify the states of knowledge because they include misperceptions that will get in the way of more proper understandings? Which mental models raise serious concerns for future learning in the area of technology?
- What constitutes evidence of transfer in technology education? How context bound is the knowledge base of students? How do current educational practices constrain transfer? What do we know about how individuals acquire their knowledge of technology and whether the process overly contextualises their knowledge in particular ways that are not intended?
- For the various sub-fields of technology, what are the communal and participatory practices? What are the rules that constitute knowing and behaving effectively in the field of technology and technology education? What are the tools that people must learn to use for participating effectively in the community? And finally, how is community established in this field?

Clearly, there are many questions and issues that can be raised about the knowledge base that should undergird the field of technology education – questions derived from important findings in other domains about how people learn. If knowledge of how people learn is to be placed at the core of curriculum, instruction, and assessment, it is critical to have rich and detailed domain based models of learning and understanding for those areas of technology that are of key interest. This is a major part of defining and refining the core research agenda.

Implications for curriculum, instruction and assessment

There are multiple benefits of focusing on issues of how people learn with regard to matters of curriculum, instruction and assessment. This is true in all areas of the instruction, including technology education. At the level of curriculum, knowledge of how people learn in specific domains will help teachers and the educational system move beyond either-or dichotomies regarding the curriculum that have plagued the field of education. One such issue is whether the curriculum should emphasise "the basics" or teach thinking and problem-solving skills. Both are necessary. Students' abilities to acquire organised sets of facts and skills are actually enhanced when they are connected to meaningful problem-solving activities, and when students are helped to understand why, when, and how those facts and skills are relevant. And attempts to teach thinking skills without a strong base of factual knowledge do not promote problem-solving ability or support transfer to new situations.

Focusing on how people learn in a domain also helps bring order to a seeming chaos of instructional choices. Consider the many possible teaching strategies that are debated in education circles and the media. They include lecture-based teaching, text-based teaching, inquiry-based teaching, technology-enhanced teaching, teaching organised around individuals versus cooperative groups, and so forth. Are some of these teaching techniques better than others? Is lecturing a poor way to teach, as many seem to claim? Is cooperative learning good? Does technology-enhanced teaching help achievement?

Research and theory on *How People Learn* suggests that these are the wrong questions. Asking, which teaching technique is best is analogous to asking which tool is best--a hammer, a screwdriver, a plane, or pliers. In teaching, as in carpentry, the selection of tools depends on the task at hand and the materials one is working with. Books and lectures *can* be wonderfully efficient modes of transmitting new information for learning. They can excite the imagination, and hone students' critical faculties. But one would choose other kinds of activities to elicit from students their preconceptions and level of understanding, or to help them see the power of using metacognitive strategies to monitor their learning. Hands-on activities and experiments can be a powerful way to ground emergent knowledge, but they do not alone evoke the underlying conceptual understandings that aid generalisation. There is no universal best teaching practice.

If, instead, the point of departure is a core set of learning principles tied to knowledge of learning in the domain, then the selection of teaching strategies, mediated, of course, by subject matter, age and grade level, and desired outcome, can be purposeful. The many possibilities then become a rich set of opportunities from which a teacher constructs an instructional program rather than a chaos of competing alternatives.

Perhaps no area stands to gain more from knowledge of how people learn than the area of assessment, a persistent concern in the educational process. Assessing educational outcomes is not as straightforward as measuring height or weight; the attributes to be measured are mental representations and processes that are not outwardly visible. Thus, an assessment is a tool designed to observe students' behavior and produce data that can be used to draw reasonable inferences about what students know. Another recent National Research Council report, *Knowing What Students Know* (Pellegrino et al 2001), emphasises that the targets of inference should be determined by cognitive models of learning that describe how people represent knowledge and develop competence in the domain of interest. The cognitive models suggest the most important aspects of student achievement about which one would want to draw inferences and provides clues about the types of assessment tasks that will elicit evidence to support those inferences.

The process of collecting evidence to support inferences about what students know represents a chain of reasoning from evidence about student learning that characterises all assessments, from classroom quizzes and standardised achievement tests, to computerised tutoring programs, to the conversation a student has with her teacher as they work through an experiment. The process of reasoning from evidence can be portrayed as a triad of three interconnected elements known as the *assessment triangle*. The vertices of the assessment triangle represent the three key elements underlying any assessment: a model of student *cognition* and learning in the domain; a set of beliefs about the kinds of *observations* that will provide evidence of students' competencies; and an *interpretation* process for making sense of the evidence. These three elements may be explicit or implicit, but an assessment cannot be designed and implemented without some consideration of each. The three are represented as vertices of a triangle because each is connected to and dependent on the other two. A major tenet of the *Knowing What Students Know* report is that for an assessment to be effective, the three elements must be in synchrony. The assessment triangle provides a useful framework for analysing the underpinnings of current assessments to determine how well they accomplish the goals we have in mind, as well as for designing future assessments.

Implications for the design of learning environments

How do we take the knowledge about how people learn, as well as the implications for curriculum, instruction and assessment and use it productively to design effective learning environments? What role is there for information and communication technologies in this process? These questions do not have simple answers and at least one implication is that to achieve the higher level thinking and learning outcomes we want for our students, we will need to build learning environments that more carefully and consistently implement design principles that foster an effective integration of curriculum, instruction and assessment. Furthermore, all three elements must be driven by theories, models and empirical data on domain-specific learning. In most cases, such learning environments will be more complex than those designed and implemented in the past. Some of that complexity will be enabled and/or supported by information and communication technologies.

To address the design challenges alluded to above, we need to ask what the findings from contemporary research on cognitive and social issues in learning and assessment, such as those described above and in the *How People Learn* and *Knowing What Students Know* reports suggest about general characteristics of powerful learning environments. Four such characteristics have been identified which in turn overlap with four major design principles for instruction that are critically important for achieving the types of learning with understanding that are espoused in contemporary educational standards. The four characteristics of powerful learning environments are as follows.

Effective learning environments are knowledge-centered. Attention is given to what is taught (central subject matter concepts), why it is taught (to support "learning with understanding" rather than merely remembering), and what competence or mastery looks like. *Effective learning environments are learner-centered.* Educators must pay close attention to the knowledge, skills, and attitudes that learners bring into the classroom. This incorporates preconceptions regarding subject matter and it also includes a broader understanding of the learner. Teachers in learner-centered environments pay careful attention to what students know as well as what they don't know, and they continually work to build on students' strengths. *Effective learning environments are assessment-centered.* Especially important are efforts to make students' thinking visible through the use of frequent formative assessment. This permits the teacher to grasp the students' preconceptions, understand where students are on the "developmental corridor" from informal to formal thinking, and design instruction accordingly. They help both teachers and students monitor progress. *Effective learning environments are community-centered.* This includes the development of norms for the classroom and school, as well as connections to the outside world, that support core learning values. Teachers must be enabled and encouraged to establish a community of learners among themselves. These communities can build a sense of comfort with questioning rather than knowing the answers and can develop a model of creating new ideas that builds on the contributions of individual members.

Consistent with the ideas about the multiple and interacting elements of a powerful learning environments, all driven by concerns about how people learn, are four principles for the design of instruction within such a contextual perspective. (1) To establish knowledge centered elements of a learning environment, *instruction is organised around meaningful problems with appropriate goals*. (2) To support a learner centered focus, *instruction must provide scaffolds for solving meaningful problems and supporting learning with understanding*. (3) To support assessment centered activities, *instruction provides opportunities for practice with feedback, revision, and reflection*. (4) To create community in a learning environment, *the social arrangements of instruction must promote collaboration and distributed expertise, as well as independent learning*. Each principle is considered briefly below.

Instruction is organised around the solution of meaningful problems

When students acquire new information in the process of solving meaningful problems, they are more likely to see its potential usefulness than when they are asked to memorise isolated facts. Meaningful problems also help students overcome the "inert knowledge" problem, defined by Whitehead (1929) as knowledge previously learned but not remembered in situations where it would be potentially useful. Seeing the relevance of information to everyday problems helps students understand when and how the information may be useful. When students see the usefulness of information, they are motivated to learn (McCombs 1994), Research on the relationship between interest and learning indicates that personal interest in a topic or domain positively impacts academic learning in that domain (Alexander, Kulikowich & Jetton 1994). New approaches to motivation emphasise motivational enhancement through authentic tasks that students perceive as real work for real audiences. This emphasis contrasts with earlier emphases on elaborate extrinsic reinforcements for correct responding.

Problem solving is at the core of inquiry- or project-based learning. Students will work on problems that are interesting and personally meaningful (CTGV 1997; Hmelo &

Williams 1998). Several contemporary educational reform efforts use dilemmas, puzzles, and paradoxes to "hook" or stimulate learners' interests in the topic of study (CTGV 1997; Goldman, et al 1996). One major challenge for inquiry-based learning environments is developing problems that are rich and complex enough to engage students in the kinds of sustained inquiry that will allow them to deeply understand important new concepts. Bringing complex problems into the classroom is an important function of technology. Unlike problems that occur in the real world, problems that are created with graphics, video, and animation can be explored again and again. These multimedia formats capture students' interest and provide information in the form of sound and moving images that is not available in text-based problems and stories. Multimedia formats are more easily understood and allow the learner to concentrate on high level processes such as identifying problem solving goals or making important inferences. Problems presented via the World Wide Web or in hypermedia allow students to search easily for the parts that interest them most. Exploratory environments called "microworlds" or simulations allow students to carry out actions, immediately observe the results, and attempt to discover the rules that govern the system's behavior. No matter what form of technology is involved, the student is primarily responsible for deciding how to investigate the problem and the technology creates an environment in which flexible exploration is possible.

Instruction provides scaffolds for achieving meaningful learning

In the previous section, we briefly described the benefits of giving students the opportunity and responsibility of exploring complex problems on their own. This is clearly a way to support the implementation of knowledge centered elements in a learning environment. The mere presence of these opportunities, however, does not lead to learning with understanding nor will they enhance a learner centered approach. Because of the complexity of the problems and the inexperience of the students, scaffolds must be provided to help students carry out the parts of the task that they cannot yet manage on their own. Cognitive scaffolding assumes that individuals learn through interactions with more knowledgeable others, just as children learn through adult-child interactions (Bruner 1983; Vygotsky 1962). Adults model good thinking, provide hints, and prompt children who cannot "get it" on their own. Children eventually adopt the patterns of thinking reflected by the adults. Cognitive scaffolding can be realised in a number of ways. Collins, Brown and Newman (1989) suggest modeling and coaching by experts, and providing guides and reminders about the procedures and steps that are important for the task. Technologies can also be used to scaffold the solution of complex problems and projects by providing resources such as visualisation tools, reference materials, and hints. Technology can help learners visualise processes and relationships that are normally invisible or difficult to understand.

Instruction provides opportunities for practice with feedback, revision, and reflection

Feedback, revision, and reflection are aspects of metacognition that are critical to developing the ability to regulate one's own learning. Many years ago, Dewey (1933) noted the importance of reflecting on one's ideas, weighing our ideas against data and our predictions against obtained outcomes. In the context of teaching, Schön (1988) emphasises the importance of reflection in creating new mental models. Content-area experts exhibit strong self-monitoring skills that enable them to regulate their learning goals and activities. Self-regulated learners take feedback from their performance and adjust their learning in response to it. Self-monitoring depends on deep understanding in the domain because it requires an awareness of one's own thinking, sufficient knowledge to evaluate that thinking and provide feedback to oneself, and knowledge of how to make necessary revisions. In other words, learners cannot effectively monitor what they know and make use of the feedback effectively (in revision) unless they have deep understanding in the domain. The idea that monitoring is highly knowledge dependent creates a "catch 22" for novices. How can they regulate their own learning without the necessary knowledge to do so? Thus, the development of expertise requires scaffolds for monitoring and self-regulation skills so that deep understanding and reflective learning can develop hand-in-hand.

Fortunately, there are now multiple examples that support a wide range of formative assessment practices in the classroom. They include exciting new technology-based methods such as the "Diagnoser" software for physics and mathematics (Hunt & Minstrell 1994), "Latent Semantic Analysis" for scoring essays (e.g. Landauer, Foltz & Laham 1998), the IMMEX system for providing feedback on problem solving (Hurst, Casillas & Stevens 1998). Such software can also be used to encourage the kind of self-assessment skills that are frequently seen in expert performance.

The social arrangements of instruction promote collaboration and distributed expertise, and well as independent learning

The view of cognition as socially shared rather than individually owned is an important shift in the orientation of cognitive theories of learning. It reflects the idea that thinking is a product of several heads in interaction with one another. In the theoretical context of cognition-as-socially-shared, researchers have proposed having learners work in small groups on complex problems as a way to deal with complexity. Working together facilitates problem solving and capitalises on distributed expertise (CTGV 1994; Pea 1993). Collaborative environments also make excellent venues for making thinking visible, generating and receiving feedback, and revising (Barron et al 1995; CTGV 1994; Vye et al 1998). A number of technologies support collaboration by providing venues for discussion and communication among learners. For example, communal databases and discussion groups making thinking visible and provide students with opportunities to give and receive feedback, often with more reflection because the comments are written rather than spoken. Networked and Web-based communications technologies, including sophisticated knowledge building software such as Knowledge Forum (Scardamalia & Bereiter 1994) can also help students form a community around important ideas. Such technology helps capture ideas that otherwise can be ephemeral and it supports communication that is asynchronous as well as synchronous.

Implications for research and development of learning environments for technology education

This paper began with the idea that three critical elements of the educational enterprise – curriculum, instruction and assessment – represent an integrated system. Often, however, such integration is lacking or if there is some degree of integration it is driven by simplistic and outmoded conceptions of the nature of learning and knowing. Contemporary research and theory on how people learn, the nature of knowing, and how we can know what students know offers us a richer perspective by which to approach issues of designing contemporary curricula, instructional practices and materials, and assessments. There are a variety of ways in which we can envision using such knowledge. Two broad approaches are outlined below: (1) evaluating the conceptual and operation base of existing curricula and materials, and (2) designing new curricula and materials and evaluating their effectiveness.

We need to consider using the principles in the *How People Learn* and *Knowing What Students Know* reports as a lens through which to evaluate existing education practices and policies. *How People Learn* and *Knowing What Students Know* emphasise that many existing educational materials and practices are inconsistent with what is known about learning. Teams of discipline-specific experts, researchers in pedagogy and cognitive science, and teachers need to review widely used curricula, as well as curricula that have a reputation for teaching for understanding. The envisioned activity could involve two stages; these might be conducted together in a project, or as sequential projects.

Stage 1: Curricula and their companion instructional techniques and assessments should be evaluated with careful attention paid to alignment with the principles of learning outlined in *How People Learn*. The review might include consideration of the extent to which the curriculum emphasises depth over breadth of coverage; the effectiveness of the opportunities provided to grasp key concepts related to the subject matter; the extent to which the curriculum provides opportunities to explore preconceptions about the subject matter; the adequacy of the factual knowledge base provided by the curriculum; the extent to which formative assessment procedures are built into the curriculum, and the extent to which accompanying summative assessment procedures measure understanding and ability to transfer rather than memory of fact.

The features that support learning should be highlighted and explained, as should the features that are in conflict. Such work should accomplish two goals. First, it should identify examples of curriculum components, instructional techniques, and assessment tools that incorporate the principles of learning. Second, the explication of features that support or conflict with the principles of learning should be provided in sufficient detail and in a format that allows the effort to serve as a learning device for those in the education field who choose and use teaching and assessment tools. As such, it could serve as a reference document when new curricula and assessments are being considered.

Stage 2: Curricula that are considered promising should be evaluated to determine their effectiveness when used in practice. Curricula that are highly rated on paper may be very difficult for teachers to work with, or in the light of classroom practice may fail to achieve the level of understanding for which they are designed. Measures of student achievement take center stage in this effort. Through the lens of *How People Learn* and

Knowing What Students Know, achievement is indicated not only by a command of factual knowledge, but by a student's conceptual understanding of subject matter, and the ability to apply those concepts to future learning of new, related material. Where existing assessments do not measure conceptual understanding and knowledge transfer, this stage will require development and testing of such measures. In addition to achievement scores, feedback from teachers and curriculum directors who use the materials would provide additional input for stage 2.

Ideally, the review of curricula would take place at several levels: at the level of curriculum units, which may span several weeks of instructional time; at the level of semester-long and year-long sequences of units; and at the level of multiple grades, so that students have chances to progressively deepen their understanding over a number of years. The curricula reviewed should not be limited to those that are print based.

As an extension of the ideas mentioned above, or in some cases as a substitute, we also need to focus on the development and evaluation of new curriculum and assessment materials that reflect the principles of learning and assessment outlined in *How People Learn* and *Knowing What Students Know*. Such development needs to be done by teams of disciplinary experts, cognitive scientists, curriculum developers, and expert teachers. Ideally, activity of this type will begin with existing curricula and modify them to better reflect key principles of learning. In some cases, however, exemplary curricula for particular kinds of subject matter may not exist, so the teams will need to create them. The curricula should be designed to support learning for understanding; they will presumably emphasise depth over breadth. The designs should engage students' initial understanding, promote construction of a foundation of factual knowledge in the context of a general conceptual framework, and encourage the development of meta-cognitive skills.

Companion teacher materials for a curriculum should include a "meta-guide" that explains its links to principles of learning, reflects pedagogical content knowledge concerning the curriculum, and promotes flexible use of the curriculum by teachers. The guide should include discussion of expected prior knowledge (including typical preconceptions), expected competencies required of students, ways to assess prior knowledge, and ways to carry out formative assessments. Potentially excellent curricula can fail because teachers are not given adequate support to use them. While instructional guides cannot replace teacher training efforts, the meta-guide should be both comprehensive and user-friendly to supplement those efforts. Finally, both formative and summative tests of learning and transfer should be proposed as well.

Once developed, it is clear that field-testing of the curricula will be needed in order to amass data on student learning and teacher satisfaction, identifying areas for improvement. Clearly, it is easier to field-test short units rather than longer ones. Ideally, different research and development groups that are focusing on similar topics across different age groups might work to explore the degree to which each of the parts seems to merge into a coherent whole. Finally, careful attention must be paid to the criteria used to evaluate the learning that is supported by the materials and accompanying pedagogy. Achievement should measure understanding of concepts and ability to transfer learning to new, related areas.

Beyond how people learn: Situating the work in Pasteur's Quadrant

As argued in Donovan, et al (1999), much of research on learning and teaching has a very weak connection to actual educational practice. A substantial portion of what is published is not picked up by teachers, often because they don't have the time to search and translate the research literature into guides for practice. There are, however, some cases where the link is more direct. This typically comes in the form of design experiments which involve collaborations between researchers and teachers to change educational practice. But most of what happens is that research impacts practice indirectly by influencing one of four mediating arenas which then in turn influence actual practice. For example, research often leads to the design of educational materials that incorporate ideas from research. Or research finds its way into the content and design of teacher education programs. Sometimes research impacts policy. An example is educational testing, much of which is still rooted in a behaviorist-associationist model of learning and knowing. And finally, research finds its way into the public arena. Sometimes the latter occurs very haphazardly, such as popularising neuroscience research and drawing inappropriate implications for instructional practice.

What is needed is a cumulative knowledge base which serves both research and practice, is rooted in both, and which becomes the common frame of reference for impacting all four mediating arenas. Technology education is like many other fields and must contend with the same four mediating arenas. Part of the agenda in technology education research is building a cumulative knowledge base that supports learning and teaching about technology. It means defining the core knowledge constructs, conducting research on fundamental learning and teaching issues, as well as doing research on current instructional practices. It also means applying knowledge about how people learn to the systematic analysis of existing educational materials, teacher education practices, and educational policies influencing technology's role in the curriculum. A final piece, not to be underestimated, is public understanding of technology as a field, including the extent to which such understanding influences educational practice.

My closing remarks focus on the idea of situating such research in *Pasteur's Quadrant*. The latter term comes from a book by Stokes (1997) that provides an analysis of America's science and technology policy, including the model used to guide research in the NSF. Stokes argues that we often think of research as falling along a uni-dimensional continuum that ranges from basic to applied. In contrast, Stokes maps research into a two dimensional space with research ranging from low to high in terms of its pursuit of general theoretical principles, and low to high in terms of its attempt to solve practical problems. Pasteur's work serves as the prototype for research that operates at the high end of each scale. His work typifies the high-high quadrant. The contrast quadrants are named after Bohr, whose work was high on theory and low on application, and Edison, whose work was low on theory and high on application. The final quadrant defined by being low on both scales remains unnamed – for obvious reasons who would like to have such a quadrant named after them?

The broader point of mentioning Pasteur's quadrant is that much of the work that needs to be pursued in the field of technology education, as in all fields of education, sits squarely in Pasteur's quadrant. It is work that should strive to be high in its contributions to theory building. At the same time the research should strive to contribute to solving practical problems of learning and instruction.

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A Week out in Wellington: Studying the Technological Practice of Television

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Television is the most common and pervasive type of information and communications technology in New Zealand homes. While less than half of New Zealand homes have computers (47%), television is an important part of almost every home. In the year 1997–98 only 3.3% of New Zealand homes were without a television. (NZ Official Yearbook, 2000). Surveys of television viewing consistently show that news broadcasts are the most watched type of programming. Although children don't necessarily choose to watch news on television, it is one of the key sources of information about life in New Zealand and the world in general. It has become common for teachers to incorporate teaching about television into English learning programmes, particularly in the Visual Language strand. However, using television fits easily within the Information and Communication Technology strand of the Technology curriculum and assists in moving beyond the "just computers" view of information technology (Brown, 1997). Learning about television is also useful as a way of bridging the gap between in-school and out-of-school learning experiences. This paper describes a technology education activity, in a school in Wellington, New Zealand, which allowed Year 5 students to explore the process of creating a television programme, based on their own experiences during an E.O.T.C. week-long programme. Small groups of students edited and produced video tapes presenting key aspects of their week, in an activity which allowed them to explore the technological practice of news and documentary production.

Introduction

The Technology in the New Zealand Curriculum (1995) states,

> "Teachers should select or devise content, contexts, and learning approaches that make connections between students' everyday lives and experiences and the world beyond the school gate, and also extend their appreciation of the ways technology impacts on their lives and society" (p.15).

The authors were guided by the principles outlined above and believe that the activities described in this paper offer an example of how technology education can be taught in an authentic context, using real experiences relevant to the students involved. While the activities are focussed around the technological practice of television production, the authors feel strongly that the technological practice of other industries could also be investigated using similar situated simulations.

Background

To provide an Outdoor Education programme for Year 5 children, who did not attend the senior camp, a week's outdoor programme was devised around the children's city environment. 'Wellington Week' comprised a variety of excursions to challenge the children physically, acquaint them with the role of the city council and to help them to explore the various recreational and educational facilities available in their community. Thus the week's programme was a set of cross-curricular activities including elements of Health and Physical Education, English and Technology. An adult with a video camera accompanied the group throughout the week and footage of the various activities was made, totaling approximately 20 minutes. At the conclusion of the week the children spent a morning editing and shaping the footage into a news/documentary video, which would serve to summarise the week's activities.

The activities

To begin this process, the children went to the editing suite at Wellington College of Education. After a brief introduction to the purpose of the activity, the children viewed the available footage of the week's activities. As a large group they brainstormed the activities from the week and listed them chronologically, noting which of these had little or no available footage. They were grouped into threes or fours to choose a suitable title for each of their videos. This served to unify the groups. They were introduced to the idea of expanding the available footage with the use of interviews that they would script and record later.

They worked within their smaller groups to write introductions to each of the day's activities. Once this had been scripted, the children were acquainted with the cameras and they each identified the essential controls for recording. VHS-Compact camcorders were used in this activity. A variety of techniques were discussed for filming their introductions; use of the tripod, placement of the camera, choice of background, signals for direction, use of the zoom lens and auto focus and allowance for rollback. Children were also asked to recall key features of the delivery of television interviewers and front-people.

The groups then went to their assigned areas to record their introductions. They were each assisted by an adult and all the children had turns at speaking to the camera and filming / directing. Interviews were also recorded at this time. The children were encouraged not to review their recordings as they worked, and made several takes of material when necessary.

After completing this task, the children returned to the editing suite to familiarise themselves with the equipment and basic editing techniques. In this case the children were working with a number of VHS edit suites comprising two professional standard VCRs, with corresponding monitor screens and an edit controller. This activity could also be carried out using "crash editing" techniques without an edit controller or using digital editing such as that available on iMAC computers. The children then began the process of selecting the appropriate introductions and interviews from their newly made tapes and editing them with selections from the footage of the week. This involved the children in a variety of activities; identifying key elements and highlights of the footage, reaching a consensus, co-ordinating the movements of the group to follow the editing process accurately. The children produced their final video in less than three hours and returned to school to share and compare the results.

Discussion

Brown (1997) distinguishes three dimensions in studying information and communication technology (ICT) in the classroom. Learning **with**, learning **about** and learning **in** information and communication technology. Learning **with** information and communication technology encompasses the use of technology in learning across the curriculum. Learning **in** information and communication technology places the focus on students becoming more knowledgeable and capable in ICT, including investigating both the structure and the function of information and communication technology. Learning **about** ICT helps students learn about the relationship between information and communication technology and society. It encourages students to recognise that ICT is not neutral but as subjective as any human process. Brown notes:

> It makes sense to try to unify all three dimensions within the same learning experience. In other words, select experiences where the students can learn with information and communication technology at the same time as learning in and about it (p.263).

The project described in this paper attempted to encompass all three of the dimensions described by Brown and furthermore set the work in a meaningful, relevant context within the "normal work" of these students.

This activity was designed to allow students to gain knowledge and understanding about the technological practice involved in television production. Where possible the process attempted to emulate, at least to some extent, the kinds of activities, problems and constraints involved in making a television product. This "opening up of the medium" (Masterman 1980) and allowing students to use it as a means of expression provides a valuable means of demystifying television, in a way which just viewing and critically analysing will not.

During the week of outdoor education activities the teacher used a video camcorder to record key features of each day's events. While this meant that the students were not actively involved in this aspect of recording, it did allow for two important things to happen; 1) the students were able to be fully involved in the outdoor education activities. 2) The fact that the teacher acted as camera operator and therefore made key decisions about what was shot and what was ignored made obvious a first important feature of television production, that it is a process of selection by many people.

> By the time a story has been through the mill… I mean we're talking about the camera people who are subjective and shoot certain things, we're talking about the reporter who is the same… I mean there's no such thing as objectivity. It comes back and then there's the editing process and before that even, the way it's scripted. You end up with a very personal… well, there a number of people who are combined and it's the amalgamation of all their views' (TVNZ Story Producer, cited by Abel 1997, p.15).

At the end of the week, the children acted as production teams with the brief of creating a short video piece to summarise their week's activities. The fact that each group were given a copy of the same videotape to work from allowed them to explore the constraints of material, which face television production crews every day. In many cases television producers must use material, the selection of which they have had little control over. Television news utilises material from around the world, from a range of sources and it is the selection and editing of this that allows a news broadcast to have its own particular style and flavour.

Many teachers have used simulations to allow students to experience various aspects of television production. Craggs (1992) describes a simulation, in which children used photographs, instead of film, to simulate the work of television news editors and presenters. The children operated under constraints of time and were restricted in the material available. Evans (2000) cites a number of beneficial outcomes for the children involved in this type of activity, including that the children become editors exercising judgements as to what photographs to include or leave out. The 'scriptwriters' have to tailor their words to the selected tape. The whole assemblage is produced under the pressure of time. This exercise teaches the children about selectivity and indeed bias. However, this simulation, like most others, suffers from being artificial and unrelated to the actual world of the children. For this reason the activity we describe in this paper was based on material that was relevant and featured the students themselves. The activity of producing a video tape not only provided opportunity to investigate television production, but also had the function of being a means to communicate what they deemed important about their week to friends and family.

When the students worked in teams to edit a tape about their week they were faced with several constraints. Firstly, they had limited amount of material available (about 20 minutes of raw footage). Secondly, they had limited time to complete the work (about 3 hours). Thirdly, they had to work in teams and were required to make decisions by consensus, or at least by majority. Fourthly, it was required that each team member have a significant role in the work. Each of these constraints is realistic in the sense that television production takes place under very similar constraints. In this way the students were able to investigate the ways in which those involved in television work to creatively solve problems and overcome constraints.

As part of the process of producing their video, each team was required to write and record introductions and interviews as a means of linking different segments and providing a cohesive message about their week. This allowed the students to integrate their existing knowledge of the medium, in terms of how presenters speak and how interviews are recorded, with their newly acquired knowledge of how to use camcorders, tripods and microphones. This experience provided a rich source that could be used in future investigation of television processes and products. Each student took turns at being director, camera operator, reporter / presenter and interviewee. The adoption of a range of roles is not only a key feature of actual television practice, but is also regarded as an important element in co-operative learning activities (Graves & Graves 1990).

While the students were required to use a range of sophisticated equipment during this process, in each case the emphasis was on learning only the skills necessary for each task, at the required time. Students were provided with specific instruction, demonstration and opportunities for guided practice to scaffold their learning in each of the procedures (Vygotsky 1978). Guide sheets were also used to assist in identifying key steps in each part of the process. The students' ease in learning how to operate the equipment was undoubtedly assisted by the collaborative nature of the activities. The students' work demonstrated many of the components of effective group investigation (Sharan & Sharan 1992).

The most important feature of the video production process was the editing of the available footage with the introductions, links and interviews that the students had recorded. Each group was encouraged to identify the shots which best suited the message they wished to present about the week. Thus, they were able to exercise some editorial influence on the material and their selections and omissions were made consciously and deliberately. Each group produced their own unique version of the events of the week. The students' selection decisions were strongly influenced by the availability of pictures, technical constraints such as poor light, focus, or sound and the demands of a tight deadline. The children were thus experiencing something of the real technological practice of editing.

> …a bustling, busy, working, somewhat non-reflective (atmosphere), presumably quite close to the kind of atmosphere with which journalists actually work (Masterman 1980, p.88).

Although the editing involved mastering a sequence of complicated manipulations of knobs and switches, editing machines and the confusion of using two monitors and three different videotapes, the children managed not only to complete the task, but also to successfully involve each group member in every aspect of the activity. Indeed, it is this collaboration, which is perhaps the most significant aspect of technological practice experienced by the students.

> Business and industry value co-operative approaches to problem solving where communication and collaborative skills are important. Technological tasks should encourage students to work together (Jones 1997, p.58).

When the students returned to school they were very enthusiastic to view their tapes and to present them to other students and parents. There was a clear sense of ownership by each of the groups and an obvious sense of achievement and pride. On viewing the tapes, students were keen to note the differences in the footage selection and the ways in which introductions and interviews influenced the messages given. Reflection on the choices made and the differences in the resulting products provided the teacher with vivid examples, on which to base further discussion about the nature of television news and documentaries. Such reflective discussion is essential to gain lasting value from an exercise such as this. Practical work alone is not enough, but it can be valuable in developing a student's "autonomous critical understanding of the media" (Masterman 1980). Grahame (1990) further asserts, "we need to actively construct the conditions and practices which will make it (learning about television) explicit for students" (p.122).

This paper has described a set of activities, which allowed the teacher to begin a programme of enabling students to develop a critical understanding of television and its role as a major information and communication technology in New Zealand society. This type of activity follows Burns' (1997) suggestion that,

> … students should be empowered not only to live and work with society and its associated technology, but to critically examine the value of both and their relationship with each other (p. 104).

Clearly to gain maximum benefit from these activities it was important that further work about television was continued as a regular feature of the classroom programme. The authors strongly believe that children indeed benefit from the unpacking and demystifying of the process of television production and such work can play a significant part in helping children become skilled, critical viewers of television and other mass media.

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Developing Standards-Based Technology Education Curricula

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Those who develop technology education curricula in the 21st Century must embrace the new International Technology Education Association Standards for Technological Literacy: Content for the Study of Technology and strive to develop standards-based curricula. The purposes of this paper are to examine the concepts of technology, technology education as practiced in the United States, present the Standards for Technological Literacy: Content for the Study of Technology, discuss the meanings of the term curriculum, describe the curriculum development process, review the backward design process, and review considerations for developing standards-based curriculum.

Technology

What is technology? To many people it means computers. But technology is so much more than computers. Technology can be thought of as modifying or changing the natural world to satisfy our needs. More specifically, technology refers to the diverse collection of processes and knowledge that people use to extend human abilities and satisfy human needs and wants (ITEA 2000a). It involves using technological knowledge, tools, machinery, know-how, equipment and skills to solve problems and extend human capabilities.

Technology is innovation in action. The computer is an important product of technology. So are airplanes, automobiles, cell phones, personal digital assistants, automated teller machines, digital cameras, wireless communication, and the Internet. Technology is typically used to solve problems and improve our lives, however, technology has byproducts and consequences. For example, gasoline engines provide power, but they also produce pollution and consume a nonrenewable resource.

Technology, science and engineering all work together to make our lives better. Technology is the product of science and engineering. In science, people study the universe in an attempt to understand how it works. Mathematics is the principal tool and language that scientists use in their inquiries. Engineering is the application of scientific knowledge to solve a problem or to improve our lives, either by creating a new technology or by exploiting an existing one.

A recent survey conducted in the U.S. by the International Technology Education Association (ITEA) and the Gallup Poll organisation interviewed 1,000 people to determine how they viewed technology. In discussing the results of the survey, Rose and Dugger (2002) conclude the following:

1. The public views developing technological literacy as a matter of great importance and it considers technology to be an important factor in everyday life.
2. The public's definition of technology is a narrow one that is likely to encompass mostly computers and the Internet.
3. There is an overwhelming agreement that schools should include the study of technology in the curriculum.

Technology education

In the United States (U.S.), technology education is a general education K-12 school subject that provides students with opportunities and experiences to learn about today's technology. Technology education had its beginnings in the U.S. in the late 1800s. Former names of technology education include manual training, manual arts, and most recently, industrial arts, where the content primarily emphasised tool and skill development related to industry (e.g. woodworking, metalworking, and drafting). Its goal today is to develop "technologically literate" students who can live and prosper in today's technological society.

What makes technology education unique is it hands-on learning environment where students have opportunities to create and innovate "new things". If you were to visit a technology education program, you would see students learning about technology in a laboratory-based environment where they would be engaging in problem solving activities using tools and materials that are representative of contemporary technology.

Today, technology education is gaining worldwide appeal. Technology education programs as practiced in the U.S. are being implemented globally to help prepare students for the technological society in which they live. Students who study technology learn about the technological world that inventors, engineers, and other innovators have created. Technology education in the U.S. is promoted by the International Technology Education Association (www.iteawww.org) that is devoted to enhancing technology education through experiences in the schools.

Technology education is sometimes confused with vocational education or educational technology. In the U.S., vocational education, commonly referred to as Applied Technology Education or as Career and Technical Education provides programs where students receive job specific training in such areas as agricultural education, business education, health occupations education and trade and industrial education. In the U.S., applied technology education is supported by the Association for Career and Technical Education (www.avaonline.org), which is dedicated to the advancement of education that prepares youth and adults for careers.

In educational technology (or instructional technology) the goal is to improve and enhance the teaching and learning process using a wide range of instructional technology (e.g. the overhead projector, video projector, computer, interactive CD-ROM programs, and digital camera) and sound instructional design practices. Educational technology is supported in the U.S. by the International Society for Technology in Education (www.iste.org) that is dedicated to promoting appropriate uses of information technology to support and improve learning, teaching, and administration in K–12 education and teacher education.

Standards for Technological Literacy: Content for the Study of Technology

It is very important that those who develop curricula be aware of "standards" related to the field of study. In the spring of 2000, the International Technology Education Association released the much-anticipated *Standards for Technological Literacy: Content for the Study of Technology (STL)*. The major purpose of this document was to identify the content required to teach technology. The *STL* contain technology content standards that specify what every student should know and be able to do in order to obtain technological literacy which can be defined as "the ability to use, manage, assess, and understand technology" (ITEA 2000a, p.9). Specifically, the *STL* lists 20 standards and their supporting benchmarks that can be used by curriculum developers to develop meaningful and articulated technology education curricula in Grades K-12.

In the *STL*, "standards" specify what every student should know and be able to do in order to be technologically literate and can be thought of as the major goals to achieve in a course or program. The "benchmarks" state the knowledge and abilities that enable students to meet a given standard and can be thought of as the "objectives" that help curriculum developers reach the standards stated in the course or program. For example, the "goal" of Standard 11 states, "Students will develop the abilities to apply the design process." A benchmark related to Standard 11 states: "As part of learning how to apply design processes, students in grades K-2 should be able to build or construct an object using the design process" (ITEA 2000a, p.116).

The *STL* is not a curriculum, but it does provide a good basis for developing technology education curricula. The 20 content standards are divided into five major categories. The first ten standards deal with "cognitive knowledge" and the last ten standards deal with "psychomotor skills". The 20 *STL* are presented below (ITEA 2000a).

Category 1 - The Nature of Technology

- Standard #1: Students will develop an understanding of the characteristics and scope of technology.
- Standard #2: Students will develop an understanding of the core concepts of technology.
- Standard #3: Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.

Category 2 – Technology and Society

- Standard #4: Students will develop an understanding of the cultural, social, economic, and political effects of technology.
- Standard #5: Students will develop an understanding of the effects of technology on the environment.
- Standard #6: Students will develop an understanding of the role of society in the development and use of technology.

- Standard #7: Students will develop an understanding of the influence of technology on history.

Category 3 – Design

- Standard #8: Students will develop an understanding of the attributes of design.
- Standard #9: Students will develop an understanding of engineering design.
- Standard #10: Students will develop an understanding of the role of troubleshooting, research, development, invention and innovation, and experimentation in problem solving.

Category 4 – Abilities for a Technological World

- Standard #11: Students will develop the abilities to apply the design process.
- Standard #12: Students will develop the abilities to use and maintain technological products and systems.
- Standard #13: Students will develop the abilities to assess the impact of products and systems.

Category 5 – The Designed World

- Standard #14: Students will develop an understanding of and be able to select and use medical technologies.
- Standard #15: Students will develop an understanding of and be able to select and use agricultural and related biotechnologies.
- Standard #16: Students will develop an understanding of and be able to select and use energy and power technologies.
- Standard #17: Students will develop an understanding of and be able to select and use information and communication technologies.
- Standard #18: Students will develop an understanding of and be able to select and use manufacturing technologies.
- Standard #19: Students will develop an understanding of and be able to select and use transportation technologies.
- Standard #20: Students will develop an understanding of and be able to select and use construction technologies.

Curriculum

Curriculum is a term that has many interpretations and meanings. A "basic" definition is "the specific details on how the content is to be delivered, including organisation, balance, and the various ways of presenting the content in the classroom-laboratory" (ITEA 2000a, p.13). Finch and Crunkilton (1999) define curriculum as "the sum of learning activities and experiences that a student has under the auspices or direction of the school" (p.11). Curriculum can refer to a single course (e.g. Foundations of Technology), or it can refer to an entire program of study (e.g. the High School

Technology Education Curriculum).

For the purpose of this paper, curriculum will refer to a strategy that takes a course's content and shapes it into an effective plan for teaching and learning. All curricula must have a plan and this plan is typically detailed in a curriculum guide. A curriculum guide is an important document that contains information to help the teacher implement the course. For example, a technology education curriculum guide may contain the following: a course introduction, a philosophy section, a listing of goals and objectives for the course, the standards and benchmarks addressed in the course, required units and lessons, recommended curriculum resource materials, facility requirements, instructional strategies, learning experiences (e.g. activities), and recommended assessment strategies.

The curriculum development process

Developing a curriculum begins with realising that the curriculum development process can be a long and tedious process that never ends. Once a curriculum is written, it must be continually evaluated and revised to reflect new standards and practices of the discipline. Also, curriculum development is a process that is seldom handled alone. To be effective, a technology education curriculum must be developed by a "curriculum team", a group of experts (e.g. technology teachers, educational specialists, and curriculum developers) who know and understand the curriculum development process and are well acquainted with the *STL*.

The curriculum team must first discuss and resolve the scope and sequence of the technology education curriculum. This is not an easy task and may require the creation of new courses in the technology education program that reflect the major goal (i.e., technological literacy for all students) of the *STL*. In the past, the industrial arts curriculum reflected the philosophy of the discipline and the needs of society. Course titles such as Woods, Metals, Graphic Arts, Automotive, and Industrial Arts were common, and their sequence was delineated by a simple numbering system (e.g. Woods I, Wood II, etc.)

Today, curriculum developers are faced with the daunting task of developing an integrated, fully-articulated K-12 technology education curriculum, wherein each level of the program must be synthesised with the whole picture. For example, given the task of developing a new high school technology education curriculum, the curriculum team must first come to a consensus on what technology education courses should be offered. This is not an easy decision, as it is based upon the philosophies and visions of the curriculum team with influences from outside factions such as administrators and state or local standards. However, one constant that must remain is that the new courses be based on the *STL*.

To help curriculum developers, ITEA's Center to Advance the Teaching of Technology and Science (CATTS) has worked diligently to identify courses, content, and contemporary practices needed to developed standards-based technology education courses. For example, in *A Guide to Develop Standards-Based Curriculum for K-12 Technology Education* (ITEA 1999) it was proposed that appropriate high school technology education courses might include: Foundations of Technology, Technology Assessment, Issues in Technology, and Engineering Design Fundamentals.

The backward design process

When developing new standards-based technology education curricula or revising existing technology education curricula to be standards-based, it is very helpful to use the "backward design" process developed by Wiggins and McTighe (1998). The backward design process presents curriculum developers with a logical three-stage sequence to follow when developing a curriculum.

Stage One: Identify Desired Results

Stage Two: Determine Acceptable Evidence

Stage Three: Plan Learning Experiences and Instruction

Stage One: Identify desired results

In stage one of the backward design process, curriculum developers need to identify what students should know, understand, and be able to do. They must consider and identify what content standards (e.g. national, state and district standards) should be addressed in the course. The content standards identify what is important to learn and understand in that course.

Before identifying what standards the course should address, curriculum developers must establish priorities. Wiggins and McTighe (1998) discuss three important, sequential concepts related to establishing curriculum priorities. Step 1: What is worth being familiar with or what knowledge should students know? Step 2: What important knowledge and skills are essential in the course? Step 3: What "enduring" understanding is required in the course? This conceptual process increasingly sharpens the focus of the course content. The enduring concepts in Step 3 refer to what students need to remember from the course after they have forgotten most of the details presented.

For example, when teaching students about electricity as a subsection of energy and power technology, the teacher might require that students know many different ways to generate electricity (Step 1). Next, the teacher might require students to know how electrical current can be generated as either alternating current (AC) or direct current (DC) and how a receptacle is wired (Step 2). Finally, the teacher might decide that in the end, students really need to know and remember that the 110 - 220 volts of AC electricity found in their homes can cause injury or even death through unsafe usage (Step 3).

In stage one, curriculum developers must understand that the standards "drive" the curriculum, not the activities. Too often teachers have a large inventory of "fun" activities at their disposal, and when faced with the challenge of developing a new course or revising an existing course, they start by planning how these activities can be incorporated into the course. This may result in a course that is not standards-based. When developing or revising a new course based on the *STL*, curriculum developers must first identify the standards and/or benchmarks that will be covered in the course.

Stage Two: Determine acceptable evidence

In stage two, curriculum developers are challenged to think like assessors before designing a course, unit, or lesson by deciding in advance what evidence will be used to determine if students have achieved the stated outcomes. As Wiggins and McTighe (1998) note, "The backward design approach encourages us to think about a unit or course in terms of the collected evidence needed to document and validate that the desired learning has been achieved, so that the course is not just content to be covered in a series of learning activities" (p.12).

When developing assessment, curriculum developers must consider a wide range of assessment methods and think of assessment in terms of a collection of evidence over time, rather than as isolated events. Further, assessment should not rely only on tests, but should include both formal and informal assessments, including student self- assessment. Wiggins and McTighe (1998) discuss using a variety of assessment techniques including traditional quizzes and tests, academic prompts (open-ended questions or problems given to students), and performance tasks and projects.

In technology education, there are a variety of assessment criteria and evidence-gathering tools available for teachers to use to determine if students are meeting the outcomes (standards) of the course. *Measuring Progress: A Guide to Assessing Students for Technological Literacy* (ITEA 2002) discusses the use of rubrics (a type of scoring guide used in nontraditional assessments) and reviews popular evidence gathering tools including, portfolios and journals, scenarios, open-ended questioning, models and prototypes, realisations/products/projects, observation, discussion/interview, concept mapping, presentation and debate and tests.

Stage Three: Plan learning experiences and instruction

In stage three, technology education curriculum developers are encouraged to do an extensive search for appropriate curriculum materials and other resources that are best suited to accomplish the goals (standards) of the course. In a curriculum material search, developers should consider print-based materials (e.g. textbooks, student workbooks, magazines, and product manuals) and other supporting materials (e.g. modules, kits, Internet sites, audio and visual materials, and computer-based media).

There are a wide variety of appropriate instructional strategies and methods available for technology education teachers to use. For example, Teaching Technology: Middle School Strategies for Standards-Based Instruction (ITEA 2000b) contains methods, activities, and resources for teaching technology in the middle school grades. Suggested teaching methods include: design briefs, cooperative learning, teamwork and leadership, methods for enhancing creative thinking, using simulations to teach technology, and using modular instruction.

Considerations for developing standards-based curriculum

A standards-based technology education curriculum should be based on contemporary criteria. A Guide to Develop Standards-Based Curriculum for K-12 Technology Education (ITEA 1999, pp.8–9) identifies important criteria that should be exhibited in a model technology education curriculum.

- Focus on students and their learning.
- Reflects exemplary practices for teaching and learning

- Emphasizes design and problem-solving activities
- Student learning experiences that help students achieve the *STL*.
- Develops a technological literacy in students.
- Integrates math, science, and other subjects
- Promotes career development in profession and technical fields.

When developing standards-based technology education curricula, developers are often faced with many key curriculum questions, problems, and issues. Listed below are four key curriculum questions that must be addressed. Under each question, are criteria that should be considered.

Question #1: What should be taught?

- Philosophies (national, state/providence, school, course, and discipline)
- Course Goals and Objectives
- Standards (local, state, and national)
- Professional Organizations and Associations
- Advisory Committee Recommendations

Question #2: How should the curriculum be organised?

- Curriculum Guide
- Professionally Organized and Presented

Question #3: How should learning experiences be presented?

- Standard-Based Units and Lessons
- Contemporary Teaching Methods and Instructional Strategies
- Using Educational Technology

Question #4: How should the curriculum be assessed?

- Students Achievement (using a wide variety of assessment techniques)
- Student Motivation
- The Curriculum (continual evaluation and revision to reflect new pedagogy and new standards)

Conclusion

To ensure that today's youth are technologically literate will require that technology education curriculum be developed that reflects the needs of today's society. The *STL* provides curriculum developers with the needed content to ensure technological literacy is achieved by today's youth. The challenge to technology education curriculum developers is to develop and implement standards-based curricula. For this to occur, curriculum developers need good understanding of the curriculum development process, technology education, and the *STL*.

In this paper, the concepts associated with technology, technology education, Standards for Technological Literacy and curriculum were reviewed. Next, the curriculum development process and backward design process were examined. Finally, questions and considerations for developing standards-based technology education curricula were presented.

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Talking a Design into Existence: Making Model Parachutes

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In this paper, I explore the conversations and actions of Grade 7 students (i.e. after instruction) working on the task of building a parachute so that it falls as slowly as possible. 3 pairs of students (two male/female pairs, 1 female pair) were videotaped as they worked on this task. Transcripts of the videotapes have been interpreted from a sociocultural perspective on designing, examining both tool-related and discursive practices. As a primary technological activity, designing is characterised by the ways in which people articulate strategies for achieving solutions to problems and assessing their artefacts, as well as by the ways in which they use tools and materials. The study has implications for the teaching of technology education in elementary schools.

Introduction

In a Grade 6 instructional unit described as problem solving through technology, one of the learner expectations spelled out in the mandatory program (Alberta Education 1996) is that students will 'conduct tests of a model parachute design, and identify design changes to improve the effectiveness of the design' (B. 31). In the year following implementation of this unit, student pairs (7) were provided with an array of materials (plastic, fabrics, tissue, paper clips, balloons, thread, string) and tools (scissors, glue gum, hole punch, tape, sewing needle). Each pair was asked 'To design a parachute that will support a washer and fall as slowly as possible. Use as many of the materials as you need. There are more materials than you need'. Student pairs were given about 45 minutes to work on the task.

In this paper, I report on the conversations and actions of 3 pairs of students.

Theoretical framework

In classroom settings of technological activity, researchers are more frequently turning to language as a critical mediator of learning, although it is rare to find elementary teachers viewing technology projects as opportunities for 'language encounters' (Ritchie & Hampson 1996). More and more frequently, it has been suggested that language may 'provide the key for linking thought to action' (Solomon & Hall 1996, p.275), and that 'productive thinking in the context of physical activity is both reflected in and stimulated by discourse between collaborators as they share and assess ideas' (Hennessy & Murphy 1999, p.3).

Technological activity may be viewed from a number of different perspectives, depending on assumptions made about the relationship of knowledge to the practice. One orientation (technical) adopts an instrumental view of knowledge, in which discrete concepts or skills can be applied to solve particular types of problems.

Rather than knowledge being applied to achieve a solution to a problem, Schon (1983) argued that it is invented during action. In confronting a problematic situation, the nature of the problem has first to be constructed; practitioners 'determine the features to which they will attend, the order they will attempt to impose on the situation, the directions in which they will try to change it' (p.165). The practitioner engages in deliberative reflection on the problem, and the iterative nature of moving forward is captured in the metaphoric 'reflective conversation with materials' (p.172).

In a third conception of technological activity, knowledge-in-practice is mediated by the use of tools, resources and language within an active community. The discursive practices of a community constitute the ways in which members approach action. The metaphor of stance is particularly appropriate for relating to technological activity (Rowell, in press), in that it suggests both physical placing as well as cognitive orientation and perspective. Stance is the way individuals position themselves relative to a community of practice, and is the outcome of relations with other members of that community (Cochran-Smith & Lytle 1999). Tools, resources and language mediate these relations. In technological communities, discourses around design and designed systems address the decisions made by people in using materials and building devices which impact the way humans live. Not only does stance capture the ways we approach and view a community, but it embraces the ways in which we participate in a community. Tradeoffs due to constraints (either physical or social) are made by people. Anticipation of possible failure, assessment of risk, and the role of human judgement in control situations are integral strands of technological discourse.

Methodology and data analysis

The students described in this report had participated as pairs in technological tasks during the first phase of a larger study of the implementation of technological problem-solving in the provincial elementary science program. Two years had elapsed since they worked on the first task (building a robot with eyes which turned on and off). In the intervening year (first year of implementation), it was assumed that each student had engaged in construction of model parachutes. However, two students (Julian and Cameron) had not done this in their classes.

Each student pair was asked to draw a picture of what they thought their parachute would like before they began to assemble it, and another sketch on completion of the activity. Students were video-taped while working on the task. The students described what they had done both orally and in writing after the task. The video-tape was transcribed for the oral exchanges, and commentaries of manipulative actions were written.

Transcripts and commentaries were coded for key features of technological activity, and subsequently grouped according to different orientations to technological activity (as outlined above). The features coded for a technical orientation to the designing of a parachute were the articulation of concepts (or misconceptions) related to movement through air and the application of specific skills, such as strengthening materials, joining materials, using tools and testing the parachute. From this technical orientation, the problem is a 'given'; it is the production of the structure.

In an orientation to technological activity as constructing a problem, a problem is talked into existence by attending to key features of the available materials and setting a path for action. From the interactions between students, we could recognise the features of the problem to which they were attending and the way in which they imposed order on the activity. From their talk and actions, we could also recognise when they modified the direction of the activity.

The transcripts and commentaries were also coded for the features of a third orientation, adopting a technological stance, in which technological activity is characterised by discursive practices which talk a design into existence, such as recognising constraints, making choices, justifying trade-offs, persuading collaborator(s), assessing risk, and anticipating and/or explaining failure.

Findings

As a primary technological activity, designing is characterised by the ways in which people articulate strategies for achieving solutions to problems and assessing their artefacts, as well as by the ways in which they use tools and materials. In this section, key features of the ways in which the student pairs tackled the design of a parachute are presented from three possible orientations, as outlined above.

Applying concepts and skills

Students' articulation of understandings related to the movement of objects through air was scant:

> Cameron: I have an idea; there's always a hole at the top of the parachute so it goes down slowly.
>
> Alison: This will go up (throws piece of tissue paper in air)

Misconceptions about the movement of balloons in particular were influential in framing the problem:

> Krista: Maybe that [balloon] will stop it from falling as fast as we had it.
>
> Robyn: If you attach a balloon to the top, - make it float?
>
> Julian: We should have all, like all four balloons. That would look cool.
>
> Robyn: That'll slow it down.
>
> Robyn: This one falls slower than the little ones [balloons]
>
> Julian: Let's see. That's 'cause it's bigger, you know.
>
> [Afterwards]
>
> Julian: I thought balloons would probably make it better, easier. It would slow it down because it had air in it.
>
> Robyn: And balloons float.
>
> Focused discussion about the desirable shape or size of a parachute was limited.
>
> Cameron: Why don't we make it like this [holding piece of plastic] Cut a circle.

Alison: That would be too small.

Cameron: Let's try and make it more round like a normal parachute.

Alison: Because parachutes are square.

Cameron: They are?

Alison: The new ones are square. Rectangle.

Cameron: Rectangle?

The properties of materials with respect to their weight or strength were considered prior to construction by only one student pair, and retrospectively by another pair.

Cameron: [The string] could rip straight through it [tissue paper].

Cameron also suggested reinforcing the corners of tissue paper when this was used in the later stages of construction:

Cameron: I guess we could try. Let's put tape on it to reinforce it.

Alison: Reinforce what?

Cameron: The corners; they'll rip.

None of the student pairs developed a valid test for comparing the rate of fall of the parachute. The height and style of drop varied from test to test for individual pairs. Robyn and Julian discussed how to carry out their tests:

Julian: We should go higher and just drop it.

Julian places chair on top of table, and climbs on top of it.

Robyn: Then it has more of a chance to open.

Julian: It has a bit more time. There we go.

Julian: Should I throw it up or?

Robyn: No, just drop it.

Julian: Like that?

Robyn: No, the other way round.

However, they were not able to agree on comparing the rates of fall:

Robyn: Well, that one went slower.

Julian: It didn't look like it.

Robyn: I think it went a little bit slower.

Julian: It didn't look like it. It probably did, [but] didn't look like it.

Robyn: Yes, it still works.

Julian: Not really; that's not really a soft landing.

And, when it came to the final test, the following exchange ensued:

Julian: Should we test this one more time? Just this last time?

Robyn: OK.

J: Try it one more time. Let's just throw it up this time.

R: I'll try. I'm taller than you are.

Alison and Cameron also adjusted the conditions for testing:

C: Hold it up as high as you can.

A drops parachute

C: That was way softer, you have to admit.

Clearly students had encountered the tenets of fair testing, as Krista expressed some doubt about these when completing a written description after the activity:

K: How did you test your parachute? From letting it fall from a certain distance or height.

E: Yes, and it was the same distance all the times.

K: Well, it could have a bit, kind of varied, you know.

E: Oh, yes.

K: So, tried it in two different distances.

Constructing a problem

There was considerable variation in students' willingness to talk the problem into existence (see Table 1). Emily and Krista spent little time considering the options available for selection of materials or the size and shape of the parachute, adopting a piece of precut cloth for the canopy. They began to work with materials immediately, in the following sequence:

1. Adopting cloth [precut rectangle]
2. Making holes in four corners of cloth
3. Measuring and cutting strings
4. Gluing strings to washer
5. Adjusting length of strings to get them equal
6. Attaching strings to cloth
7. Testing

After carrying out their first drop of the parachute, there was no assessment of its performance other than to note that it was 'lop-sided'. Emily suggested:

E: We might be able to blow a balloon and put it underneath.

With no further discussion about the materials, the pair proceeded to add successively more balloons, with further 'drops'.

Robyn and Julian also had no discussion about the selection of material for the canopy; plastic was adopted. Their initial focus was on the number of strings supporting the washer and the length of the strings. Having attached the strings to the pre-cut plastic and the washer, they discussed the use of balloons, both expressing some reservations about such a move:

R: If we attach them [balloons] to the top, then it will float.

It won't really be a parachute.

After inflating the balloons, Julian tossed one in the air, and remarking:

> J: See, well look, it doesn't really seem to float. It just comes down.
>
> R: Well, it might slow it down. We should try it first without them and then see. Put them on.

Julian and Robyn attended more to the problems of attaching materials (strings to canopy, strings to washer) than to the key function of the canopy. However, dissatisfied with the parachute's performance, they began to articulate possibilities:

> R: Maybe if we made the top a wider spread open place.
>
> J: Make it come out farther or something?
>
> R: We probably want it lighter?
>
> J: I wonder why that is [apparent slowing of fall with 2 balloons]? Why wouldn't it; why wouldn't 3 be better, or 4?

After they had concluded the activity, Julian and Robyn reconsidered the task:

> J: Maybe we should have used cloth, 'cause that could have trapped it [air] better or something. 'Cause I think there's like tiny, tiny holes in this [plastic].
>
> R: Well, there's definitely holes in this one.
>
> J: Oh yes. But we could have used tissue, maybe?
>
> R: But it's not very strong.
>
> J: But I know we couldn't use tin foil because its too weak. It would probably break. It might work, I don't know.

Adopting a technological stance

In adopting a technological stance, we looked for students to move beyond merely constructing and testing an artifact or discussing the selection of materials for the artifact. We looked for indicators of design practices, such as recognition of constraints, justifying trade-offs and recognition of the possibility of failure. Being able to argue in favor of (or against) the selection of a specific material or a specific shape on the grounds of why its contribution to the performance of the artifact might work exemplifies technological stance.

The student pairs displayed few indications of technological stance with respect to the task of building a parachute. Emily and Krista supported each other's suggestions in an uncritical manner, with an apparent disinterest in why any of their procedures might contribute to success or failure. Dissatisfaction with the performance of their parachute led Robyn and Julian to move into an iterative movement between the parachute's performance and properties of materials, but they were not able to articulate justifications of trade-offs or deal with the failures. Alison and Cameron were the only pair of collaborators who displayed indications of adopting a technological stance.

The collaboration between Alison and Cameron was marked by challenges and counter-challenges, in which one or the other student was provoked to justify a decision.

C: I don't think we really need those strings.

A: Yes, they'll help.

C: How?

C: I don't see why we need to use the balloons, anyway.

A: Because it will help.

C: How come all parachutes don't have balloons?

A: 'Cause they're made out of special material, not garbage bags.

A: Look at how slow it [tissue paper] goes down.

Then look at how slow this one [plastic] goes down

C: Yes, but look at this [plastic]. When it's down like this [holds it in the centre], it's cut in a circle. It's down like that. OK, where do you think it's going to go?

However, this student pair also fell into a 'make it work' approach at times:

C: If this doesn't work, we'll make the parachute bigger.

A: Or smaller.

C: Bigger.

A: Smaller.

C: OK. We'll do bigger first. If bigger doesn't work, then smaller.

Discussion

The presentation of the observations above is not intended to suggest that application of concepts and skills is necessarily detached from the process of constructing a problem or adopting a technological stance. Clearly, the understandings and skills which collaborators bring to the task are resources to be drawn on in the iterative stance of the technologist. Likewise, the willingness to work with materials to 'construct' a problem is also a domain in the technological field. But it is discursive features which characterise technological stance; expression of how a parachute works and why.

Emily and Krista did not talk either a problem or a design into existence. They did not recognise the building of the parachute to be a problem, and they worked in a linear fashion with no application of concepts and with limited skills. The conversation between Robyn and Julian during the initial phase of the activity focused largely on the mechanical operations of assembling the selected materials. The problem confronting the students was one of attaching strings to plastic and to a washer. As the time for the task drew to a close, Julian contemplated the use of alternative materials for the canopy, hinting at reasons for these. In these conversations, Julian was giving shape to the nature of the problem.

Clearly, these students had limited conceptions about the movement of objects through air, even they had all been given instruction on this topic the previous year. The distraction of the balloons and the misconception that balloons float led each of the pairs to construct devices with balloons attached in a variety of ways. Robyn adopted balloons as part of the structure because she had built a parachute before with balloons. Julian accepted this, although he was obviously doubtful about the usefulness of attaching balloons. However, after the first test with the balloons, Robyn admitted to Julian that the parachute she had made the previous year with balloons 'didn't work'. Julian puzzled further over the contributions of the balloons when it appeared that the parachute appeared to fall more slowly with two balloons than with four. Julian could be said to be moving toward a technological stance to the task. Although their initial strategy was to attach a balloon to each corner of the canopy, Alison and Cameron ultimately rejected this approach. As a result of dissatisfaction with performance, both Alison and Cameron adopted a technological stance and attempted to address the design problem through a discussion of both materials and shape, and the contribution of these features to the parachute's performance.

Since none of the student pairs developed a quantitative test for the rate of fall of the parachute, they really did not have a reliable or valid means of comparing the performance of their different structures. Only Julian was sceptical about making comparisons between the test 'drops', the other students being satisfied with qualitative assessments. While the notion of 'testing' was seen as part of the technological activity, none of the students articulated criteria for a 'soft' landing.

Implications

The students in this study had been given instruction about the movement of objects through air in the previous year. All but two of them had built parachutes before. What is clear from these observations is that none of these students in this study was able to adequately talk a design into existence. If students engage in a task merely to assemble a device through the use of tools and materials, but without engaging in explicit discussion of how technologists place themselves in a situation with respect to those tools and materials, then students do not learn how to participate in the discourse of technological situations. In this task, and presumably in their classrooms, the focus had been on assembling and testing their structures, rather than designing them (Cajas 2001). Teachers need support to scaffold a discourse of design; studies have shown the language of the teacher in supporting technological stance is critical (Murphy & Hennessy 2001; Stein, McRobbie & Ginns 2002).

As McGinn and Roth (1995) observed, discursive practices are less readily appropriated than tool-related practices. Students need extended opportunities in which to recognise, use and make their own the ways of talking about constraints, tradeoffs, possibilities of risk or failure. They will need to talk, read and write in these genres in order to recognise what is being accomplished. But ways of talking, writing and drawing in technological activity have not received serious attention, in part due to a school culture of viewing learning as an individual accomplishment, and the assumption that all students should be directed towards identical tasks. However, if participation in technological activity is regarded as a communal activity, then considerably more emphasis is likely to be given to the ways in which inquiry is constituted through language forms. Programs which support technological stance position learners as critical inquirers into both tool-related and discursive practices of technology.

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Table 1

Constructing a problem

ALISON AND CAMERON	ROBYN AND JULIAN	EMILY AND KRISTA
Attending to features and imposing order	**Attending to features and imposing order**	**Attending to features and imposing order**
1. Adopting balloons	1. Adopting plastic	1. Adopting cloth
2. Selecting plastic	2. Choosing the number of strings	2. Making holes in four corners of cloth
3. Making plastic bigger (taping 2 pieces together)	3. Selecting string rather than thread	3. Measuring and cutting strings
4. Making plastic oval	4. Cutting holes in corners of plastic for attaching strings	4. Gluing strings to washer
5. Inflating balloons	5. Measuring strings	5. Adjusting length of strings to get them equal
6. Selecting string rather than thread	6. Attaching strings to plastic	6. Attaching strings to cloth
7. Cutting holes in plastic for strings	7. Attaching strings to washer (tape)	7. Testing
8. Attaching balloons to plastic with strings	8. Inflating balloons	
9. Measuring strings	9. Testing without balloons attached	
10. Attaching strings (cutting holes) to plastic		
11. Attaching strings to washer (tape)		
12. Testing		
Directing changes	**Directing changes**	**Directing changes**
1. Cutting small hole in top of canopy	1. Re-attaching strings to washer	1. Attaching balloon to washer, below cloth
2. Testing	2. Testing	2. Choosing round rather than long balloon
3. Adjusting strings to washer	3. Attaching 4 balloons to top of canopy (tape)	3. Testing
4. Testing	4. Testing	4. Attaching second balloon on top of cloth
5. Removing balloons	5. Removing long balloon	5. Testing
6. Testing	6. Testing	6. Attaching two more balloons
7. Selecting alternate material for canopy (tissue paper)	7. Removing all balloons and tape	7. Testing
8. Making canopy rectangular	8. Testing	
9. Strengthening corners for attaching strings	9. Attaching 2 balloons	
10. Testing	10. Testing	
11. Cutting hole in top		
12. Testing		

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Resource Sharing and Collaboration as a Strategy to Improve Quality

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TAFE in South Australia is a Registered Training Organisation and has 30 campuses across the state. As a requirement of registration TAFE must be able to demonstrate that there are appropriate standards of delivery and assessment being maintained and there must also be underlying processes and systems to verify and continuously improve on the base standards. This paper examines what is intended of the various quality assurance systems that are available and used in Education. A model directed at collaboration and resource sharing as a strategy of continuous improvement and staff development within a framework of assuring quality is proposed.

The current situation in training

The Australian Quality Training Framework (AQTF) for Vocational Education and Training (VET) aims at enhancing national mutual recognition of training providers and Quality Assurance (QA) in the delivery of training. Requirements of registration are that staff must maintain skills and knowledge and that there are persons available with responsibility and relevant experience to evaluate training and assessment materials (ANTA 2001).

There is compatibility of AQTF with other quality systems such as ISO9001 (TAFE 2002). The organisation must demonstrate that a range of criteria are met including staff participation and ownership of improvement processes, implemented strategies of staff training and development and processes to continuously improve its VET products and services through the use of performance indicators (ANTA 2001). Karapetrovic and Willborn (1999) stated the purpose of QA in academia is to provide confidence to customers and stakeholders that the requirements of quality education and research are continuously met. Reference was made to the ISO standards being internationally accepted but due to their generic nature they require interpretation for application in an education environment. Several of the elements that are absolutely necessary for the effective operation of the ISO system, such as inspection and testing and statistical techniques are not appropriate in the application to education.

Technical and Further Education (TAFE) in South Australia is an RTO and has 30 campuses across the state. Although having one registration it operates as seven autonomous Institutes. As a requirement of registration TAFE must be able to demonstrate that there are appropriate standards of delivery and assessment being maintained. The state wide policy for course standards (TAFE 1997) also specifies a requirement for consistency across Institutes and systems of verification of standards across each course. The same policy specifies that Institute Directors are responsible for maintaining the quality of the programs offered within the Institute. The actual task of giving effect to the policy rests with groups composed of representatives of the teaching staff who provide leadership in a program and they detail the process of operation of QA for that program area. There is no direct linkage across Institutes to resource the QA, nor management involvement in the process to embed it in administrative support systems.

In a practical sense there is difficulty in establishing an effective system that will deliver an outcome that meets the requirements of registration. Also there is no clear statement of what is meant by QA or the indicators by which it is to be measured. Within a program, such as Information Technology (IT), which is delivered at twenty-two campuses of TAFE, by over 250 different lecturers, QA is difficult. IT is rapidly changing, technically complex and contains a range of fields and encompasses twenty three qualifications from Certificate I level to Advanced Diploma level. Indicators in one field are not appropriate in another and when they are too generic, they are not sufficiently focused to identify improvement or consistency. Further, the geographic spread of staff, high teaching loads and constant change of content, leads to a position of abdication of QA involvement. Teaching staff tend only to take part in additional tasks, if there are direct benefits delivered to them in achieving the task of teaching. Registration of the organisation, consistency across institutes, continuous improvement and ongoing development of the individual are seen as either irrelevant to the task at hand or a matter that will be dealt with at some time later. Teaching staff also jealously guard their teaching and assessment resources seemingly for two important reasons:

- A view that they have an implied ownership and releasing them to others would reduce their advantage;
- A fear that to show their work to others would risk criticism or worse ridicule if their materials were in some way flawed or deficient (or exemplary).

This exacerbates the non involvement of the 'coal face' teacher in the QA process and magnifies the isolation of lecturers even within the same campus. There is no requirement for a staff member to participate in a state wide QA process. If staff at a Campus does not deliver up evidence verifying consistency there seems to be few responsive and expedient mechanisms to redress the non compliance. Where there seems to be substantial divergence from an arbitrary standard it is not clear as to who will arbitrate on levels of performance and their enforcement. The ultimate consequence of failure of one location during a registration audit will have an effect on the whole program across the state, as in South Australia TAFE is one RTO.

What is understood by Quality Assurance in education?

The role of quality must be understood from the perspective of the business for it to be fully appreciated. There can be judgmental criteria, product based criteria, user based criteria, value based criteria or manufacturing based criteria and each of these could be explained by examining principal quality dimensions (Evans & Lindsay 1999). In the context of an RTO there is an implication of quality management involving all employees, throughout every function and level of the organisation to pursue quality. This aligns with the intent of Total Quality Management (Bounds et al 1994).

Girwood and Ekhaguere (1999) suggested there are three basic approaches to QA:

- The threshold model, which will accredit a provider's capacity to deliver a minimum standard, and results in a yes/no judgement.
- A summative or judgmental model, which may rank institutional performance and give a numerical or descriptive judgement (sometimes as the basis for competitively awarded funding).
- Models designed primarily to develop or improve performance, and to change institutional culture on an incremental but systematic basis.

Among the recommendations of the Dearing report on Higher Education for the United Kingdom there was a forth category of "conformance to specifications or standard" view of quality. An example being: the ratio of students enrolled to the number of computers on campus. There is as yet no recognised baseline for which all institutions conform, nor is it clear, if such a baseline existed, what purpose it would serve (White 2000). In the United Kingdom through the QA Agency for Higher Education there has been adoption of Teaching Quality Assessment (TQA). This is a four level evaluation of six aspects of provision. This produces a twenty-four point easily used league of tables. The scale is considered useful and transparent by outsiders but flawed in the eyes of educators.

A survey of twenty five UK universities and colleges of higher education found a time related split between the intent of audits within organisations (Jackson 1996). Pre 1992 institutions had centralised management framework which undertook structured processes to check the health of an academic departments activities. Post 1992, on the other hand, carried out quality audits to check the fitness for purpose and effectiveness of the arrangements for management of the quality and standards of education. This latter one was based on a more decentralised quality management framework of autonomous departments. In both cases the academic quality audit does not directly evaluate (through peer judgement) the quality of education or service.

Johnson and Golomskiis (1999) detailed several metrics of quality related to universities as being: the number of times published research is cited, which journals in terms of prestige publication occurs, through to process measures of research. The measurement of performance of teaching was mainly done as a post activity process.

In Ireland, Colleges of Further Education are being encouraged to adopt the Business Excellence Model (BEM). The model belongs within the Total Quality Management stand of broad quality improvement. The basis of the model is the achievement of good results through the involvement of all employees in the continuous improvement of their processes. There are nine criteria to assess and measure for excellence and target continuous improvement. The criteria are divided into two areas: enablers and results. McAdam and Welsh (2000) raised the questioning of other researchers of the likely success of BEM in the public sector in regard to cultural differences to the private sector, lack of ownership by individuals, centralisation of authority and lack of clarity about customers and stakeholders. The timeframe for significantly improved business results was estimated to be at least 3 to 5 years. This can in itself be problematic for publicly funded organisations that must respond quickly to political turnarounds.

A study of the Hong Kong Higher Education by Pounder (1999), showed that quality was absent as an effectiveness dimension and was not found to be valid and reliable for institutional performance rating. The interpretation of this result was to support the view that quality defies generally agreed definitions. It was argued that getting too preoccupied with defining quality can detract from the fact that quality (with whatever suffixes) has provided the basis for positive and constructive initiatives.

A definition of quality was suggested in line with the Administrative unit of University of Wales, College of Cardiff, as:

> "the degree to which agreed standards relating to the priority requirements or needs of the users of the College's administrative services are achieved and continuously improved, bearing in mind resourcing levels and other local constraints" Pounder (1999).

It was noted that while it may be acceptable for administration it was not acceptable as an adequate definition of quality for academic units. Further, it was noted that idiosyncratic definitions of quality lead to idiosyncratic measurement initiatives and results.

In Australia, schemes for QA of teaching and learning use student evaluation as a prime source of information. Little thought though is given to the relationship between the assumptions underlying what constitutes high quality teaching and learning, the assumptions on which QA procedures are based, and the assumptions underlying the development of the student evaluation procedures which are a constituent part of the QA process (Martens & Prosser 1998).

High quality teaching is not just about high quality presentation of content, nor high quality teaching skills. Martens and Prosser (1998) suggested it is fundamentally about affording high quality student learning. High quality learning is learning focused fundamentally on the development of meaning and not on reproduction. It is a deep approach where the students intention is to understand the material they are studying. The deeper approaches to study are ones in which they report that the teachers are good and that the goals and standards are clear. Subjects with surface approaches are reported with overly high workloads and assessment strategies aimed at reproducing learnt materials. High quality teaching is also context related, uncertain and continuously improvable. There needs to be allowable variation between disciplines, years of study, and even compulsory versus elective subjects.

QA measures are commonly course or program accreditation, external examiners and teaching appraisal. Quality enhancement aims for an increase in the quality of teaching. In practice it encourages the better teachers towards higher quality and more innovative practices, with the expectation of a knock-on effect on the majority. It cannot be imposed by regulation and so relies on academics volunteering to participate. Teaching quality enhancement tends to be both more diverse and less clearly defined than QA (Mckay & Kember 1999).

Approaches to QA are often based on fundamentally opposing schemes (Martens &

Prosser 1998). One scheme is emphasis on the intrinsic characteristics of the institution; the confidential, and self directed improvement of quality through trusting peers and self-evaluation. This runs the risk of being unreliable, impressionistic and uneven. In this approach the subject as a whole, and not just the teachers, are contributing to the improvement of student learning over time. Alternatively, the emphasis is on the extrinsic characteristics of an institution, insisting on external managerial control, comparable, statistical data and public reporting, but which runs the risk of losing trust and commitment of the participants. Here it is based on ensuring that staff fulfils their duties, and identifying those who are not performing adequately, often relying on standardised student questionnaires to monitor staff performance. For there to be successful introduction for change in either case the following needs are to be met: compatibility with institutional traditions, support and resources provided by those in power, members being informed of the process of change and have opportunities to influence it, and external pressures on the institution being be taken into consideration (Martens & Prosser 1998).

In the educational context, Gore et al (2000) raised two paradigms of quality and professionalism in relation to academic provision:

- Technical-Rational: where it is a matter of technical performance and follows a logical sequence as part of an efficient system. The three significant drawbacks though are; that it is costly, it tends to discourage innovation and exploration of alternatives and continuous evolution to excellence, and its main failing is lack of peer and self evaluation with effectiveness that is determined by the staff. This system of control and monitoring does not in itself ensure much about the real product in terms of delivery to the customer.
- Professional-Artistry: where education and quality is a practical art which takes a holistic approach, measured from a multi-stakeholder perspective. Here the emphasis is placed on creativity, innovation and exploration. The failing in this system is that there can be fragmentation of the approach to quality enhancement where co-operation and sharing of good practice can break down owing to time constraints.

These two models can be used in conjunction and are able to counter-balance the limitations inherent in each other. The key factor is to appropriately target either system at different processes within the organisation.

Educational institutions have in the majority of cases adopted prescriptive models of QA, focusing on the Techno-Rational approach. It is most likely that this is because they are administratively easy to manage and can be constrained in terms of cost. They generally do not deliver tangible enhancements to delivery and assessment or improve customer satisfaction. Principally the function of the system is to demonstrate that a system is in place for the external accreditation or auditors. For a QA system to deliver quantifiable measures and contribute to continuous improvement there must be involvement of staff at all levels and a commitment and evolution to an improved product. Not only must the staff embrace the system there must also be immediate and tangible benefits to those involved. It is probably not sufficient that the staff are paid to undertake a QA process as it must also be perceived by them to be useful.

Administrative or managerial levels will not be content (and committed to ongoing funding) without some certainty that the core assets of the organisation are enhanced and documented.

Technology and collaboration can contribute to the process of QA

The market value of organisations is several times its book value. More recently this extra value has been categorised as social capital of the organisation. The difference between the two is found in an organisation's employees. Their individual skills, know-how, information systems, designs, supplier relationships and client contacts add value and generate wealth (Appelbaum & Gallagher 2000). In a competitive and rapidly changing environment an organisation needs more people to know where to get information, know how to share it, know how to store it, retrieve it, and use it. In essence the people in the organisation are the "core process".

Understanding the nature of knowledge itself is important, allowing the creation of an environment in which knowledge is both generated, stored, co-ordinated and diffused. The challenge revolves around developing organisational knowledge by formalising the context, structures and procedures which promote the building and sharing of knowledge (Stonehouse & Pemberton 1999). Although learning is an integral element of knowledge acquisition, there are occasions where it must be discarded or "unlearned". With technology it is generally archived or superseded by new knowledge. However, inaccurate or outdated knowledge should be discarded and not be allowed to influence individual or organisational decision-making. The individual learning process is accelerated and enhanced by sharing of information or knowledge, accompanied by an openness that encourages questioning, debate and discussion of existing practices. Organisational learning, like individual learning is concerned with the building and adaptation of knowledge, but with more formalised storage, sharing, transfer and co-ordination of its knowledgebase.

Knowledge management promises to improve business performance by using technology to capture and share lessons of experience. Without opportunities to learn from others there is the danger of stagnation. Employee learning can also stagnate when there is exploitation of an individuals current expertise rather than helping the person to develop new or complementary skills. Employee turnover can also be high, and through this there can be the loss of organisational memory. Knowledge repositories play an important role in preserving organisational memory. Learning from the experience of others and reusing materials that have been effective elsewhere improves the quality and speed of problem solving. Also embedding learning in an organisation's core processes or support systems has a long term positive effect on employee behaviour (Cross & Baird 2000).

Information sharing is a usual practice but some times avoided because individuals are not able to see the organisation as a system, where global objectives should be accepted as a common value. Knowledge levels of individuals can be an asset to an organisation only if they are enhanced and efficiently used. Information technology is assuming a decisive role in knowledge management. Adequate software can capture and distribute to knowledge workers all the useful information a company has stored over time (Carneiro 2000).

Emerging technologies such as group ware products and the Internet, offer to dramatically improve the ways in which people communicate and collaborate (Stenmark 2002). Organisations that successfully utilise technology to support organisational memory have the following characteristics (Olesen & Myers 1999):

- technology, policies, and procedures to ensure that lessons and reusable materials are screen by panels of experts,
- rapid entry into distributed technologies so that others benefit,
- and leverage the knowledge and encourages engagement in dialogue.

The information gateway (Belcher et al 2000), has potential to assist an organisation and its staff in managing information. They are quality control information services that:

- are online providing links to other sites or documents,
- resource selection is an intellectual process according to published quality and scope criteria,
- content descriptions and possibly keywords and controlled terms,
- a browsing/classification structure,
- and in part metadata for individual resources.

Gateways are characterised by the focus and quality of their collections. To be high quality it needs to be targeted to a user group, have selection of resources based on semantic judgements about relevance and value, and content chosen by those that have knowledge, experience and expertise in the subject. Where educational delivery is in geographically dispersed locations, or the volume of information is not screened and ordered it loses its usefulness, or worse is lost or not accessible. Here there tends to be a substantial barrier to sharing, joint development and use. This in turn becomes an impediment to QA, continual improvement and efficient use of scarce resources.

Conclusion

QA is a required and expected component of the operation of RTO's and educational delivery. There are many and varied definitions of QA, how it operates and what are the metrics of performance within it. Delivering additional benefits as a result of collaboration and sharing, a direct and immediate positive to teaching staff, ensures their co-operation and involvement. Enhancement and protection of the organisations capital increases the commitment by management both in resources to support QA and indirectly support of Lecturers in preparation and delivery of teaching.

The introduction of collaborative processes can deliver tangible benefits. Through the use of technology this collaboration is also a mechanism of building organisational knowledge. To be successful the collaboration must have clear context and there must be an appropriate supporting framework not only in terms of technological structure but also management of the data and the people. All involved must understand what is to be achieved, both for the individual and also the wider benefits that may be met over time.

The introduction of such a collaborative scheme may be useful and relevant to QA functionality as an informal mechanism within a well defined context of continuous improvement.

Through the use of mentors or subject experts to screen and critique contributions a more formalised strategy can be adopted. Rather that the best floating to the surface by widespread acceptance, a clear communication of the value of the contribution can be attached and feedback provided on how other improvements could be included. This in itself contributes to uniformity and consistency an important ingredient delivering QA. This approach is in a more effective than bureaucratic procedures, cumbersome tools and poor communication that could create barriers to QA and organisational improvement.

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Holistic Technology Education

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How do we know when we are teaching technology holistically and why must we do so? Increasingly, more is asked of technology educators to be holistic in the understanding conveyed of technology itself and so in curriculum, assessment framework and modes of delivery. In NSW two good examples of this has been the shift from Engineering Science to Engineering Studies where social/ethical and environmental factors have to be learned while in the new and emerging 2003 Design and Technology 7–10 syllabus 'holistic solutions' are described. This paper advances historical and theoretical research and articulates classroom practice changes for holistic technology education with particular emphasis on offering a grounded frame of reference to guide student learning and understanding in the holistic character of any technological activity and decision event. A First Principles framework for structuring learning for holistic understanding of technologies and processes in design is therefore presented. The case is made for technology to not merely be a 'know how' learning experience, but necessarily and increasingly also a 'know why' learning experience. The latter being essential for innovation and transfer, especially for adapting to and taking decisions towards solutions that may need to accommodate rapid-change settings.

Introduction

A school that adopts curriculum which aims for an holistic understanding of technology, does so because it produces a better educated person, than a curriculum which does not. The notions of holistic education are in themselves not new. Work on the importance of holistic education date back in Western settings to include Pestalozzi (1746–1827), Thoreau 1817–1862, Emerson (1803–1882), Alcott (1799–1888), Dewey (1859–1952), Steiner (1861–1925), Montessori (1870–1952) and more recently (Dufty, Dufty, Australian Curriculum Studies Association & Holistic Education Network 1994) and (Fowlers 1998). Significant work on holistic education maintains its influence on much of contemporary education policies and pedagogy. This is evident in many generic Public School policies and syllabus rationales across curriculum. However, what is relatively new in Australia is that expressions such as 'holistic solutions' are entering design and technology Secondary School syllabi and research (stated or implied). There is a need to understand technology itself holistically in order to teach it with greater knowledge transparency to learners. The object being to develop more informed and capable adapters, designers and developers in our increasingly technologically driven and reliant lives. The new NSW 7–10 courses due for release in 2003 state both generic requirements for content to respond to holistic themes and specific requirements in the new 7–10 Design and Technology course for 'holistic solutions'. It is timely then to examine useful schemas for how education can be structured to assure that learning experiences in technology courses are indeed holistic in presentation, assessment and reporting. What is needed is a robust universal framework.

Often a counter point to holistic themes entering science, technology and innovation/design education has been whether the Australian commercial sector sees any value for school graduates with technology studies to gain core holistic capabilities. There is mounting evidence that this is indeed a desired vocational attribute. Just as reporting is a driver for what schools will focus upon in the delivery of their courses, so to is it an emerging expectation for corporations and organisations to report on 'The Triple Bottom Line': profit/loss, social and environmental balance sheets of effort and expenditure (Elkington 1997; Wand 2002). Increasingly, a desired innovation capability is for employees to naturally be disposed to include social and environmental decision factors in their contribution to enterprise and production.

A schema for holistic technology education

There can be many approaches to understanding the phenomenon we label technology. Presented here is a phenomenological view to offer the reader a deeper grounding into why certain conclusions are drawn and schemas proposed. A schema gives teachers a framework to evaluate just how holistic a lesson or curriculum is. A framework for deciding what educational tasks to include and how to construct the education context and experience for technology and design students.

We begin with the premise that holistic technology education is a necessary, rather than desirable, outcome of schooling. Many teachers would argue that they already teach technology holistically. However, the question we must pose is, how do we know?

Q (1): How do we know we are teaching technologies holistically?

There are many responses teachers give to this question. Typically they range from 'because my students discuss many issues in the design process' to 'I make sure they engage in social and environmental perspectives'. What remains a problem with such responses is that what is holistic is not grounded in some universal reason or coherent context. Why should discussing social and or environmental issues be included for claims of holistic technological learning? I have seen the typical frustration where teachers often conclude that to teach holistically one needs to teach and consider everything. At this point we are lost. Very often, at this point, we find the task to revert to traditional tool skills and task technique is all we can do. We revert to our narrow, but comfortable zones of teaching and learning.

Phenomenology of technology and knowledge development allows a teacher to use a first principles approach to the task based on a universal schema (framework). With first principles a teacher can indeed determine what to include in lessons and evaluations to ensure reasonable holistic coverage of any technical education. Surprisingly, we discover that technology education and practice is not only a how to experience, but significantly a why should experience: the latter is fundamental to the human act of creating new knowledge itself not just using knowledge. Why should capability is important for principles development to foster understanding for the reason why of things in many settings. Holistic education in technology enables transfer of understanding to novel life long encounters, a quality lacking in much of how to training in technology. Both are required. However, we lack details in why should learning in technology.

Knowing and understanding through practical engagement in technology learning

The schema developed here begins with foundations in understanding how technical or material experience, as a phenomenon in human activity, develops a socially defined view of what is knowledge. When can we claim we know something? Dialectics and Praxis are very useful reasoning tools to understand the nature of an answer to this question in the context of technology education. Why is this important? Because there is a good case that 'knowing' and especially 'understanding' occurs best through holistic educational experiences in technology if structured properly compared to other modular or task skill approaches. It is significant in our construction to recognise that theory and practice dichotomies, as currently presented in many schools in technology, is a problem. "Theory is taught through practice and good practice is grounded in good theory" as my education lecturer often drilled. We do not really want to present technology education as separating conceptual tool experience (how to think skills) with physical tool experience (how to do skills). We do not want to see 'theory classes' estranged from 'practical' classes, nor that 'theory' be devalued or even employed as punishment in learning technology and design.

Tool is defined here as anything we give use-value to as a tool. A brick or our fist is a tool if we decide to use it as a club. A car is a tool if we decide to use it as a means to get us from A to B. An engineering algorithm is a tool if we decide to use it to determine a load on a beam. In each case, tools help us do things normally to manipulate a material (whether that material is at a scale we relate to in ordinary experience (like our bodies being moved from A to B, or the nut being crushed with a brick) or extraordinary (abstract) material like information/data material that we manipulate with an algorithm tool.

Curriculum and pedagogy that normally segregates these things raise substantial educational concern and has so for many years. For Dewey, "A divided world, a world whose parts and aspects do not hang together, is at once a sign and a cause of a divided personality. When the splitting up reaches a certain point we call the person insane. A fully integrated personality, on the other hand, exists only when successive experiences are integrated with one another. It can be built up only as a world of related objects is constructed" (John Dewey 1963a, p.44).

Dewey was quite strong on this issue. We need to show how things are interconnected, related to each other to give the technology or technique meaning to students. This prepares the importance for holistic education. A segregated 'education' for Dewey was not an education, "On the intellectual side, the separation of 'mind' from direct occupation with things throws emphasis on things at the expense of relations or connections" and, "[Education] must find universal and not specialised application" (Dewey 1916, p.143). Dewey's work opens clearly one of the differences between technology education and technical training. The latter being geared to vocational specialised short term task skills, the former life long capability. Our concern is technology education that shows us the first principles for teaching technology understanding, for holistic education: the interconnectedness of technologies and techniques. Our next question may therefore be,

Q (2): What exactly should be interconnected in our teaching of technology?

The following builds a case to answer this question. We will build the first principles of what the minimums are for an holistic technology educational experience ideally, expressed in universal terms to permit knowledge transfer in teaching and learning for any technology curriculum. The learner needs to possess life long principles and so capability in technology and design matters.

From dialectics to praxis in technology education: Building understanding and knowledge

The road from Dialectics to Praxis is an interesting one for technology educationists as it addresses twists and turns (even head flips) from knowing as an essentially theoretical (idealistic) process to understanding as a social material (surprisingly Design and Technology like) process. We will begin with Hegel.

George Wilhelm Friedrich Hegel (1770–1831) was a German idealist philosopher born in Stuttgart. He was an idealist because for him thought does not merely correspond to reality; it produces reality (Speake 1979). 'Dialectic' was Hegel's name for the pattern that logical thought must follow. Broadly, he argued that conscious thought proceeds by contradictions. Its process was by triads, where each triad consisted of thesis, antithesis and synthesis. The concept of 'sharp' is not adequately understood without reference to an alternative 'blunt'. Both the thesis 'concept of sharp' and the antithesis 'concept of blunt' define each other and therefore require each other. To see each concept as related, as mutually defining, is their synthesis. At this moment a new level of reasoned understanding is achieved. Put another way, a person starts with a proposition, the thesis; this is consciousness as 'understanding' and proves to be inadequate by itself. The person's mind must therefore generate its alternative, the antithesis. However, this on its own also proves inadequate. The resolution of the opposites, therefore, requires they be taken up into a synthesis. This is the level of conscious thought as reasoned understanding. From here, the whole triadic process may be repeated, the synthesis leading to a 'new thesis' and so on. This is elaborated in Hegel's 'Phenomenology of Mind (1807)' (Vazquez 1977, p.371).

The essence of Hegel's dialectics is 'the grasping of opposites in their unity' (Hegel & Miller 1989): a significant first step in building our First Principles for holistic technology education. This is the immanent goal or 'telos' of Hegel's philosophy. In the words of Suchting, "So, in Hegel, Spirit is essentially rational freedom and the source of the dialectical development; the conflict between the necessity for Spirit to attain its telos and the various successive inadequate conditions for this to occur ...insofar as the system has an immanent telos the development envisaged is one towards reconciliation of conflicts in a larger harmony, hence, the Hegelian dialectics is conservative in its very foundations and not merely as a consequence of certain historical and personal factors" (Suchting 1983, p.181). Important to Hegel's philosophy of dialectics is that 'knowing' for him begins, proceeds and ends at the level of ideas. For him, matter is a product of mind, rather than mind being the highest product of matter.

Feuerbach and Hegelian dialectics: The head flip

Ludwig Andreas Feuerbach (1804–72) was a Bavarian philosopher and theologian. Although he was Hegel's student, much of his work was critical of Hegel's idealism. Broadly, Feuerbach was a materialist in the sense that he distinguished between consciousness of an object and self- consciousness, while at the same time connected the material object with the subject by pointing out that consciousness of the object always reveals some element of self-consciousness, "In the object which he contemplates, man becomes acquainted with himself, consciousness of the objective is the self-consciousness of man" (Vazquez 1977, p.75).

Feuerbach is important because his view of knowing and understanding introduced material objects as a necessary, not merely desirable, condition for knowledge. This revelation further builds our First Principles for holistic technology education. Object experiences are now significant. For Feuerbach humans are sensual beings, not spiritual beings as in the Hegelian sense. "I unconditionally repudiate absolute, immaterial, self-sufficing speculation, that speculation which draws its material from within. ...I found my ideas on materials, which can be appropriated only through the activity of the senses. I do not generate the object from the thought, but the thought from the object" (Matthews, n.d., p.2).

It is often said, Feuerbach inverts Hegel, turns him on his head. For Feuerbach, mind now becomes the highest product of matter rather than matter being a product of mind. In the words of Matthews: "[Feuerbach] focuses on body rather than mind; material rather than spirit; this world rather than the next" (Matthews, n.d., p.2).

The Young Marx on Hegel's idealism and Feuerbach's materialism: Resolving the theory-practice opposing views of knowledge

Karl Marx (1818–83) was regarded by some as more of a social theorist, interested mainly in economics and history than any particular philosophical doctrine. Essentially Marx, too, inverts Hegel's idealism. He extracted and supported Hegel's notion of dialectics, but rejected his idealist approach. He supported Feuerbach's inversion of Hegel, but differed from his concept of materialism in terms of the central notion of human practice, specifically the social dimension of practice (Matthews, n.d., p.2).

Marx rejected Feuerbach's relation between subject (the person) and object (the world) in which the subject is passive and contemplative, restricting himself to receiving or reflecting reality. Here knowledge was simply the result of the actions of objects in the external world and their effects upon the sense organs (Vazquez 1977, p.118). Marx, therefore, identified the strengths and weaknesses of Hegel's idealism in dialectics and Feuerbach's passivity in materialism. Matthews commentates on this, "The chief defect of materialism is at once the strength of idealism - that is, it fails to recognise the significance of the subject [the person] in the act of knowing. The knower plays an active role in the process of knowing the object . . . in materialism we have abstract objects [the world] whose nature can be known independently of the subject; in idealism we have an abstract subject whose knowledge is abstracted from and independent of the objects." (Matthews n.d., p.4)

Marx attempted to resolve the problems of idealism and materialism in his system of historical materialism, the central concept of which is the practical interaction, which must occur between a person and his/her material and social environment. In parallel with Hegel's dialectics, the synthesis of people and their environment, via practical human socially contextualised activity, meant that a new level of awareness was achieved. Both the person and the environment were transformed. "Marx proposes a materialism the central specific notion of which is practice: an active relation between subject and object which changes the character of both and is the basis of the generation of knowledge (in further practice)" (Suchting in Matthews n.d., p.4). This leads to another important concept, which Marx addressed in his system of historical materialism.

Q (3): What is it - and how is it - that a person comes to know something of the world?

Marx argues the answer in at least three areas of practice:

(i) "The world is constituted by the material practice of people. The things that we claim knowledge of have been constituted by human labour" (Matthews n.d., p.4). We do not have an adequate knowledge of a tree until we manipulate it, interact with it and/or experiment with it. Broadly, manipulation, interaction and experimentation are modes of human labour. These modes contrast with 'pure' observation and contemplation of a tree because, for example, experimentation (like science or early proto-typing in design work) synthesises thought and practice (if we do it properly) rather than pursuing either on their own. Manipulation is in fact central to experimentation.

(ii) "The world is perceived through senses that are altered by material practice and extended by material practice" (Matthews n.d.). As a classic historical example, Matthews wrote, "This point is brilliantly illustrated by the opposition to Galileo in terms of his telescope being something that disturbed and deformed proper perception of the moon's surface and of other planets. It was only later with developed material and technological practices that the telescope was regarded as a satisfactory instrument and hence, a satisfactory extension of the senses" (Matthews n.d., p.4).

(iii) "Practice mediates between people and the world not just in a haphazard way ... but in a manner which is related to needs [and aspirations] and their satisfaction" (Matthews n.d., p.5). The individual acts to satisfy either basic/fabricated needs or aspirations. The community acts first to satisfy both personal and social needs; for example, cars for transportation needs, produce for nutritious needs, or radar for weapon guidance needs in war.

Marx departs from Hegel and Feuerbach by the importance he places on actual human labour or practice. He adopts a dialectic methodology in that he contrasts and identifies the inadequacy of 'pure' idealism and 'pure' materialism; he synthesises the two at the new level of historical materialism. Thus, both theory and practice are resolved best according to Marx, via human material practice in social context. Marx's Historical Materialism is essentially the foundation of praxis.

Praxis and technics: Arriving at our first principles of holistic technology education

Praxis and technical activity concerns the effect of instruments and tools in the human transformation experience. The contributions of Don lhde on instrumentation are summarised as key notions to a schema for constructing First Principles in Holistic Technology and Design Education.

Praxis, so far has been concerned with practical human activity and the interaction of mind and matter, or being human and environment. Ihde's work identifies certain features of this interaction when instruments or artefacts mediate it. The human-environment interaction becomes a more complex paradigm when an artefact modifies the experience. The paradigm:

Human---------World
is modified to:
Human-------Artefact/tool------World
Examples include:
(Observer---------Microscope---------Microbe)
(Student-----------Internet Computer -----------World Information)
(Human: Sources of Technique------Artefact: Instruments/Tools-------World: source of materials)
(Human: Socio-economic drivers----------Artefact: Polluting Industries---------World: Ecosystem)

The observer does not gain feedback from the world any more, but from the world via the instrument or tool. That is, Tools and so technologies are values rich in their design use and context active in their cause and effect tendency. However, lhde points out that this modified interaction, although non-neutral, is not necessarily a problem: "My thesis is that any use of technology is non-neutral. However, non-neutrality is not a, prejudicial term because it implies neither that there are inherently 'good' or 'bad' tendencies so much as it implies that there are types of transformation of human experience in the use of technology" (Ihde 1979, p.66). Ihde here acknowledges that technologies need to be understood in context and in purpose of application. That is, different kinds of technologies and tools transform our knowledge differently. Also, same tools and technologies placed in different 'world' settings transform our knowledge differently (including same tools/technologies in different social and/or material environment settings (different 'World' settings).

This is significant as it raises the necessity to understand that both choice and design of tools and choice and design of world settings alter our knowledge. Technologies are context sensitive. Designs of tools and environments are socially and environmentally interdependent. To present technology teaching and learning as value and context neutral is to mis-inform the learner. The ability of the learner to naturally consider social and environmental factors when seeking solutions to design and technical challenges is fundamental to a genuine education in technology. Human, Tool and Environment are the minimum elements to any technological activity. That is, Technology cannot be reduced to less than these three elements and as such, Technology is their product. We therefore may need to understand and teach this relationship explicitly.

What develops as important in lhde's work is the notion that praxis, though necessarily producing artefacts from the human-environment interaction, must increasingly include artefacts as a mediator in the interaction. Hence, the paradigm:

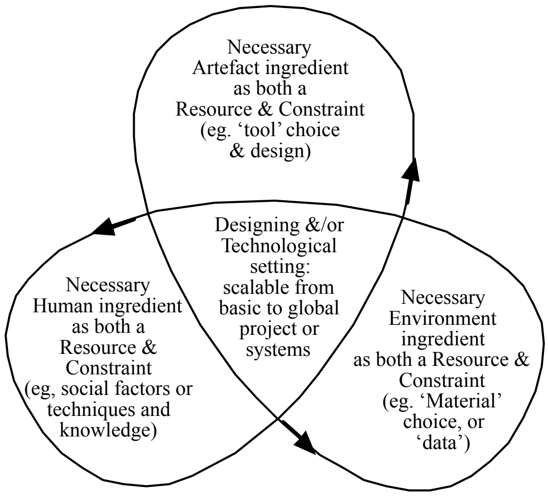

Figure 1

Minimum factors (or ingredients) and their interconnectedness to teach in any design and/or technology lesson or process

We now have a basis for determining the absolute minimum inclusions to what constitutes holistic technology education (Seemann & Talbot 1995). To teach any technical process, to evaluate technologies or to take design decisions that ignore this interdependent triad of human, artefact/tool and environment is indeed not an education in technology. In the theme of Dewey, the interconnectedness of knowledge constitutes a key feature of an education. "Any experience is mis-educative that has the effect of arresting or distorting the growth of further experience . . . Experiences may be so disconnected from one another that, while each is agreeable or even exciting in itself, they are not linked cumulatively to one another ...Each experience may be lively, vivid and 'interesting', and yet their disconnected-ness may artificially generate dispersive, disintegrated, centrifugal habits. The consequence of formation of such habits is inability to control future experience" (John Dewey 1963, p.49).

The First Principles of Holistic Technology Education now appears to have structure. A structure articulated elsewhere as technacy education (Seemann & Talbot 1995). When a teacher instinctively claims that they include social [Human] factors and environmental [material] factors in their lesson on specific technologies [artefact factors], they indeed have good reason to believe their pedagogy is heading towards being holistic. However, this coverage cannot be delivered in a general way. It is important to present the interconnections in explicit details at appropriate levels that make sense. A key requirement is to set assessment tasks for each lesson and unit of work that not only address highly specific links that define the factors in relation to each other, but also their total effect as a design and technology solution. In a very real sense, technology is the product of the triad factors interacting to satisfy a need or an aspiration.

Conclusions: First principles in holistic technology education

Teachers who seek a deep justification for deciding what may constitute the bare minimums of holistic solutions in design and technology may refer to the schema proposed. Technology understanding develops holistically through structured or enabling learning experiences that make explicit in detail the inter-connectedness of human, *tool* and environmental factors where these three factors mutually require and define each other and are acting as both resources and constraints to the applied purpose and its setting. The schema gains strength through historical examination of the nature or phenomenon of technological activity where not only are all three factors defined by each other, but that design and technology experiences, if taught holistically, as interconnected, are a condition to new knowledge creation. Technology education is not merely a know how, but necessarily must be understood and presented in the curriculum to learners as a know why subject. Only then may there be reasoned claims to technology being learned holistically. Peters provides a fitting end. "We would not call a man who was merely well informed an educated man. He must also have some understanding of the reason why of things. The Spartans, for instance, were militarily and morally trained . . . But we would not say that they had received a military or moral education; for they had never been encouraged to probe into the principles underlying their code" (Peters 1971, p.8).

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Constructivist vs Behaviourist Approaches in Design Computing Education: Implications for the Innovation Economy

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This paper presents findings from an action research study over 2 years. The study compared competency standards driven (behaviourist) approaches with discovery (constructivist) approaches in the task of introducing and developing design computing prowess and highly adaptive independent, socially confident, learners. Two first year university student groups were compared. It was found that students exposed to the behaviourist approach initially showed better self confidence in skill tasks but quickly became highly dependent on detailed instruction. They generally displayed relatively little or no initiative to problem solve or meta-learn the software's capability and seemed to have difficulty transferring the use of the software skills to new design tasks without being dependent on new detailed step by step instructions. The constructivist group displayed significant initial anxiety, particularly among most (but not all) mature age students during the first half of their total learning time. However, in the latter stage of the constructivist groups learning period, the vast majority accelerated in their learning to produce advanced use of the software and a high willingness to share their 'discoveries' with peers compared to the first group. They also displayed high confidence to transfer to new design tasks and explore features of the technology independently and socially.

Introduction

Innovation is emerging in Australian technology education settings. This is in part a response to knowledge economy demands world wide. The imperative to develop leaders and flexible people in technologies, science and other areas was initially identified in the foresight study "Matching Science and Technology to Future Needs 2010" (Australian Science and Technology Council & Jack Hilary and Associates 1996) and in the National Innovation Summit recommendations (Innovation Summit Implementation Group 2000). Within this setting it becomes an important task to determine whether the training and development level of new age pre-service technology teachers ought maintain the current post war behaviourist learning tradition that merges trade/industry level training with some 'top up' university level education, or whether the new knowledge and innovation intensive demands of the global economy requires technology pre-service teachers to gain higher order understanding of their profession and be adaptive to a range of new technologies as they develop. There is at the very least a need to establish choice: technical teachers in schools for the trade and manufacturing age and/or skilled professional technology educators who foster understanding among their students in order for them to thrive in the increasingly technologically and globally driven knowledge age. In such shifting settings it is timely to ask how we ought teach Australia's new age technology educators and school students?

The new directions in Australian technology education policies and State courses are towards innovation in, albeit modest, recognition of the emerging knowledge economy. This is not restricted to technology as computer education. Innovation and knowledge economy capability requires new ways of thinking to substantially challenge standardised practices in a range of technologies in order to effect innovation: mostly for wealth creation but also for developing greater social and environmental capital. Nonetheless, information technologies are profile enablers of knowledge sharing and formation in most new networks. The idea is to lever knowledge transfer capability and creativity as the export product rather than necessarily the technology 'thing' itself as the product. The new commodities include ideas, innovations, 'knowledge clusters' and intellectual property. These intangibles are increasingly dominating new world currencies (Desert Knowledge Australia 2002).

One core capability on the increase in preparing people for the innovation and knowledge age is transfer of understanding and fast positive adaptation to respond to or lead rapid change in any setting (Walker 2000, 2002). Adapting to unfamiliar technologies rapidly, positively and sharing discoveries to facilitate knowledge growth in a team is one key capability to be fostered. It is not surprising that it is the simple things that technology educationists must now scrutinise in their work to determine just how well learning approaches in technology promotes desired and often intangibles qualities. Qualities such as knowledge transfer, team capabilities and communication, rapid and creative adaptation and judicious risk taking are much sought after for life long learning, contribution to productivity in innovation and for simply managing personal challenges through life.

Burns (2000) outlines seven stages for conducting formal action research. They include: problem identification, fact finding, critical review of fact finding to create hypotheses, information gathering, establish procedure, implement action and interpreting findings (Burns 2000, p.447). Action Research, however, is very often conducted by teachers 'on their feet'. The objective being to hone in on improved learning outcomes based on adapting teaching approaches, resources and learning settings and monitoring effects on learning. The feedback from the monitoring process is used to further adapt teaching approaches (actions) until a desired learning outcome is observed. Classroom action research follows similar stages to Burns' above. Typically they include:

Stage 1: Problem identification

Stage 2: Plan of action

Stage 3: Information collection

Stage: 4: Interpretation of information

Stage: 5: Planned adaptation to future action. (MMSD, URL accessed Sept. 2002)

This paper summarises the case findings from an action research study of teaching design-computing, at an introductory level, to first year technology teacher students at university.

Problem identification

A fundamental problem in conventional industry standards driven training is that this essentially behaviourist model of teaching appears to be at opposite ends to the new learning goals of the knowledge and innovation economy which seeks intuitive, risk assessing, creative, innovation driven and socially engaging graduates in technologies. Just as the new economy seeks to develop innovators, people who naturally and critically think outside the box, there remains a highly institutionalised technology training tradition and system, typical in vocational instruction, that rewards and demands standard approaches and outcomes: to perform inside the box. Indeed, the more a learning area is expected to meet standard approaches and outcomes, determined by some established body, the less, it is suggested, will there be inclination for teachers to deliver technical education outside the box of conventions. It is not clear whether outcomes based, standardised technology training yields adaptive learners in design computing compared to constructivist approaches.

McInerney and McInerney sum up the typical differences between learning modeled upon behaviourist compared to constructivist approaches. "Constructivist programs emphasise individual initiative and creative thinking in learning. In many behaviourally based programs there is little if any, scope for individual initiative as students are locked into programmed material to which they have to make a controlled (predictable) response" (McInerney & McInerney 1998, p.121).

Design computing education for the innovation economy needs to extend significantly beyond mere technical software or aesthetic skills. Ability to exploit and use new and different software and hardware (different tools for the same task) and to use new learning approaches so as to enhance communication and team sharing are also to be developed. The ability to have confidence to explore and test what a design computing software can do, between demonstrations of milestone techniques, is important for developing teachers in innovation.

The goal for the action research study was accordingly, to trial two different learning and teaching approaches with essentially equivalent cohorts and determine which kind of teaching approach tends to yield not only more confident design CAD students (pre-service technology teachers), but more adaptive, team/share oriented and efficient learners.

Plan of action

A difficulty that may arise in knowledge intensive technologies such a learning new design computing software and hardware, is deciding whether a given 'training standard and perceived technology norm' does more harm than good in fostering adapters and innovators. If we teach technology via one genre (one design computing software and hardware brand to one traditional 'industry' standard way), will the process be inclined to foster adapters, innovators and sharers of knowledge? Will the one genre presentation hinder transfer and innovation?

While performance based approaches and standardised task specific skilling to learning design computing has been the dominant genre in schools, understanding (necessary for transfer and independent adaptive capability) may have been the cost to the perceived benefit. In the standardised content and learning approaches where task performance rather than understanding is the assessed goal, Fosnot (1992) suggests we can expect greater difficulty among students to transfer their skills to new tasks. With learning Mathematics, the example is given where, "Students may be able to perform particular academic activities without really understanding the meaning behind them. It is not unusual to see students skillfully doing mathematical calculations without understanding place-value, and teachers having to re-explain it with the introduction of each new operation because learners never understood it in the first place" (Fosnot 1992).

Table 1

Behaviourist versus constructivist teaching and learning settings for comparing two design computing classes

BEHAVIOURIST CLASS SETTING (GROUP 1)	CONSTRUCTIVIST CLASS SETTING (GROUP 2)
Assessment: determined by signing off competency criteria and standards sheets. One project to construct.	Assessment: determined by five set challenges: 5 project briefs which earned higher grades as students showed increasingly 'inspired' use of discovered software features and techniques. Each brief exposed the learner to a new feature set in the software at its basic level.
Learner choice in set tasks: closed. All learners were required to construct the same identical project.	Learner choice in set tasks: open. Tasks one to four required all to complete common project briefs but rewarded for degree of new software features used to add value to the briefs. The 5th project brief was fully learner determined. Marks were awarded for capacity to both integrate and transfer understanding of software gained in projects 1-4, and for extended and inspired use of discovered software features.
Learning Resources: Each student was required to follow a standardised highly detailed step by step tutorial manual designed specifically to produce the identical project. A basic menu help function was available on screen.	Learning Resources: No manual was issued. A basic menu help function was available on screen.
Learning Style: teacher/standards centred, sequence directed. Dependent learner oriented. Social communication/ collaboration not planned.	Learning Style: learner/discovery centred, sequence explored. Independent learner centred. Social communication collaboration encouraged.
Role of Teacher: To demonstrate and facilitate each step presented in the tutorial manual. To help students follow the tutorial manual. To trouble shoot for and with students the typing errors in the manual.	Role of Teacher: To demonstrate and highlight key mile stone techniques at least twice per class session for each of the 5 set challenges. To facilitate problem solving and guided discovery of software as required.
Role of Learner: To follow detailed sequence and instruction (in tutorial manual) in order to show performance against common and identical task specific skills. To individually get competencies signed off to complete the course.	Role of Learner: To actively explore and discover software features to satisfy and add value to each set project brief. To share discoveries and solutions with others.
Degree of risk taking for learning software: negligible.	Degree of Risk taking for learning software: required and encouraged
Total allocated face to face learning time: 14 weeks, average 2 hrs p/week.	Total allocated face to face learning time: 6 weeks, average 2 hrs p/week.

The plan of action for determining whether the behaviourist or the constructivist learning models yielded more capable design computing technology teachers for the innovation economy is outlined in the following dot point categories:

- Ability to transfer software features to new tasks

- Adaptable
- Risk management
- Discovery learning style
- Collaborative style
- Self directed learning
- General level of confidence
- General level of positive disposition
- Overall length of time to achieve.

The key question of this action research study was, 'does one approach to teaching design computing yield observable learning benefits to another where innovation, knowledge sharing, risk taking, transfer and independent learning are desired outcomes?'

Common core elements or constants were established within the feasible bounds of a core design computing study unit in a first year university technology teacher education degree. This enabled the main variation between two student cohorts to be the teaching approach used. These common core elements included:

- Same cohort year level (prior learning level)
- Similar gender balance and age ranges (i.e. distribution)
- Same design computing software and hardware
- Same Instructor/lecturer.

Being an Action Research study in a classroom setting, there is an acknowledgement that the findings may be cohort specific rather than universal.

Information collection

Overall constructivist approaches appeared to have produced better retention and enthusiasm for the Design Computing software. It was found that students exposed to the behaviourist approach initially showed better self confidence in skill tasks but quickly became highly dependent on detailed instruction. They tended to display little or no initiative to problem solve or meta-learn the software's capability and seemed to have difficulty transferring the use of the software to new situations without being dependent on new detailed step by step instructions. When a typing error existed typically students either did not notice the error until later in the manual sequence or on discovering the error or omission, expressed great anxiety in their ability to proceed. In terms of risk taking, the behaviourist group had typically few students who would spend in-class time exploring and discovering software features for fear of "breaking it" and for fear of "wasting time" away from following the manual. Students who had prior vocational level training or experience in different "design computing software" had great difficulty in learning the given software. Typically they asked for where certain features were and if these were not in the same place or even if done more efficiently in the given software, the fact that it was not what they had been drilled in to learn raised complaints about the software's value. It appeared that students in the behaviourist group who had no former exposure to similar or same design computing software and hardware, learned the software a little faster and better than those who had such a background. Prior learning, in the context of skills transfer, was generally a negative attribute where the prior learning experiences were likely to have been behaviourist oriented and centred on standardised instruction.

The behaviorist group generally felt highly focused on their own assessment task and rarely took time out to communicate and collaborate with peers. There was a substantially better overall learning outcome in the amount of software skills developed to the time allocated among the constructivist group compared to the behaviourist group.

The constructivist group displayed significant initial anxiety, particularly among most (but not all) mature age students during the first half of their total learning time. One student in this group with a long history and formal VET level training in Design Computing became very distressed and their frustration in not being able to transfer CAD skills to different software and hardware settings and never adequately achieved the learning briefs in some cases. In contrast, there were several younger students who had declared they have never used design computing software before, but accelerated in their learning to produce high value work in a very short period of time, far exceeding the seasoned CAD user in their ability to explore the software and adapt without cries for step by step manuals as aids. This suggests that extensive prior learning from industry training and experience could be an undesirable pre-requisite for innovation-oriented new age technology teacher courses. The complete opposite to the fashion in many States to reinforce such backgrounds as desirable. In the latter stage of the constructivist groups learning period, the vast majority accelerated in their learning to produce advanced use of the software and a high willingness to share their 'discoveries' about the software to peers compared to the first group. They also displayed high confidence to transfer to new situational tasks and explore features of the technology independently and socially.

In summary, it was found that compared to the behaviourist group, the constructivist group generally:

- showed more ability to understand software features by transferring their use to new task situations
- adapted to problems more willingly than blaming the software
- took risks to 'see what happens' rather than stop and seek teacher or 'text book' instructions
- displayed more evidence of new software discoveries in advance of desired minimal software tools to be learned
- demonstrated a higher desire to spend time to share new software features discovered with others rather than more time focused on meeting content task goals
- were substantially more self directed in exploring new use of the software beyond course time, rather than not showing post course interest to further use the software

- demonstrated a higher level of confidence and collaboration to exploit software features and achieve new effects
- displayed positive disposition towards problems as challenges in learning rather than negative expressions of software/hardware inadequacies
- developed a greater range of design computing and adaptive software capabilities in a shorter overall time.

Interpretation of information

Often the most argued position against a constructivist and discovery oriented approach to learning is the despair among both teachers and students in the first stages of learning. Here a high desire occurs for step-by-step instruction for skill establishment. If students and teachers can ride through the initial phase of 'anxiety dips' in a constructivist approach to learning, it is suggested that their meta learning and social learning prowess will far exceed that of the behaviourist group and in better overall learning times. The study suggests that if independent and adaptive graduates in new technologies are desirable for the knowledge and ideas economy, then constructivist and discovery approaches may yield far better results than behaviourist and conventional industry competency training approaches.

Planned adaptation to future action

The action research results appeared substantially in favour of the constructivist model of learning for developing innovation oriented technology teachers. In order to verify and improve this finding, the Action Research continued into a third year with the following modifications.

Students were forewarned to 'expect' feeling anxious in the early stages of their learning. This was described as anticipating 'anxiety dips' while they were doing a lot of testing and trialing to get project tasks completed. This appears to have improved the way students manage their learning (greater confidence less blame) compared to the first time the constructivist approach was delivered.

A shared set of reference manuals are planned to be available in the computer lab to facilitate those students struggling to learn independently such as mature age students with a developed background in, for example, conventional CAD. Clearly, a background in an industry course does not appear to be a sufficient basis to issue credit in a constructivist learning program if the objective is to develop independent learners and adaptive graduates.

Conclusions

Design computing skills for developing innovators appears to be significantly enhanced through constructivist approaches rather than behaviourist ones, through challenged and facilitated discovery of software characteristics and features rather than through dependence on reporting to standardised content and through promotion of guided discovery learning as well as team and social learning. Such constructivist oriented pedagogy in design computing, it is suggested, not only develops significantly more independent learners in the software, but also more adaptable and socially confident ones capable of knowledge transfer, exploiting new or unfamiliar technologies and tasks, risk assessment oriented learners and faster all up learning time in software capabilities.

It can be concluded that to produce technology teachers who themselves value developing learners for the knowledge and innovation economy, those teachers are better prepared if nurtured through constructivist experiences in design computing rather than behaviourist oriented learning experiences where typically standardised content and detailed task skills are emphasised. Accordingly, it is suggested that technology teacher education for developing innovators should emphasise the professional higher order end of technology learning which encourages up stream knowledge discovery and knowledge maker rather than the operative end of learning designed to produce standardised approaches reporting to specific tasks and content: the downstream end of the knowledge user.

In the knowledge and innovation economy where being first, adaptive and fast in new ways of thinking, it is argued that preferred teaching and learning in such aspects as design computing is better oriented to the upstream source where teacher and student engage in knowledge development. Where the outcome is to task skill people for the regular maintenance of production, perhaps the downstream approach is more suitable as the standardised knowledge user. The former, however, appears to be significantly better suited for the new knowledge economy and lifestyle demands.

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Information Technology Students' Changes in Personal Constructs About Technological Activity

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The study described in this paper is an interpretive embedded case study which presents changes in personal constructs about technological activity held by a group of first year undergraduate students enrolled in a design studio course within an information technology degree program. Data sources included a repertory grid, interviews, video and audio recordings of classroom interactions, field notes of classroom observations, and artefacts such as handouts and other course materials. The repertory grid, used at the beginning and end of the one semester course, is examined in conjunction with other data sources to describe changes in students' views about technological processes involved in engaging in design projects within an information technology context. Using the case study of one of the students, links between her changed views and the structures and implementation of the course are made. Implications for incorporating explicit teaching about technological and design processes within information technology degree programs are discussed.

Introduction

The study reported in this paper investigated the developing understandings of technology and design held by a group of first year undergraduate students enrolled in an information technology degree program. The study extended earlier studies undertaken in primary school settings by investigating the learning of the undergraduate students aiming to become competent practitioners within a specific professional technological context, namely, information technology.

Technology in its many forms (e.g. as part of general education, and as part of more specialised courses at TAFE and university, such as engineering and information technology) is a means through which learners, through iterative, cyclical and recursive interactions develop their knowledge, understandings and skills of the processes of investigating, ideating, producing and evaluating, as they create products and processes to meet human needs (QSCC 2002). The importance of strengthening the design component within information technology education at tertiary education levels, particularly in software engineering, is recognition that the processes of technology and design are not just relevant for general education. There is a growing awareness of the importance of the designer aspects of a software engineer's role in developing computer environments that acknowledge the interconnection between humans and computers (Winograd, Bennett, Young & Hartfield 1996).

Exploration and investigation of design and design processes have been undertaken extensively in the past as educators in the fields of, for example, architecture (e.g. Schön 1987) and engineering (e.g. Fordyce 1992), have sought to understand more about learning and teaching design. Various approaches have been used to gather data and studies have repeatedly confirmed that design processes are not linear sets of steps that one takes to solve problems (Matchett as cited in Jones 1992), but a complex interplay amongst various elements within a context or situation, such as the designer/s themselves, the materials, the overall purpose and problem, the 'client', knowledge, skills, tools, theories, and including, in educational settings, the teacher, too (Roth 1998). To gain a better understanding of this complex interplay, researchers have used various means in their attempts to reveal what happens when a designer engages in designerly thinking and action. Think aloud protocols (e.g. Christiaans & Dorst 1992) have been used, as have diagrammatic representations of group interactions (McRobbie Stein & Ginns 2001) to acknowledge that identifying what happens during design thinking requires a richer data source than can be produced by verbal data alone (Middleton 2000). Yet others have tried to identify and name types of knowledge types drawn upon during design activity (Faulkner 1994) and the cognitive structures created and utilised (Oxman 1999). Including a design perspective within the activities engaged in by information technologists has been regarded as being increasingly important in recent years (Winograd et al 1996). While no one answer has emerged from these investigations, where design education is concerned, the continuing existence of these types of studies suggest strongly that there is an acceptance of the need to make design processes explicit within learning environments and to move away from the "black box" idea of design, and the "learning by osmosis" approach.

The aim of this study was to investigate the general understandings about technology and technological practice (including design) held by a group of undergraduate information technology students, and how those understandings developed over the period of one semester as they engaged in a studio course as part of their information technology degree program. Specifically, the study intended to investigate changes in students' understandings of design during the studio course and draw implications for the place of design in student education in information technology contexts.

Design and methods

An interpretive research approach (Erickson 1998) framed the study, because it was important for the researcher to understand the perspectives of the participants. The participants were drawn from a cohort of approximately 60 university students enrolled in a first year, first semester, design studio course that was one subject within a three year information technology degree program. Twenty students volunteered to be part of a focus group to be monitored more closely.

The studio course and degree program

The information technology program focussed upon the development of skills to implement highly sophisticated, networked, and distributed computer-based information environments. The aim of the program was to develop students' understanding in three core areas: design, with particular reference to the design of virtual (i.e. computer-based) artefacts; information technology; and organisational structure and communication. Each semester included a studio project as the major focus with a surrounding family of courses designed to complement and reinforce the studio work (Course materials). The course, which was the focus of this research study, was the first studio course for the whole of the program. It aimed to introduce the idea of the design of information environments to the students and provide structures and support for them as they undertook a number of design projects and design exercises (e.g. designing a web site and a poster, both about the information technology course itself).

Data sources and analysis

The multiple data sources included: audio recordings of interviews; student responses to repertory grid statements about design activity (described below); video recordings of tutorials and workshops; audio recordings of lectures and short "on the run" interviews with students and tutors during or immediately after classroom events; field notes of classroom observations made by the researcher; artefacts, such as handouts and notes provided to students during lectures, tutorials and workshops; students' reflective diaries, containing their written thoughts, ideas, sketches, drawings and other notes made as they worked on their design activities and reflected on their learning.

The repertory grid

At the beginning and end of semester, all students in the cohort completed the repertory grid, concerned with ascertaining students' perspectives on the nature of design activity and processes. The repertory grid had been constructed prior to this study, through work undertaken in an investigation into pre-service teacher education students' perceptions of technology (McRobbie Ginns & Stein 2000). The grid was made up of a set of constructs, shown in Table 1 (terms and phrases commonly used by students about technology and the conduct of technology investigations within formal learning environments), and a set of elements, shown in Table 2 (typical situations or experiences in the conduct of a technological investigation). Students rated their perceptions for each element, for each construct, in turn, on a seven point rating scale situated between pole positions (see example in Table 1). For example, the first Element was Selection of a problem for investigation by you, and students rated each of the constructs as they pertained to this element. They then rated the same constructs on the next element, and so on. Table 1 shows the grid for Element 7 filled in by one of the students, Tricia (**bold** response was from the beginning of the semester; the response in *italics* was from the end of the semester; ***bold and italics*** indicates no change).

The repertory grid responses from the beginning of the semester were reviewed on an individual basis, to gain a sense of the breadth of the understandings about design activity held by each student. The responses gathered at the end of the semester were compared with the first responses, again on an individual basis, to detect changes in ratings. Particular attention was paid to the responses where the student had made a change of more than two pole positions.

Table 1

Sample repertory grid chart – Tricia

The following statement is a brief description of a typical experience you, as a participant, might have while conducting a design and technology project: **ELEMENT #7: Modification of original models may be required.**

Rate this experience on the scale of 1 to 7 below for the following constructs, or terms and phrases, you may use when describing the steps in conducting a design and technology project. CIRCLE YOUR RESPONSE.

	CONSTRUCT	SCALE		CONSTRUCT
a.	I will be creating my own ideas	**1** <u>2</u> 3 4 5 6 7	a.	I will be just following directions
b.	I will find this process challenging, problematic, troublesome	1 2 3 <u>4</u> 5 **6** 7	b.	It will be easy, simple
c.	I will have some idea beforehand about the result	1 <u>2</u> 3 4 **5** 6 7	c.	I will have no idea what will result
d.	I will using imagination or spontaneous ideas	1 **<u>2</u>** 3 4 5 6 7	d.	It will be recipe-like prescriptive work
e.	It will be a frustrating experience	1 2 3 <u>4</u> 5 **6** 7	e.	It will be a satisfying experience
f.	I will be doing real technology	1 2 3 <u>4</u> **5** 6 7	f.	I will be doing things unrelated to technology
g.	There will be theoretical considerations	1 2 3 <u>4</u> **5** 6 7	g.	There will be practical considerations
h.	I expect to use a specific method to solve the problem	1 2 3 <u>4</u> 5 6 **7**	h.	I expect to not using any particular method
i.	The experience will be process oriented	1 2 <u>3</u> 4 **5** 6 7	i.	The experience will be product oriented
j.	I expect group based/collaborative discussion	1 **2** <u>3</u> 4 5 6 7	j.	I expect individually based work

Table 2

Repertory grid - Elements

LABEL	DESCRIPTOR	LABEL	DESCRIPTOR
1.	Selection of a problem for investigation by you	6.	Modification of original plans may be required
2.	Identifying and exploring factors which may affect the outcome of the project	7.	Modification of original models may be required
3.	Decisions about resources, materials, equipment, etc may be needed	8.	Appraisal of the process and product may be required
4.	Drawing of plans and diagrams may be involved	9.	Solving of problems may be needed
5.	Building models and testing them may be required		

The interviews

The students who volunteered to form the focus group for the study were interviewed individually, once at the start of the semester and again at the end. During the first interview, questions were asked to ascertain the students' perceptions of technology. Together with their responses from the repertory grid, a determination was made about whether the students held a limited or broad understanding of technology and technological activity. Particular attention was paid to how the students expressed their understanding of technological activity, specifically, their expressed understanding about design and design processes.

During the second interview, the 17 focus group students (3 withdrew from the course during the semester) were asked to summarise their experiences and to describe their knowledge development. Each student was asked to respond to the repertory grid statements for a second time. Students were invited to comment on why they responded as they did and particularly when they made different responses to the ones they made at the start of the semester. Finally, assertions that were emerging from the study were presented to students for their comment.

All interviews were recorded on audiotape and transcribed as soon as possible after the interviews were held. The transcripts were returned to the interviewees for checking. At the end of the study, case studies of focus group students were assembled. The case studies described students' knowledge (concept and process) development, particularly as it related to design and design activity, and made links with the learning opportunities provided through the studio course implementation.

Results and discussion

The results of the aggregated changes for the focus group pre-test to post test are presented. This is followed by examples of changes in personal constructs for one student, Tricia (pseudonym), drawing on other data sources to illustrate and elaborate on some of those changes.

Table 3

Frequency of element-construct combinations changes of 2 or more units on the 7 point scale from pre-test to post test, and the no. students who changed (n=17)

			ELEMENTS									
Constructs	(SD)	Mean Change	1	2	3	4	5	6	7	8	9	Total Changes
a	0.37	0.47	7	6	8	6	6	6	5	*4*	5	53
b	0.37	0.91	10	6	6	7	8	7	8	9	5	66
c	0.27	0.76	8	8	6	7	7	5	7	10	8	66
d	0.35	0.67	6	7	9	9	5	6	5	6	8	61
e	0.30	1.56	6	8	7	8	8	8	6	6	8	65
f	0.40	0.74	6	5	5	6	6	7	6	*4*	5	50
g	0.28	1.05	7	9	6	6	8	7	6	8	10	67
h	0.43	0.94	7	7	8	7	7	6	6	7	6	61
i	0.34	0.80	*4*	8	6	6	6	7	7	7	7	58
j	0.28	-0.04	11	6	8	6	6	5	5	*4*	7	58
Total Changes			72	70	69	68	67	64	61	65	69	
Students Changing (n=17)			17	16	15	15	14	15	13	15	14	

Aggregated focus group results on the repertory grid instrument

Table 3 reports the aggregated changes in personal construct responses for the focus group of 17 students. Table 3 shows that 86 of the 90 combinations, 5 or more students (~20%) recorded pre-test post-test changes of two or more units on the seven point scale of the repertory grid.

The highest frequency changes were recorded for 1j, 1b, 8c and 9g. The lowest frequency changes were for 1i, 8f and 8j. Summing these frequencies over elements across constructs shows that most changes were observed as associated with Elements 1, 2, 3 and 9. Element 7 recorded the lowest frequency of change in ratings, with 13 of the 17 students making a change. As has been reported elsewhere (Stein Docherty & Hannam 2001), in this study there was little evidence to show that students and teachers in this course put emphasis upon appraisal and testing procedures.

An individual case study – Tricia

As a result of engagement in the studio course, Tricia made 10 pre-post changes of at least two units over nine elements. While many aspects of the changes indicated by the data could be presented and discussed, two particular aspects related to Tricia's views of technology and the emphasis she placed upon the development of technical skills are presented. These two aspects have been chosen for discussion, as they highlight experiences of most of the students across the focus group.

At the start of the study, Tricia expressed a number of views about technology, but they were not comprehensive or elaborated. For example, she was unable to provide a succinct summary of what was involved in technological activity. Rather, she concentrated upon explaining the need to think about and acknowledge future users of whatever was being designed, and the collaborative work of designers. For example:

> You have to create with other people when you're designing a web-page…You have to think of people who are going to use it, people who might be colour blind, older people…So when you're actually designing, you've got to take into account just about every range of person you can possibly think of. (Tricia, Interview 1)

Tricia continued this theme of highlighting the role of people within the technology process by explaining that design activity in information technology would be a shared task. She stated that in the information technology industry, collaborative approaches to working were normal ways of operating.

> The IT industry is based on team-work.…You have to be able to communicate with everyone on every different level...and also work with people that you might have conflicts with…So I find that implementing a lot of group work [in this course] is really good…because when you go out into the real world, it will help you work as a team. (Tricia, interview 1)

At the end of the semester, Tricia's experiences of the course, had led her to be able to express how the individual designer (rather than a group) played a larger role than she had predicted earlier, at least in order to survive the kind of technological activity that formed part of the studio course. It was indicated through her repertory grid responses that her role as learner and designer became important to her, as her experiences with other students turned out to be less than she had expected. Indications of this change were shown in the alterations she made to construct j on Elements 1 (from 3 to 6) and 6 (from 2 to 6).

During her second interview, there were indications as to why Tricia may have made these changes. Tricia revealed the difficulties she had experienced across the semester with learning how to operate various software packages. She had expected that members of the project group to which she belonged would support her through her learning, and together the group members would share their expertise. However, her expectations about group support had not been met and she attributed this to limited time and to the fact that the students did not know each other very well–"Maybe as the year goes on, maybe people might get to know people better…With the groups you don't get time to think about a process… people just nominate what they're good at and people are just left stranded" (Tricia, interview 2). Field notes recorded by researchers indicated that the practical sessions were, essentially, quick demonstrations of some of the major functions of the packages with little attention being paid to individual needs, even though tutors moved around the room ready to answer individual questions and to provide extra help (Field notes, video). As a consequence, some students, like Tricia, resorted to finding out how to use the packages through books or through the tutorials provided with the software packages. "That's where I actually learned how to use [*Photoshop*], not by the class notes or going to the tutorial sessions, actually by doing the tutorial that came with the program" (Tricia, interview 2). Tricia found that she was unsure of where to concentrate her efforts. For example, she spent more time learning about the software packages than working on the overall task that she had to achieve (designing the web page or the poster). She was confused about the knowledge that she needed to concentrate upon in order to meet the needs of the task set. This can be supported through the overall tally of changes that Tricia made to the repertory grid responses. It could be that she only made 10 changes across the 90 combinations because she was generally unsure about the processes of design – "I spent hours and hours on *Photoshop*, it's certainly not an easy program to learn" (Tricia, interview 2).

During the second interview, Tricia was still unable to provide a comprehensive description of what was involved in design processes. She tended only to describe her direct experiences with the artefacts that she developed and was not able to talk about design and design processes on a more principled level. Of course, this could also be taken to mean that she was not able to express her knowledge in appropriate terms. However, the learning journals from across the focus group students, too, revealed very few instances where students described principled knowledge about design practice. This could be attributed to the students' limited ability to write reflectively. All the same, classroom observations indicated few, if any instances, where students were encouraged to reflect on design practices from a principled perspective. While there were many activities that encouraged creative thinking and the use and development of skills such as sketching, and examining and critiquing artefacts (Video, field notes), there were very limited opportunities for students to draw commonalities from the variety of experiences, and to compare and contrast them on a principled, rather than artefactual, level. The conclusion drawn by students in the focus group was that there was need in the course for more explicitness about design and design activity – "[The course needs] not really more structure…maybe a little more direction, maybe to get people to really start looking outside the square that they live in" (Tricia, interview 2).

Learning involves the ability to be able to differentiate among various elements within an experience and to draw from the experience greater or more developed conceptualisations. While planning for breadth of experience within a variety of situations is surely necessary, differences and variations between situations also need to be determined. Then the relevance and importance of the various elements can be made clear (Marton & Pang 1999). In the studio course, the students were given the opportunity to explore the many elements of a design situation, but because they were novices, many of them were unsure about what was more or less important to achieve the tasks. It could be said that in this course, there were students who may have benefited from being guided through thinking about the explicit features of the context and situation more closely. As was found with other novices (e.g. Crismond 2001), more guidance/structure/direction at this early stage of their learning may have provided more of an opportunity for them to sort out which features of design and design activity to emphasise and which to de-emphasise, and how to integrate design principles of information technology environments as they concentrated on the context of the particular project they were working on.

Across the focus group, Element 7 was the one with the least number of pre-post test changes (61) made by the least number of students (13) (see Table 3). However, it was to Element 7 that Tricia made most changes across her repertory grid responses: construct b– 6 to 4; c– 5 to 2; and d– 6 to 4. These changes suggest that the realities of doing a project herself had made her realise the need for individuals to have to work at balancing the efforts to develop and apply processes with the use of imagination, creativity and open-endedness. This can be supported when another change to element 7 made by Tricia is considered. She made a change in construct h, from 7 to 4. While she advocated in her interviews that no specific method was used–"It's not like a recipe where you say well you're going to start up here, you have to do your background first and you … have to plan your images. There's no set method" (Tricia, Interview 2) – she also indicated that there was some sort of method that she was employing:

> Basically I read the criteria sheet and it just said to investigate and look into what [the course] meant to you, so then…I did idea generation…and came up with my words and thought well ok now how am I going to put this on here and them I took little bits of context from each [course] subject and popped them onto the poster. (Tricia, Interview 2)

Her change from 7 to 4 on this construct, as well as the other changes she made to the constructs in Element 7, seemed to indicate that she was starting to refine her understandings of what having or not having particular methods for modification of original models might mean for her. However, she was not able to explain her thoughts succinctly and comprehensively. The seemingly overemphasised concentration on developing technical skills over design process skills, may have been the reason why Tricia tended to believe that it was the products of design activities, rather than the drawing together of a variety of knowledges, skills, attributes (design processes), that were a major focal point of the studio course. This may have been because the students, like Tricia, with limited prior knowledge of the software, for example, expended much time and energy on learning the type of new knowledge and skills associated with learning about how to manage and use a piece of software to produce particular outcomes. Their emphasis was on getting to know and understand tools and to produce the perfect artefact, rather than engaging with and reflecting upon the processes of design–"It was basically the product [orientation], because that's what I assumed that studio would be; learning new software applications and implementing them, so it was …very product-oriented" (Tricia, interview 2). This problem of overemphasis on products, rather than a balanced consideration of product and process in technological design activities, has been noticed to occur in school classroom situations too (McCormick & Davidson 1996). When there is an emphasis on making and/or using technical devices and tools, design process and problem solving skills can be neglected by the students in technological problem solving activities.

Implications and conclusion

The repertory grid data, supported by other data sources, indicated strongly that Tricia, as representative of the focus group of students, expressed unclear ideas about technology at the start of the course, but had begun to refine her ideas by the end. However, her descriptions remained sketchy and were directly related to her experiences of working with other students. She was unclear about which aspects of design knowledge to focus upon and expended much energy on developing technical skills over the more important understandings of understanding information technology contexts. This study implies that there is need for the developers and implementers of the studio course to include in their teaching explicit foundations about design and design activity. While there is no one way of designing, and it was indeed the intention of this course to emphasise this point, students need some firm foundations upon which to rest their growing knowledge and to make links with their prior understandings. The development of principles about design and designing can be a way to help them develop these important foundations to assist them as their learning continues throughout the program. Tricia and her co-students were novices, and like novices in other technology education contexts will benefit from guided scaffolded activities (Crismond 2001), which help them to identify the relevance and importance of the various knowledge and skill elements that make up an information technology activity/experience (Marton & Pang 1999). This is particularly important if the stated goals of the studio course, which include a particular focus on the human side of computers, are to be met, and if a major criticism of computer-based artefacts that often the purpose of the product or the centrality of the user/audience/client is lost during the development (Winograd et al 1996) is to be addressed.

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An Integrated Approach to Describing Technology Education Classrooms

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In past studies, the authors have proposed a number of theoretical frameworks/models to describe, analyse and interpret technology classrooms. In this paper, the authors contemplate the frameworks/models in an integrated way, as a means to unravel the many complexities evident within technology classrooms. The aim of interpretivist studies is described and the ultimate goal of understanding the various knowledges in operation within technology classrooms is explored. An outcome from this reflective analysis is the production of an integrated model for describing technology education in the classroom as a whole. The model is an amalgamation of a number of participant perspectives and knowledges.

Introduction

In our past studies of classroom interactions we have developed a number of theoretical models/frameworks to help explain our developing conceptualisations about aspects of technology and technology education. Our studies have been into the learning and teaching of technology in primary classrooms, professional development of pre-service and in-service teachers in technology and technology education, design processes used by teachers and students; concepts and processes of design and technology; views and understandings of technology and technology education; and changing understandings of how teaching and classroom interactions can limit and facilitate learning. In this paper we reflect upon our research experience in a number of different classroom contexts and consider the need in technology education research to be able to attend to the complex interrelationships and interdependencies of elements that make up a classroom/learning interaction.

When investigating classrooms a variety of sources of data are collected. Much of the analysis of the data takes place after the classroom event, as researchers and participants review and reflect upon happenings and draw meanings from them. Synthesis of meanings occurs in the light of any conceptual models of understanding framing the interpreters' perspectives, emerging from the intentions of the study and interests of the researchers. In the immediacy and complexity of classroom events some issues become evident during the observation phase and further issues reveal themselves upon reflection. Keeping track of the many facets of a classroom interaction is a large organisational and management task that has to be orchestrated and thoroughly planned beforehand. Classroom researchers are at once, running and monitoring data collection instruments and equipment, asking questions of students and teachers (and indeed themselves!), making field notes, providing guidance at times to students or conversing with teachers, while at the same time attempting to draw some meaning from the experience in the light of the research questions and intentions. Specific research questions may be more about one element of a classroom interaction than another (e.g. the study being undertaken may be about the way the teacher is using a particular technology task, so a focus for attention is upon that particular task). However, classroom interactions cannot be broken up to be examined in separate parts without acknowledging and taking into account the interdependence of the many elements that make up a classroom. Thus, whatever the research intention or question, a researcher needs to be alert to and aware of the many elements of a classroom and be able to sort through that which is more or less significant at any particular time.

In our investigations we have recognised the complexities within classrooms and have strived to make sense of what we have experienced. To assist our analysis of data and conceptualisation of what happens in technology education as a result of our studies so far, the following models and frameworks to describe various aspects of technology education classrooms have emerged from our work.

A socio-cultural model of technology

The socio-cultural model of technology (Stein, McRobbie & Ginns 2001) described technology as being situated within and emerging from social contexts. Specific technology activities were described as being purposeful and relevant to individuals and groups, and the nature of those activities as being developed and enacted by practitioners within communities utilising various knowledges, skills, language refined for utilisation within that community, but being related to the knowledge, skills and language of other communities. All these activities take place within a broader social world/context and can influence, and be influenced by, that broader context. This model focussed upon teacher conceptualisation of the technology context and drew upon research beyond our classroom study to create a framework for teacher thought and planning.

A model to describe technology units of work

This model (Stein et al 2001) focussed upon the sequencing and development of units of work. Three main stages were described in this model to support and scaffold students through their developing understandings of technology, of technology contexts and technology problem solving. Elements of technology concept, process and discourse knowledge were highlighted as important elements to feature in explicit ways in teaching technology units of work. The contextual aspects of technology activity were also an important feature. The focus of this model was the translation of an appropriate conceptualisation of the technology context into a framework (e.g. the socio-cultural model described above) to guide teacher planning for sequenced learning experiences for students.

Designerly thinking knowledge types

Our aims to describe the knowledge drawn upon, utilised and generated in technology classrooms has been facilitated in our past studies by the use of Faulkner's (1994) knowledge types, together with additional features as suggested by Roth (1998) and Stein (1999). The knowledge types match readily with curriculum frameworks and syllabi for technology education (e.g. the syllabus in Queensland (QSCC 2002); (Ginns, McRobbie & Stein 2000). This framework focussed upon identifying the technology concepts and processes, to make them explicit elements within teaching and learning situations. We have argued that teachers should make concepts and processes explicit in order to be able to identify student learning needs and plan for future student learning (McRobbie, Ginns & Stein 2000; McRobbie, Stein & Ginns 2001; Stein, McRobbie & Ginns 2002a b). Crismond (2001), in his study of naïve, novice and expert designers, noted that in the design activity of all the groups he studied, non-expert designers in particular, tended not to recognise the emergence of concept and process knowledge without scaffolded assistance through directed (teacher) questioning.

These three models/frameworks encapsulate many of the thrusts of our investigations in technology classrooms. While in specific terms we have examined curriculum planning, teaching, assessing, teacher and student understandings, learning and development as well as technology processes and concepts, globally, we have been researching teacher (pre-service and in-service) and student knowledge of technology and technology education to explore what counts as knowledge in the field, what teachers and students count as knowledge in the field, and how that knowledge is developed and supported.

While these models/frameworks have been useful, providing assistance in helping us to sort through the masses of data that have been collected in classrooms, each focusses upon a particular aspect of a classroom and does not give a "full story" by itself. We regard the models/frameworks as complementary and interdependent. However, we wish to explore further the possibilities for drawing together these ideas to develop a tool (framework/model/guiding structure) to take a more comprehensive and macro view for classroom investigations. The purpose of this paper therefore, is to consider the integration of the outcomes of our studies in terms of the models and frameworks related to technology and technology education, in the light of our research approach, as a way of enhancing future studies in this area.

Our research approach

In our studies, an interpretive design (Erickson 1998) was adopted each time. In an interpretivist approach the researcher views himself or herself as a participant observer, aiming to understand the human meaning in the social life being lived (Erickson 1998). An interpretivist believes that the human meaning within the complex world of lived experience can be interpreted from the point of view of those who live it (Schwandt 1994). Meanings embodied in action and word within social settings are sought and the researcher's task is to make clear the process of meaning construction (Schwandt 1994). Ultimately, any report will be a reading in itself, the interpreter's interpretation, or in other words, "the inquirer's construction of the constructions of the actors [he or she] studies" (Schwandt 1994, p.118). We have also integrated a collaborative action research approach (Oja & Smulyan 1989; Grundy 1995) in which teachers and researchers work together on all aspects of the research project for mutual benefit.

An assumption of constructivist interpretivism is that in order for meanings to be understood, the observed (the subject/s under investigation) and the observer (the researcher/evaluator seeking to understand) need to be linked in an interactive relationship. It is through this relationship and the interchanges that occur within it, that different constructions or voices (Lincoln & Denzin 1994) are given the opportunity to come to light and be exposed in a variety of ways. Together, the observer and the observed generate a consensual construction about the experiences of the observed (Guba & Lincoln 1994). Processes used to generate this consensus involve the comparison and contrast through the testing of perspectives by discussion and logical disputation of various and varying perceptions and ideas. In essence, the relationship is hermeneutical and dialectical (Guba & Lincoln 1989) and is facilitated as a variety of data sources are collected and due concern given to the issues of providing opportunities and ways of representing the voices of the participants (Lincoln & Denzin 1994). Data sources varied across the studies we have conducted, but predominantly included: individual and group teacher and student interviews (the transcriptions of the interviews were member-checked where appropriate); video recordings of classrooms events and focus group activities; artefacts, such as student work, teacher writing, curriculum plans; survey instruments for example, Rennie and Jarvis' (1994) questionnaire and a repertory grid (McRobbie, Ginns & Stein 2000); field notes made by researchers of classroom observations and their reflections.

The specific aims of our studies varied. However, generally, we have been interested in investigating the beliefs and practices of teachers and the learning of their students during the implementation of technology education units of work. In most cases, planned or explicit technology education had not been experienced before by the teachers or students we worked with. It is only recently that a formal syllabus (QSCC 2002) has been introduced in schools in Queensland. In order to understand how the students made sense of the classroom experiences and the teachers went about developing and implementing units of work in technology, and to gain insights into the reasons behind decisions, modes of operation and how they spoke about their experiences, it was necessary for the researchers to develop a hermeneutical and dialectical relationship with them. In this way, we could gain an understanding of the world and the context from the points of view of the teachers and the students involved and so be able to report the social and experiential meanings of their situations.

Knowledges at work in technology classrooms

Banks (1996) considered professional development in technology in terms of teacher professional knowledge. He regrouped Shulman's (1986) seven professional knowledge types (viz., knowledge relating to content; general pedagogy; curriculum; pedagogical content; learners; education contexts; and educational ends) and matched them to technology education needs/knowledges. Figure 1, is based upon Banks' (1996) classification.

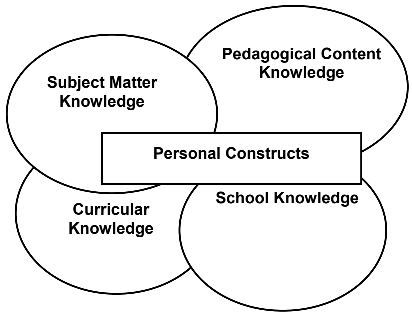

Figure 1

Framework for participant knowledge in research in technology learning events

While Banks' (1996) ideas were related only to teacher knowledge, we suggest that versions of these same knowledges can be displayed and/or developed by other participants in technology classroom research episodes (see Table 1). In Figure 1 subject matter knowledge refers to the knowledge teachers need to have of the content, such as materials, information and systems technologies. Pedagogical content knowledge refers to the "subject matter for teaching" technology (Shulman 1986, p.9) (emphasis in original). It includes an understanding of the best ways to represent technology ideas to students; knowledge about ways that make those representations easy or difficult; and strategies to help students comprehend more easily. Curricular knowledge is knowledge of relevant mandated curricula. For example in Queensland, Australia, this would be knowledge about the four strands of the technology syllabus (QSCC 2002). This knowledge would also include knowledge about the various alternatives available for teaching and learning technology, including teaching resources (e.g. Barlex 1998). They may be published kits or programmes, for example, the Nuffield materials. They may be identified routines or tasks that match aspects of planning, teaching, learning and assessing technology. School knowledge refers to the understanding of the differences that necessarily exist between technology in the world beyond school and technology within schools. It encompasses the changes that are made to make "outside world" technology accessible to students in school. Personal constructs are related to the personal experiences of the teacher in technology, technology education and in life. Thus, it encompasses the teacher's personal viewpoints, background, desires, aims, biases, and so on about technology and technology education, but also about teaching and learning in general. This knowledge, as shown by the diagram in Figure 1, impinges upon all the other teacher knowledges.

Table 1

Examples of knowledges at work in technology classroom investigations (after Banks 1996)

	EXAMPLES OF RESEARCH LITERATURE KNOWLEDGE	EXAMPLES OF RESEARCHER KNOWLEDGE	EXAMPLES OF STUDENT KNOWLEDGE	EXAMPLES OF TEACHER KNOWLEDGE
Pedagogical Content Knowledge **e.g.**	• subject specific strategies to organise learning • most useful forms of representation e.g. construction kits, demon-strations, • use of analogies, construction tips/techniques	• subject specific strategies to organise learning • most useful forms of representation e.g. construction kits, demonstrations, use of analogies, construction tips/techniques	• ability to recognise/develop technology understandings through the teaching strategies & representations used by the teacher	• subject specific strategies to organise learning • most useful forms of representation e.g. construction kits, demon-strations, use of analogies, construction tips/techniques
Personal Constructs **e.g.**	• views of technology & technology education • views of teaching & learning • recorded experiences/studies in relation to use & development of technology • recorded experiences /studies of being taught & learning technology • intentions of research studies into design & technology education	• view of technology & technology education • view of teaching & learning • past experience particularly in relation to use & development of technology • experiences of being taught technology related subjects • past research experience • intentions of research study	• view of technology & technology education • view of teaching & learning • past experience particularly in relation to use & development of technology • experiences of studying technology related subjects • perceptions of what is valued about technology education shown through, e.g. the assessment program	• view of technology & technology education • view of teaching & learning • past experience particularly in relation to use & development of technology • experiences of being taught technology related subjects • perceptions of what is valued about technology education shown through, e.g, the assessment program
Curricular Knowledge **e.g.**	• the structures & strands of national statements/ mandated curriculum documents • types of technology tasks & their purposes • published resources • established planning, teaching, assessing strategies	• knowledge of structures & strands of national statement/ mandated curriculum documents • knowledge of published resources • knowledge of established planning, teaching, assessing strategies	• response to the use of teaching resources & tasks • development of understandings about technology through the teacher's use of resources & tasks	• knowledge of structures & strands of national statement/mandated curriculum documents • knowledge of published resources • knowledge of established planning, teaching, assessing strategies

	EXAMPLES OF RESEARCH LITERATURE KNOWLEDGE	EXAMPLES OF RESEARCHER KNOWLEDGE	EXAMPLES OF STUDENT KNOWLEDGE	EXAMPLES OF TEACHER KNOWLEDGE
School Knowledge e.g.	• comparing & contrasting school technology experiences & "beyond school" technology experiences • identification, description & explanation of the dynamic elements of technology contexts • showing & exploring how students are both designer & maker • technology & its relationship with society • the place of designing, making & appraising within technology contexts & within curricula • roles of artefacts, product & process in technological activity & in technology education • the function & make up of school technology • communities as *learning* communities	• ability to compare & contrast school technology experiences & "beyond school" technology experiences • knowledge of the dynamic elements of technology context • how students are both designer & maker • technology & its relationship with society • place of designing, making & appraising • place of artefacts • roles of product & process • function & make up of school technology • communities as *learning* communities	• ability to compare & contrast school technology experiences & "beyond school" technology experiences • knowledge of the dynamic elements of technology context • how students are both designer & maker; • technology & its relationship with society; • place of designing, making & appraising; • place of artefacts; • roles of product & process; • function & make up of school technology; • communities as *learning* communities	• how students are both designer & maker • technology & its relationship with society • place of designing, making & appraising • place of artefacts • roles of product & process • function & make up of school technology • communities as *learning* communities
Subject Matter Knowledge e.g.	• elements that make up technology as a field of study/endeavour • technology contexts & their variations	• knowledge of current research literature • working knowledge of the content of technology	• knowledge of what constitutes technology • knowledge (content) of technology contexts e.g. materials, food, communication, information technologies etc	• working content knowledge of technology contexts • knowledge (content) of technology contexts e.g. materials, food, communication, information technologies etc

Links can be made in terms of learning needs between ideas in Figure 1 to the three models/frameworks described early in this paper. The furthest right column in Table 1 presents a list of the examples of aspects of the teacher knowledge, based on those outlined by Banks (1996) that are displayed and developed as teachers engage in teaching design and technology. We suggest that the other main participants within the teaching and learning environment, namely, the students and researcher, display and develop aspects of these knowledges too. The central columns in Table 1 presents lists of elements of knowledge developed and displayed by researchers and students. Similarly, the body of research literature in the area of design and technology and design and technology education provide documentation of these same knowledge aspects explored by researchers outside the immediacy of the classroom situation. In a research situation in which the teachers and students are new to technology education, it has been, in our experience, the researchers who have brought this "external" knowledge to bear upon the classroom.

As summarised already, what counts as knowledge and how that knowledge is developed has become the thrust of our investigations. Table 1 delineates aspects of those knowledges in terms of the main participants within classroom situations. Our research approach provides the rationale for understanding the emphasis placed on the importance of the perspectives of all of the participants within a classroom interaction and ways to represent those perspectives. The Table 1 list of knowledges of the participants is therefore a useful guide for keeping track of the intricacies and complexities of the technology classroom during research.

An integrated model to assist interpretivist research in technology classrooms

Figure 2 presents a model drawn from the three theoretical models/frameworks described earlier, based within the perspective of interpretivist approaches to understanding classroom events, and acknowledging the various participant knowledges at work as described in Table 1. Box 1 in Figure 2 represents examples of key features often under examination within a technology classroom. Box 2 lists examples of how those features are brought together into units of work (one or more "lessons"); and box 3 is the outcome of the classroom interaction, gauged by the researchers as the degree to which there has been authentic learning and teaching in technology. We use the word authentic here, in association with student learning in general, with classroom environments, with learning opportunities, with activities, and in relation to the nature of the "real" world beyond the classroom, as well as in relation to student personal meaning making. Our view is that authenticity, like Tochon's (2000) description, is the intersection of the "mind" of the discipline with the here and now of the pedagogical moment. Authentic classroom practice is, therefore, that which reflects, for the students, a combination of personal meaning and purposefulness within an appropriate social and disciplinary framework. The learning experience is authentic for the learner while, simultaneously being authentic to a community of practice. Throughout an interpretivist study of technology classrooms there are continued efforts made to understand the developing, emerging, changing knowledges of students, teachers and researchers in the light of the documented research studies in the area emerging from the wider technology education research community. The integrated model shows these disciplinary framework knowledges (see Table 1) and their infusion into the classroom event in the circulating ring around the three boxes.

Conclusion

This integrated model for describing technology education in classrooms has been developed from complex integrated conceptualisations of the features of technology classrooms that occupy several varied layers of depth and perspective depending upon the aspect of view and the depth of analysis attempted. The model is to be used as a tool to facilitate the task of sorting through the variety of the interdependent elements that make up a classroom interaction, simultaneously acknowledging its complexities and interpretivist research approaches. We see this model as being useful for other researchers undertaking classroom research in technology and attempting to make sense of the data collected.

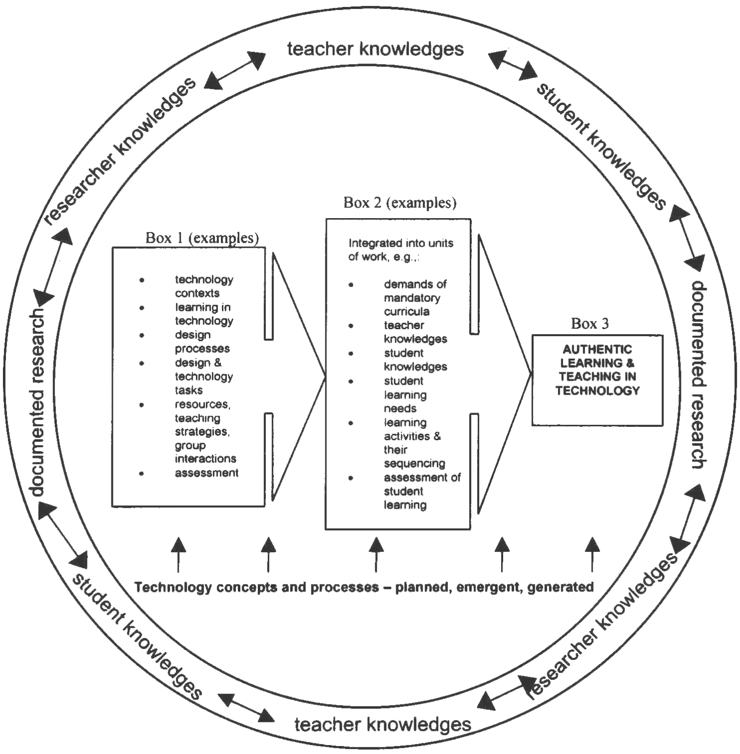

Figure 2

An integrated model to guide studies of technology classrooms

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Transforming Learners Through Technology Education

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This paper discusses some approaches that might be taken to the question of transforming learners through technology education. It adopts the idea of replacing the quest for transfer with a quest for consequential transitions (transformations in self, knowledge and skill as a result of a developmental change in relation between the individual and one or more social activities)(Beach 1999). On this basis, the paper suggests that instructional activity should be directed at developing both ' knowledge-with' (Broudy 1977; Bransford & Schwartz 1999) and engagement in 'consequential transitions', with both contributing to a building of a rich inter-connectedness among different kinds of technological meanings. The paper uses activity theory to propose contextual and experiential instruments for engaging learners in consequential transitions directed at preparing them to deal successfully with change.

Introduction

In its *Statement on Technology for Australian Schools*, the Curriculum Corporation (1994) identifies four learning strands: Designing, making and appraising; Information; Materials and Systems. There are also statements for each of these strands across four developmental bands. The technology curriculum statement does not exist on its own, but is one of the 8 key learning areas, which, together, are expected to contribute to the progressive development of students in schools. In all of the curriculum statements the aim is the Common and Agreed National Goals for Schooling in Australia, as well as individual state variations of these. Among other things, these goals seek to 'respond to the current and emerging social needs of the nation, and to provide those skills which will allow students maximum flexibility and adaptability, in their future employment and other aspects of life' (Curriculum Corporation 1994, p.43). It is this overall aim of schooling and the technology education contribution to it that this paper addresses. The question is: how might the teaching of technology, in accordance with the Statement, be approached in order to ensure development of learner capacities for meeting and dealing successfully with change.

Presumably one of the reasons for adopting a problem-solving-based approach to technology education such as that captured in the phrase, 'designing, making and appraising' is to develop the capacity to engage in such activities for a variety of different kinds of problems in future different situations. That is, its purpose is to transcend in some way the particulars of a specific problem and use these subsequently. I haven't used the phrase 'general knowledge' or the term 'transfer' here, because of the difficulties that such ideas are now seen to present, e.g. it is now recognised that:

- Much of the quest for transfer is ill-conceived, relying on examination of *direct application* of knowledge in sequestered situations (Bransford & Schwartz 1999, p.68) without recourse to the instruments that most of us use in solving new problems successfully–e.g. discussing the problem with others, reading and so on.
- Acquisition of knowledge is best when the purposes are explicit, functional and purposive rather than abstract, general and disconnected with its intended use (e.g. Pea 1987)
- Knowledge is situated and the idea of generic knowledge is at odds with this (Collins, Brown & Newman 1989; Lave & Wenger 1991; Stevenson, in press a, in press b 2001)
- Key aspects of using knowledge in a situation are perceptions of its relevance and appropriateness to utilise it (Pea 1987)
- The seeking of transfer is paradoxical as, for example, there is as great a need for non-transfer of inappropriate prior knowledge as there is for transfer of appropriate prior knowledge (Simons 1999).

Nevertheless, in seeking to achieve the development of technology learner capacities for meeting and dealing successfully with change, various suggestions can be drawn upon. One is to adopt a socio-cultural view of generalisation (Beach 1999) and seek to have learners engage in *consequential transitions*, i.e. transitions that 'involve a developmental change in the relation between an individual and one or more social activities' (p.114). Another is to focus on the need for learners to develop what Broudy (1977) called *knowledge-with* (Bransford & Schwartz 1999, p.69) as preparation for future learning. This suggestion focuses on the need for developing learner capacity for using previous understandings of context or field, as preparation for future learning, in guiding the noticing and interpretation of important aspects of new situations (Bransford & Schwartz 1999, p.69). These ideas are outlined in the following paragraphs. Then, the ideas are used in conjunction with activity theory and applied to the problem of transforming learners through technology instruction.

Consequential transitions

The first suggestion made above is to focus on the nature of the transition itself and theorise a socio-cultural view of generalisation (Beach 1999). Beach takes generalisation to be 'continuity and transformation of knowledge, skill and identity across various forms of social organisation, [involving] multiple interrelated processes rather than a single general procedure' (p.112). That is, he rejects the 'decontextualisation of mediational means' … of the formation of concepts at ever increasing distances from particular contexts and referents' (p.112). He recognises the importance of 'symbols, technologies, and texts, or systems of artefacts, in creating continuities and transformations through social situations' (p.113). His view is that 'the processes of generalisation and systems of artefacts weave together changing individuals and social organisations in such a way that the person experiences becoming someone or something new, similar to Dewey's (1916) notion of development as "becoming"' (p.113).

Thus, as for Lave & Wenger's (1991) idea of a change in individual identity arising from movement of the newcomer from peripheral to more central participation in a community of practice, Beach advances that this and other transitions are transformatory only if the interaction is one that challenges one's relation with the social. 'Thus, the experiences of continuity and transformation are important to, reflected on, and struggled with by individuals participating in multiple activities: playing, studying, working, parenting, loving and so on' (p.113). Beach refers to these transformative experiences that involve a 'developmental change in the relations between an individual and one or more social activities" (p.114), *consequential transitions* (p.114)– 'consequential for the individual and … developmental in nature, located in the changing relations between individuals and social activities' (p.113). Consequential transitions are also consequential beyond the individual: A 'consequential transition is the conscious reflective struggle to reconstruct knowledge, skills and identity in ways that are consequential to the individual becoming someone or something new, and in ways that contribute to the creation and metamorphosis of social activity and, ultimately society' (p.130).

This latter approach seems applicable to the goal of developing learners' capacities to deal successfully with change, and it seems to address contemporary research issues concerning the concept of transfer, because of

- Its focus on consequences for future learning;
- Its approach to contradictions such as paradoxes;
- Its acceptance of contextualisation as a central aspect of, and key concern for effecting learning;
- Its rejection of decontextualisation and abstraction from situations; and
- Its view of consequential learning as a struggle, rather than a direct transfer of pre-learned information.

As such it may have considerable potential in designing learning experiences that might prepare learners in technology education to address the challenges of change.

Knowledge-with

One implication of Beach's approach is for our idea of what constitutes contextualised knowledge. The idea of *knowledge-with*, advanced by Broudy (1977), and used by Bransford & Schwartz in arguing for preparation for future learning, assists in understanding these implications. Broudy (1977) differentiates knowledge-with from knowledge-that and knowledge-how. He regards knowledge-that as *replicative* knowing and knowledge-how as *applicative* knowing (p.10) e.g. the content of a theoretical discipline and its application in solving problems, respectively. But he recognises that we bring to situations an *interpretative* (p.11) and *associative* (p.10) knowing, derived from other (e.g. scientific or 'humanist') fields, so that the 'schooled man [sic] thinks, perceives and judges with everything that he has studied in school, even though he cannot recall these learnings on demand' (p.12).

For Broudy, associative use of knowledge includes 'contiguity, resemblance, frequency, effect and the familiar laws of association' and the resemblance may be 'iconic, structural, functional, analogical and metaphorical' (p.11). Interpretive use of knowledge 'refers to categorisation, classification, prediction and inference… [eliciting] a response that is logically related to the situation. The categories and concepts of the various disciplines guide our expectations, perceptions and judgements with respect to both fact and value' (p.11).

Importantly, Broudy recognises that knowledge-with may be tacit. Broudy uses the word 'contexts' (p.13) to refer to the tacit knowing provided by knowing-with. Knowing-with is seen to '[furnish] a context within which a particular situation is perceived, interpreted, and judged…[It is] a pattern for construing the import and relevance of its constituents'. 'Contexts can be cognitive, affective, aesthetic, moral, social religious' (p.13). Thus, Broudy unites meaning making with its socio-cultural context.

Bransford et al argue for the development of a 'coherent well differentiated framework for "knowing with"' (p.87), and for individuals, therefore, to interact actively with their environments, 'bump up against the world' and receive feedback (p.93). They argue that 'when properly mediated, lived experiences can provide powerful resources for "knowing with"' (p.85).

Transforming technology education learners

In order, then to develop technology education learners for dealing successfully with change, we have a number of tools at our disposal: theoretical ideas about what constitutes consequential transitions involving transformation, theoretical ideas about the contexts or fields that we know with, the various curricular statements, and the human and physical tools in learning settings including settings beyond the school. The problem, then, is to achieve consequential transitions: transformation of learner's knowledge, skill and identity through socio-cultural transitions that involve a conscious reflective struggle. This struggle should involve the development and coherent differentiation of contexts - knowledge-with - as a basis for future learning.

Learners' knowledge, skill and identity may be considered in relation to meanings. This term, following Leont'ev, refers to collective, mediated understandings, such as those expressed in the words of the culture. Consider the following views of Leont'ev,

> 'Psychic reflection inevitably depends on the subject's relations with the reflected object, i.e. on its vital meaning for the subject…but with the transition to human consciousness something new develops…When a primitive beater raises game–and that is the direct objective of his action–he is conscious of this goal, that is to say it is reflected for him in its significance in objective (in this case direct labour) relations. The meaning or significance is also that which is objectively revealed in an object or phenomenon, i.e. in a system of objective associations, relations and interactions" (p.125)…
>
> 'Meaning is the generalisation of reality that is crystallised and fixed in its sensuous vehicle, i.e. normally in a word or a word combination. This is the ideal, mental form of the crystallisation of mankind's social experience and social practice. The range of a given society's ideas, science, and language exists as a system of corresponding meanings. Meaning thus belongs primarily to the world of objective, historical phenomena' (p.126)…

> 'Man finds an already prepared, historically formed system of meanings and assimilates it just as he masters a tool, the material prototype of meaning. The psychological fact proper, the fact of my life, is this, (a) that I do or do not assimilate a given meaning, do or do not master it, and (b) what it becomes for me and for my personality in so far as I assimilate it; and that depends on what subjective, personal sense it has for me' (p.128).

Words, however, are just one way in which meanings can be rendered. They can also be rendered in other symbolic forms, in images and in practical or creative action, for instance. Presumably, the 'contexts' of knowledge-with that enable interpretative and associative knowing of a new situation (Broudy 1977) can be thought of in terms of different kinds of collective meanings: meanings derived from various fields of practice. Some of these fields may well be the theoretical disciplines, usually expressed in words and other symbols such as mathematics; but they may also be those of such everyday activities as 'playing, studying, working, parenting, loving' as suggested by Beach as examples of the multiple activities in which we engage and which can lead to consequential transitions. Phenix (1964) has suggested a fuller set or 'realms' of meaning: symbolics, empirics, esthetics, ethics, synoetics and synoptics.

If we think of various kinds of meanings as tools, rather than as oppositional constructions to be overcome in favour of some privileged construction, we may begin to develop an approach to developing differentiated kinds of knowledge-with by engaging learners in consequential transitions. The meanings and meaning making frameworks that could be drawn upon would include

- The meanings that learners bring from everyday living
- The meanings that are provided by science and engineering
- The technological meanings that have been described in the Statement
- The meanings described in the competency statements of vocational education that are supposed to reflect the experiential, functional understandings of practice, and
- Aesthetic, affective and normative meanings that apply to practice.

Individuals may already utilise one or more of these 'contexts' (meaning making frameworks) in perceiving, interpreting and appraising technology; and the context that they may already use may be more or less powerful in addressing different kinds of change that arise when solving technological problems. Moreover, individuals may or may not be able to render in words the context that they are using. The suggestion here is that learners be encouraged to develop plural frameworks for perceiving, interpreting and appraising technology by developing their capacities to inter-relate different meanings or ways of knowing. Combining Bransford and Schwartz's concept of 'bumping up against the world' and Beach's concept of 'consequential transitions', it is suggested that awakening learners to alternative contexts (frameworks to know with), the meanings they provide and their interrelationships might occur through carefully designed socio-cultural transitions. This means engaging learners in experiences where the forging of continuity and transformation occurs through struggle and reflection in the relationship between the person and the social activity. That is, individuals need to engage in a struggle that results in their changing their knowledge, skill and identity as a result of contextualised experiences; and thereby create a more differentiated framework for perceiving, interpreting and appraising technology.

The problem-based approach of technology education already lends itself to designing such experiences. What is offered here is a structured approach to selecting a focus for the problem solving activities. It is suggested that the focus be one that:

- Involves a variety of ways of giving meaning to experience (e.g. practical, theoretical, aesthetic…)
- Contextualises each meaning-giving framework socio-culturally (e.g. in workshops, lecture theatres, libraries, workplaces…)
- Involves moving (transitions) between the different kinds of social organisation (e.g. from engaging in classwork to engaging in situations of applications of technologies)
- Involves engagement with the symbols, technologies, and texts, or systems of artefacts, in each social situation (exploiting such features as: contiguity, resemblance, frequency, effect; be they iconic, structural, functional, analogical and metaphorical; for categorisation, prediction and inference)
- Involves developing connections among different frameworks; their symbols, technologies, texts and artefacts; and their social organisation; for use in expectations, perceptions and judgements e.g. through:
  (1) active and shared renditions of meanings in symbolic form and reflection
  (2) using meaning making frameworks (contexts) from one community of practice to examine meanings from another and vice versa) (Leinhardt et al 1995).

As argued elsewhere (Stevenson, in press c), one can draw upon cultural historical activity theory in order to conceptualise the various tools that can be utilised in instructional activity. The list of tools illustrated there would be extended to include meaning-making frameworks from different communities of practice. Thus the list of tools would include:

<u>Physical Tools</u>
Equipment, materials, …
Working systems and models
<u>Theoretical Technology Education Tools</u>
Concepts of Technologies (e.g. Materials, Processes, Systems, Information)
Concepts of design problem-solving (e.g. Design – Make – Appraise)
Theories of Teaching and Learning
<u>Contexts</u>
Meaning-making frameworks from different communities of practice

Conclusions

This paper suggests an enhanced approach to transforming learners through technology education in order to prepare them for the future learning involved in addressing the challenges of change. This preparation for future learning (Bransford & Schwartz 1999) is envisaged as the development of knowledge-with (Broudy 1977), by engaging learners in consequential transitions (Beach 1999); using a set of conceptual and physical tools..

The benefits are that the focus moves away from the development of decontextualised knowledge in the hope that it will be applied to new situations, to a focus on the unity between context and knowledge. The approach starts from a premise that the context is not static, but supplies a framework for meaning-making: perceiving, interpreting and appraising. Different contexts develop different kinds of meaning-making and different meanings rendered in different ways. These include the contexts of everyday living, theoretical disciplines, the technology curriculum and work practices. It is suggested that movement among contexts can be used as a tool to have learners engage in consequential transitions. That is, moves need to be designed so that learners will undergo a developmental change in their relations with the social activities – they will see the activities (make meaning) in new ways that will have consequential effects on their knowledge, skill and identity.

It is also suggested that these different ways of making and rendering meaning become explicit in the experienced curriculum and that learner operate upon them, e.g. by inspecting meaning derived from one context using the frameworks that come from another and vice versa (Leinhardt et al 1995). Cultural-historical activity theory is suggested as a conceptual framework for identifying and drawing upon the various tools available for designing consequential transitions.

Then, perhaps, learners may be more prepared to meet the challenges of societal and technological change. They will experience a sense of 'becoming' and be able to draw upon, apply and interconnect various ways of giving meaning to new challenges and be able to synthesise new approaches to their solution. Perhaps, also the approach may create a space for critical thinking – a re-examination of the plural values of a technological society and the dominance of various ways of thinking.

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Nurturing All-Rounded Problem Solvers: Enabling Students to Recognise, Discover, and Invent Problems

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More and more educators are aware of the importance of students engaging in problem-solving activities. However, the activities are still emphasising the narrow meaning of problem solving, so that most of the time students are only expected to give solutions on provided problems. They are rarely provided the opportunity of participating in the entire problem-solving process, that is, they have little opportunity of engaging in the problem-finding activities. This paper first reviews different natures of problems. It then reviews the limitations of the current problem-solving activities with regard to the limited opportunity for students to engage in problem finding. By discussing the findings of an in-depth interview with students, this paper explores some key issues and directions we need to consider in order to nurture students to be all-rounded problem solvers in term of enabling them to recognise, discover and invent problems.

Introduction

It should be an inarguable truth that problem-finding necessarily comes before problem solving for emergent or potential problems. Thus, the importance of problem finding skills is obvious. However, today, we pay much attention to problem solving, but little to problem finding.

Some scholars/thinkers further point out that sometimes finding problems is much more important than generating ideas. As Jay and Perkins (1997, p.257) stated in their article Creativity's Compass, 'The act of finding and formulating a problem is a key aspect of creative thinking and creative performance in many fields, an act that is distinct from and perhaps more important than problem solving'. In fact, as early as 1938, in his book The Evolution of Physics, Einstein asserted that, 'The formulation of a problem is often more essential than its solution, which may be merely a matter of mathematical or experimental skill. To raise new questions, new possibilities, to regard old problems from a new angle, requires imagination and marks real advance in science' (p.92). In 1945, Wertheimer also pointed out in his book, Productive Thinking, that: 'The function of thinking is not just solving an actual problem but discovering, envisaging, going into deeper questions… Envisaging, putting the productive question is often a more important, often a greater achievement than the solution of a set question' (p.123).

In discussing problem finding, Starko (2000, pp.234) reminds that '[we] must examine the nature of problems, determining what it is that must be "found" '. In his articles about creative thinking and achievement, Getzels (1964, 1982, 1987) distinguishes the difference between presented and discovered problem situations—these differ according to the degree to which the (a) problem, (b) method, and (c) solution are already known. Dillon (1982) examines 'problem' in another way and distinguishes among levels of problems: existent, emergent, or potential. That is, an existent problem is evident, —a problematic situation exists, and the appropriate activity is to recognise it and solve it. An emergent problem is implicit. It must be discovered (found, identified) before it can be solved. A potential problem does not yet exist as a problem. '[Its] elements exist and may strike the discoverer as an unformed problem, interesting situation, or idea worth elaborating. By combining the elements in some way, the observer creates or invents a problem where no problem previously existed' (Starko 2000, p.234). In general, however, we seldom consider the importance of how we invent this type of problem.

Limitation of problem-finding nowadays

As stated by Starko (2000), if the only problems students address in school are the existent problems already defined, problem-finding behaviours are not likely to emerge. However, the fact is that students nowadays, particularly the technology students (including those studying design and engineering) who are usually expected to 'initiate', 'create' and 'invent' something, have to interact with many situations that may involve emergent or potential problems. Consequently, students only tackling existent problems in schools would only obtain biased experience.

In 1987, Getzels was already complaining about the limitation in our curricula that most school problems are presented problems. However, this situation today has not changed in any significant way (Siu 2001). Students in school are usually presented with a predetermined problem to be solved. Several studies conducted in Hong Kong indicate that technology students are weak in finding problems as well as identifying project titles (Siu 1994 1997a, 1997b, 2001). The major reason is that students lack opportunities to practice this skill. However, the studies also indicated that this kind of experience is important for students at all levels, and is a particularly important area in the design process (Bullock 1986; Department of Education and Science 1989, 1990; Eggleston 1996; Norman, Cubitt, Urry & Whittaker 1995). However, it is unfortunate that many students enjoy only limited flexibility and freedom to identify project titles, particularly in public examinations, and even in their university studies. In short, problem finding does not seem to be a requirement in the assessment criteria and seldom people would consider it (in particular the skill and experience of inventing a problem) as a necessary part of the curricula.

Method

In 2001, a case study was carried out in Hong Kong in order to identify the difficulties and limitations in problem finding and to explore some possibilities for allowing students to gain this kind of experience. By using an interview, the study aimed at gaining an in-depth understanding of how different individual students think and their practical constraints in identifying needs for their projects.

In the study, four students were randomly selected to take the interview. Two of them studied the programme in a full-time mode while the other two studied part-time. The part-time students were working in the engineering industry. They were all volunteers to join the study and were free to refuse. The selected students came from the engineering department of the university. They all took a compulsory design subject called 'Introduction to Industrial Design'. According to the subject requirement, all students were required to tackle a project in which they had to identify the project needs by themselves. The only requirements of the project were that the students had to (a) find/identify a problem, and (b) based on design theories provided in lessons, and previous engineering experience, propose a creative idea/concept to meet the need. The students pointed out that they had not gained such experience in their engineering studies. They had only tackled projects whose titles or topics were assigned/prepared by their teachers.

The focus of the in-depth interview was on their experience in identifying the needs of their projects, their feedback on the subject requirements, and their attitudes in identifying their project titles. In order to minimise the uneasy feelings of the students interviewed, they were interviewed together and the interview was carried out in the manner of a casual conversation. The interview was also conducted in Cantonese, because this made it easier for the students to express their opinions. The topics and areas for interview were (a) willingness, expectations; (b) difficulties, constraints, limitations; (c) gains, satisfaction; and (d) suggestions.

Results and discussions

In Table 1, the key questions and responses were extracted from the interview. They are translated from Cantonese, and presented in a direct manner. Only the major and significant questions and responses are presented in the following paragraphs.

The responses obtained in the in-depth interviews are consistent with several studies on the experience of Hong Kong students in identifying project titles (Siu 1994, 1997a, 1997b, 2001), which indicate that Hong Kong students get very little experience in finding problems by themselves.

In detail, for convenience of project administration and assessment, most of the time teachers prefer to set a title (also called topic), or a set of titles for students. Even in advanced level examinations and many undergraduate examinations, freedom for candidates and students to identify their project titles is very limited.

Because of the common emphasis on the final solution, particularly in assessment, students often neglect the importance of experience and ability in problem finding. Students only consider 'How can we do (or solve) it?' and seldom ask: 'What should we do, tackle, solve?' and 'Why do we need to do it?'

Moreover, the nature of the industry in Hong Kong allows graduates very little opportunity to participate in the decision process, particularly defining the direction of product/system development. The students interviewed agreed that this results in the education system, even at university level, putting relatively little emphasis on students' abilities to find (in particular, to invent) problems. However, the students also agreed that Hong Kong (similar to many developed and economic-oriented regions) will not provide cheap labour any more when the Chinese mainland can offer a cheaper and greater labour force, and therefore the ability for our graduates to find/invent a problem is very important.

According to the in-depth interview as well as the studies carried out since the mid 1990s (Siu 1994, 1997a, 1997b, 2001), to nurture students to be all-rounded problem solvers in terms of enabling them to find problems (in the following paragraphs, unless otherwise specified, 'finding problems' include the meaning of 'recognising, discovering and inventing problems'), there are some areas teachers should keep in mind in providing project experience for students (For details of the discussion and the feedback from students, see Table 1).

1. The experience of problem finding for students should not only be available in extra-curricular activities. This is insufficient, and this kind of experience should also be provided in the regular curriculum.
2. The assessment criteria of the project should not only be related to the final outcome, but also to the process, particularly the ability of students to identify a project title. This means projects should not be final outcome-oriented, but process-oriented. Students should accept problems which may not have solutions at the present moment. The possibility of a final outcome should not be a factor which affects students' consideration of a need (a problem) for further investigation.
3. Convenience in administration should not be the most crucial factor to affect the design and arrangement of projects. This means it should not be a factor limiting the opportunity of students to find problems.
4. The experience of students in finding problems can be accumulated. Through providing examples, helping students to confine their titles, and setting particular scopes, teachers can help students to build the confidence necessary to enable them to set their own project titles. This kind of activity can range from concrete to abstract, simple to complex, small to grand, and local to global.
5. Teachers should realise that defining project titles or finding problems by students themselves can result in a higher motivation for students to tackle projects — to learn. Thus, providing an opportunity for students to identify their project titles or to find out 'what should be solved?' should not be considered as an inconvenience and barrier to teaching and project guidance, even though teachers are sometimes faced with diverse needs and preferences of students.
6. Teachers should always remind students that they should appreciate others' found problems, particularly the invented problems which seem ridiculous and do not make any sense. In fact, there are no nonsense questions, but only nonsense solutions.

7. Students (and even teachers) always have the mistaken perception that identifying needs is an easy job. Only through practical experience can students realise the importance and their shortcomings in this ability.

Finally, teachers should remind themselves that balance in problem finding and solving is very important. Teachers should also remind themselves and their students that problem-finding learning and practice should not only aim at instant return. Only constant practice and positive and constructive reinforcement for brave discovery and invention (in problem finding as well as problem solving), will enable students to be the all-rounded problem solvers and enable them to survive in the ever-changing world.

Table 1

Key questions and record in the in-depth interview

I — interviewer
F1, F2 — full-time students (interviewees)
P1, P2 — part-time students (interviewees)

GENERAL UNDERSTANDING	
I:	Do you have any experience of identifying project titles freely on your course?
F1:	No. Generally, our teachers provide us with the topics or titles of the projects.
I:	What do you mean by 'providing topics and titles for you?'
F1	For example, the teachers give us a problem, and we try to find a solution for it.
F2:	Our first year consisted of fundamental study; our projects were only small in scale. As 'F1' said, most of the time, we only needed to solve the problems provided by the teachers.
I:	Anything else?
P1:	Sometimes our teachers gave us a set of topics and titles to choose from.
I:	How about in secondary school? Did you get any project experience?
F2:	I got some project experience in the subjects of Geography, History, and Design and Technology.
I:	You (F2) mentioned that you had learned Design and Technology before. Did your teachers allow you to identify a title by yourself?
F2:	No.
I:	Besides Design and Technology, did you (F2) identify any project title by yourself?
F2:	No.
I:	How about the others? Did you (F1, P1, P2) get any experience in defining project titles in school?
F1, P2:	No.
P1:	I conducted a project with some classmates in extra-curricular activities. We identified the topic of the project as being related to environmental concerns.
I:	Besides this experience in extra-curricular activities, any other similar experiences?
F1:	I got a little experience of defining project titles in a Children and Youth Centre. The social workers discussed with us and asked us to initiate a project which could improve the environment of the Centre.
I:	What was the final outcome?
F1:	We decided to re-paint a room which was provided by the Centre for us to play cards in. We used spray-paint to decorate the room.
I:	Can you comment on this activity?
F1:	It was interesting and we enjoyed doing it, since the whole activity was initiated by us. Our motivation was very strong. The task was not assigned by the social workers, and they provided us with a high degree of flexibility.

I: How about you (P1, P2), before you started this degree course? Did you study any other post-secondary courses, and did you get any experience in defining project titles by yourselves?

P1: Yes, I studied a higher diploma course before. All project titles were assigned by our teachers. For the final project, it was a group project. Our teachers provided us with a set of project titles. We had to form groups, and each group had to select a title from it.

I: Did you or your classmates ask the teacher to allow you to identify a project title by yourselves?

P1: No.

I: Why?

P1: We knew that it would not be permitted. However, some of us asked to select the same title.

I: Why?

P1: Some of the titles were more difficult.

I: Were your requests granted?

P1: Not really. The teacher expected our selection to cover all of the titles. We had to reach a compromise by ourselves if more than one group of students wanted to select the same title.

I: What was the final outcome? Did different groups select different titles?

P1: Yes. As mentioned previously, the teacher ignored our request, and we had to settle the issue by ourselves.

I: What do you think about this kind of method of selecting project titles?

P1: Not so bad. We did not need to put too much effort into defining the title. I think it would have been difficult to find a project title by ourselves.

I: Why do you say this? How can you know that it would have been difficult for you to find a project title by yourselves if you had not tried before?

P1: We had no experience in this area. As the time schedule was very tight, providing a title for us was much better. However, as I already mentioned, sometimes, when several groups wanted to tackle the same title, it was not allowed. We had to compromise, and some of us had to select another title though unwilling to do so. This was a waste of time.

WILLINGNESS/EXPECTATION

I: You (P1) mentioned that you had no experience in identifying a project title, and that it was difficult for you to do so. Now that you are working, do you think that the experience and skill of 'identifying a project title' is important in your current job?

P1: I don't really think so, though I think this kind of experience may be useful for me later. Since my current position is not in a high rank and does not involve decision-making, particularly making decisions about the direction of the company's projects, I only follow my supervisor's instructions, though I can give my opinions. However, the nature of the projects is not decided by me. Let me put it like this: even my supervisor cannot make the decision whether a kind of job or a project should be done or not. Most of the time, we only get a project brief from 'the top,' and we need to finish it. You cannot say 'I don't like this project brief or project requirement,' and then do something else which you have identified. You know, there is not much emphasis on R&D (research and development) in many 'factories' (manufacturing companies) in Hong Kong.

I: How about your (P2) opinions?

P2: I agree with him (P1) that we have very limited opportunities to make decisions in our jobs, particularly regarding the project brief. In spite of this, I think that getting more learning experience in identifying project titles will be useful for us in the future, since the nature of the manufacturing industry is changing. Most of the factories have moved to the Chinese mainland. People like me need to go back to the Chinese mainland at least three times a week. All the manufacturing processes of my company are carried out on the Chinese mainland. In fact, today, people on the Chinese mainland can do (produce) the same things that Hong Kong people can. We always claim that we can create and manage things better than people on the Chinese mainland. However, I don't think this will be so in the future. I think that this kind of experience and skill can prepare engineers not only to produce a product, but to design a new product.

I: Do the others agree with her (P2)?

F1: Yes. This is also the reason that I chose to study this design subject. I expected to learn more about industrial design, more about design. As they (P1, P2) said, if we could not get this kind of experience at school (university), we might not have the same kind of opportunity to try when we go out to work.

I: What do you think of this project's requirement that you identify the title by yourself?

F2: It's interesting. However, it was not easy for me, even though you gave us two guidelines: creative, and related to Hong Kong culture.

P1: I agree. It was particularly difficult at the beginning. I did not know what should be done. Or, rather, it seemed that anything could be done.

F1: I didn't know how to set the scope of a title. Honestly, it seemed safe for me to set a simple title which had a high feasibility to be tackled.

I: What do you mean by 'a high feasibility to be tackled'?

F1: Easy to achieve a final solution.

F2: I agree with him (F1). Some of our colleagues set easy project titles for themselves. They could solve the problems and propose solutions easily. So, although you suggested that we identify a title which should be meaningful and related to Hong Kong culture and life, what was always in my mind was a good outcome.

I: Would you explain more about what you mean by 'a good outcome'?

F2: I mean a final solution which can get high marks. As the requirement of the design project, I always kept in mind that I needed to have a creative solution for the title I identified. Actually, I did not need to identify a creative title, but a creative solution for the title.

I: Any other comments on the project in which the title can be identified by students?

P2: I know that some of our colleagues only copied projects that their companies were working on, and claimed that they had identified these projects and their proposed solutions. This was unfair to us.

F1: Some copied from magazines, and claimed that the project titles were identified by them.

I: It's not easy for me to detect these situations. I understand most of you will not report these cases to me.

P2: Of course. It's also the reason that I think it would be fairer to give the same title to all students, ask them to propose solutions, and compare their ability in design.

I: This may also raise the same difficulty where a student has tackled the assigned problem before. He/she also can get an advantage from it.

P2: This probability is not so high.

DIFFICULTIES, CONSTRAINTS, LIMITATIONS

I: You (P1) mentioned that it was difficult for you to identify a title at the beginning of this project. Could you explain more about this?

P1: It was because we had not had this kind of experience before. Moreover, as engineering students, we pay attention to technical matters and seldom talk about creativity. In our engineering course, the assessment method of most of our subjects is examination. Even when we need to tackle projects, their focus is only on problem-solving, not problem identification.

F2: We don't know what is a good project title. As he (P1) mentioned before, it seemed that anything could be a project title, and anything could be done.

P1: We also don't know how much time should be spent on defining the project title.

I: What do you think?

P1: I think it should not be too long. I think we should spend more time tackling the identified problem.

I: Do you mean proposing solutions?

P1: Yes.

F1: I don't think so. If you set a very bad project title, no matter how good your outcome is, it will be meaningless.

P1: However, if your title is identified very well but you cannot propose a good solution, it will also be meaningless.

I: How about the others?

F2: I think a balance of time is important. But it is very difficult.

I:	Why? How much time did you (F2) spend on defining the title of this project? I mean as a percentage.
F2:	I spent about half of the total project time (3 to 4 weeks), because I changed the title several times after having tutorials with you.
I:	Any other difficulties and constraints in defining your project title?
F1:	As I mentioned before, although you taught us how to confine a project title, I could not handle it well. I still did not know how detailed the title should be, and what the degree of depth should be.
F2:	Like some of my colleagues, I always wanted to change the identified project title.
I:	Why did you want to change it? Didn't you feel satisfied with it?
F2:	The main reason was the difficulty of the identified title. I think some of the titles I identified were good. However, they were difficult to solve when I started to analyse and propose solutions. So, as the projects were to be assessed according to not only the identification of the project title but also the solution, I preferred to select an easy project title.
I:	I mentioned that the marking criteria of the project were based on the title identification and creative thinking. Do you think that a difficult project title cannot easily illustrate your creative thinking?
F2:	No, but as students we need to play safe.
I:	Do you think that the requirement of this project that your identified project title should be related to Hong Kong life and culture constrained you in identifying project titles?
P1:	I don't think so. As some of them (F1, F2, P2) mentioned before, more hints and requirements helped us to identify a project title more easily.
I:	How about the others?
P2:	I think it gave us more scope.
I:	Any other difficulties and constraints?
F1:	At the beginning, I spent two days thinking about the title, but I could not find one. I walked on the street, as you suggested. Sometimes I was very happy, since I thought I had found the topic for my project. However, when I thought about it more carefully, I abandoned the topic.
I:	Why?
F1:	Sometimes, I found that it was impossible for me to tackle it, or it seemed that the existing solution for the problem was good enough. My work seemed meaningless and redundant.
I:	Many of you mentioned having changed your project titles. What made you not want to persevere with the problems you initially identified?
P1:	Sometimes, when I found a project title and thought it was good, and tried to propose solutions, some of my colleagues or you would tell me that the problem had some existing good solution. Then I would give up the title, particularly when my proposed solution already existed on the market.
F2:	Sometimes, when I talked with my colleagues about my proposed project title, they would laugh at me. Sometimes, their reasons were quite strong, and I had never thought about them before.
F1:	Yes, I agree. Sometimes, my identified problems seemed too 'small.' And my colleagues also seemed to have no difficulty in proposing very good solutions right after I told them my identified problem. It seemed not worthwhile for me to go further. Besides, sometimes my colleagues identified the same title as mine and spoke it out first. I didn't want to repeat it again, and say that I also identified the same title.
P1:	I had some good problems identified. However, they seemed not to belong to our discipline (that is, engineering). I mean that these project titles are difficult to solve in an engineering way.
I:	Please explain further. Can you give an example?
P1:	Such as social problems. For example, young people like to use foul language. This is not related to our discipline. It's something about culture and attitude.
I:	Why didn't you change your ways of seeing this social problem and look at it from an engineering perspective? Does anybody have any comments?
P2:	I think we can relate it to engineering, such as by designing a machine to publish the names of young people who always speak foul language. Based on this machine, we can change the attitudes of young people who like to use such language.
I:	How do you (P1) feel about his (P2's) comments?
P1:	Maybe. But it seems very difficult.

I:	Yes, I agree. But we are not concerned with the possibility of a social issue being your project title, but the difficulty in proposing a solution for this title.
P1:	Yes, I agree. But, as he (F2) said, as students, we need to play safe. In this project, I preferred to identify a problem for which it seemed easy to find a 'possible' solution.
I:	Please give me an example.
P1:	Such as one of my colleagues' projects: a small lighting device in a coin-wallet, which can be used in a dark environment.
I:	Can I make a tentative conclusion that you were very much concerned with the possibility of an outcome when you identified a project title?
P1:	Yes, you could say that, since we faced time constraints. For your assigned seven-week project, we had to finish it on time.
I:	What did you feel about this project?
P2:	I only took this project as an exercise. It seemed not directly related to our current work.
I:	Would you explain?
P2:	As (P1) said, in our workplaces, we only follow our supervisors' instructions. Creative thinking in defining project titles does not seem so important for my current job. I would prefer to learn some creative methods in engineering and technological matters, rather than 'finding' a problem to solve.

GAINS, SATISFACTION

I:	Did you get any new experience from this project?
F1:	Before I tried to identify a project title, I always thought it would be easy to do. However, as I mentioned before, I went out and walked on the street and tried to find a good title. I still could not get a good one.
I:	Finally, how did you identify your project title?
F1:	I got some hints from a magazine.
I:	Any other methods?
F2:	I learned how to observe and be concerned with Hong Kong people's daily lives.
I:	Would you explain?
F2:	Since we were required to identify project titles related to the culture and life of Hong Kong people, I needed to consider the 'goings-on' around me.
P1:	I think what (F2) said is that this project could increase our 'awareness.' For example, one of our colleagues identified the existing design of public rubbish bins as his project, and redesigned the device to contain cigarette ends and ash. Although you mentioned it during your lectures, I agree that I was seldom aware of this kind of issue in our society.
I:	How about the design process? Did you gain any different experience?
P2:	I think in the past, we placed all of our attention on 'product development.' In this project, I first needed to consider 'what should be designed and developed.' Even in the product development process, I always had to worry about whether it was the right title.
P1:	I agree. Given the nature of my current job and some of my previous projects, what I have been concerned with is the final outcome. I have never worried about or questioned the nature and title of the projects. However, in this project, I needed to defend my project title in the project presentation.
I:	How about ways of thinking?
P2:	It provided more space for us to develop our thinking. Of course, as I mentioned before, this also presented me with difficulties in finding a direction, particularly at the beginning of a project, if I had to identify the project title by myself.
F2:	If a project title is determined by teachers, I agree that the space for thinking would be narrower, since many things would have been predetermined and well fixed. However, in this project, since I needed to identify the project title by myself, before I started thinking about the solution, I had to refine the title step by step.
F1:	I think there are different objectives for projects whose titles are identified by teachers and those whose titles are chosen by us. For project titles identified by teachers, more attention is paid to the solution. For the project titles identified by us, the attention is on identifying a need.
I:	What are your overall comments?

F1:	I find it is not an easy job to identify a project title.
P1:	A good start — I mean a well-identified project — is very important. I observed that some of my colleagues got good solutions and they tackled the identified titles very well since they could identify the needs and objectives of their project clearly. Their ability to observe 'small items' in our society was very good.
I:	Do you think that you also can have this kind of good ability?
P1:	I think more practice and more discussion, such as we had at the final project presentation, is very important. What I learned is that simple items or issues can also pose design problems, which is something I have never thought about before.

SUGGESTIONS	
I:	Do you have any suggestions for improving the arrangements for such kinds of project title identification?
F1:	Since I have not had this kind of experience before, I think it would help if more examples or cases could be provided in class. Moreover, as I mentioned before, how to confine a project title is also important.
P2:	Although you gave us three to four weeks to define the project titles in this seven-week project, I noticed that most of us started late. I think most of us thought that it was an easy job. I would suggest that tighter contact between you and us is important.
I:	How?
P2:	Maybe we need to have more tutorials with you. An interim presentation for our project title before the final solution might be useful.
I:	Some of you mentioned the marking scheme and assessment method; do you have any suggestions regarding these areas?
P2:	I think the marking criteria should be only the creativity of the title and the process of defining it, and should not include the solutions. This would provide more freedom for us to identify a project title without considering the feasibility of the outcome.
F1:	I don't think so. I agree that the weighting of the solution should be minimised but not totally eliminated. It's unrealistic if a title is identified without considering the possible solution.
P2:	I don't think so. I think it totally depends on the project objectives.
I:	What do you think about one of the requirements of this project, that your project title should be related to Hong Kong culture and life? Did this requirement present difficulties?
F1:	I don't think so. As she (P2) said, it gave us a good direction.
F2:	I agree. Daily life provides plenty of scope, and as you mentioned before, this brief could increase our social awareness. But I would suggest a more specific area, for example, the daily lives of young people or housewives.
I:	But you can identify these by yourself.
F2:	Yes, I agree. But if all of the students can identify project titles within a specific scope, the outcome (project titles) would be more interesting.
I:	But this seems to go back to the situation in which the teacher provides you with the project title.
F2:	I agree. However, as it is the first time for us to define titles by ourselves, a more specific scope may make it easier for us to handle.
I:	Do you mean more hints should be given?
F2:	Yes.
F1:	I would expect you to provide us with more examples. It was really difficult for us to start to identify a project title, as we had no prior experience. As he (P1) said, it seemed that anything could be a title.

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Hands-On, Minds-On Technology to Reinforce Understanding of Fundamental Science and Technology Principles

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Climate change and the global greenhouse effect is arguably the most damaging environmental problem facing humankind. This paper discusses learning outcomes that result from children's experiences with Greenhouse Lab, which is an interactive, mobile field study centre. Greenhouse Lab adopts the "mountain to Mohamed" principle of taking a field study centre to the school in order to help children understand the causes, consequences and possible actions that they can take to help reduce the impact of global climate change. In turn, these findings have led to the development of new interactive multimedia materials for upper primary and lower secondary school children that help them to understand the science, technology and social issues behind the global greenhouse effect. Although this paper is research based much of the presentation will involve demonstrations of the curriculum materials that are discussed in this paper.

Educationalists acknowledge the importance of first hand experience in helping children to develop knowledge, skill and understanding (Stables 2000). In the case of science and technology-based ideas, deep learning as opposed to superficial understanding of important concepts is more likely to take place if students are able to relate formal learning situations to meaningful life experiences or problems (Duit 1994: Gunstone 1994; Fleer & Jane 1999). Woolnough (1994) observed that the development of positive attitudes is an important part of children's science education. Positive attitudes developed during school years have an important influence on subsequent career choices.

The influence of field trips on children's learning was commented on by Falk, Martin and Balling (1978) who demonstrated that "novelty, and the very powerful needs for exploration it generates, is an extremely important educational variable" (p.133). Other researchers have found similar positive findings. Rix and McSorley (1999) reported an improvement in primary school children's attitudes towards science after they had interacted with a number of exhibits of the kind typically found in interactive Science Centres. They argued that for this one reason alone interactive science exhibits need to be considered as a useful resource in the development of children's science education.

This paper discusses learning outcomes that result from children's experiences with Greenhouse Lab, which is an interactive, mobile field study centre that adopts the "mountain to Mohamed" principle of taking the field trip to the school. In turn, these findings have led to the development of new interactive multimedia materials for upper primary and lower secondary school children that help them to understand the science, technology and social issues behind the global greenhouse effect.

The global greenhouse problem is arguably the most damaging environmental problem facing humankind. Climate change is now widely accepted by scientists, many politicians and other informed individuals as being directly linked to society's selfish and extravagant reliance on fossil fuels. Within democracies like Australia, education will be the key to the widespread acceptance of the difficult and expensive steps needed for society to adopt large-scale conservation measures and acceptance of environmentally sustainable energy practices. In this paper we describe a number of student-centred teaching/learning approaches that we have developed and evaluated in recent years, during our efforts to situate our teaching within the framework of a real world problem. Specifically the paper will focus on the development of novel technology-related teaching materials that have been designed to help primary and secondary age children to understand the causes and consequences of, and possible solutions to, global climate change.

Introduction

Griffith University is the only education institution in Queensland to offer degree-level courses to tradespersons wishing to qualify as TAFE teachers or teachers of high school technology. In the early 1980s, in order to tailor a course to the practical needs and interests of these mature adults, we redesigned our traditional science education course around basic technology teaching/learning principles of "design, make, appraise". The science content was applied to a study of the emerging real world concerns about the global greenhouse effect. For many years successive groups of our science/technology students used their specialised trade skills and knowledge to design, construct, evaluate and modify a number of unique working models that demonstrate fundamental principles of renewable energy. Collectively the models represent thousands of person hours of intellectual capital. Each model is unique. Each would be very expensive to replicate.

Every semester each new group of students exhibited their models at a daylong display in the Brisbane city square. The students also provided conservation advice to the general public. In addition to these twice-yearly public displays our students also ran energy open days for local schools. Many schools transported groups of children to the Mt Gravatt Campus in order to take part in these displays. Our students used these occasions to interview children and further refine their exhibits. The popularity of the displays and the number of requests by schools for access to the models and associated curriculum materials led to our students designing plans for a caravan that could store and transport the materials. In 1993 the Federal Government provided funds for the construction of such a caravan, which was named Greenhouse Lab.

Schools, conservation groups and other appropriate organisations may borrow Greenhouse Lab for periods of up to a week. For the past nine years Greenhouse Lab has made an important contribution to students' and members of the wider public's understanding of the global greenhouse problem and the pros and cons of possible solutions. The exhibits are presented in a detailed but non-technical way so that the problem, as well as ways by which individuals and groups can help to lessen the problem, can be readily understood. Evaluation sheets from schools show that more than an estimated 60,000 schoolchildren have actively used the resource to date in over 180 visits to schools.

Greenhouse Lab and associated curriculum materials are the practical outcomes of a traditional science course that was completely redesigned around basic principles of technology education as the fundamental way of operating.

Investigating the effectiveness of Greenhouse Lab curriculum materials

A: Greenhouse Lab

Method

The Griffith University Greenhouse Lab is a caravan that has been designed and equipped principally to help primary and secondary school students to understand the causes and consequences of the enhanced Greenhouse Effect. Teachers may borrow Greenhouse Lab for up to five days after they have completed a daylong seminar on the safe and effective use of the facility. The exhibits encourage student learning through hands-on interaction with a number of working models and commercially available renewable energy devices. Interactive exhibits include a solar hot water heater, wind energy devices, solar barbecue, solar still, solar cells, solar reflector, Stirling engine, solar sausage cooker, solar oven, a model roof hot water heater, and a solar powered, water saving shower display. A number of futuristic, sustainable, alternative energy solutions have been included to challenge students to think creatively and critically about future alternative energy sources. Eight illustrated information panels covering different aspects of the Greenhouse Effect (e.g. how a greenhouse works, the global greenhouse effect, the influence of human activity, possible short and long-term consequences, possible solutions) are complemented by video programs operated by a solar powered television and video player unit. Cross-curricular teaching/learning materials, which outline a range of interdisciplinary classroom activities that the teacher may use with or without Greenhouse Lab, have been designed specifically for primary or secondary school use.

A quasi-experimental study was carried out to investigate whether hands-on interaction with Greenhouse Lab equipment and curriculum materials would result in a change in year six and year seven children's conceptual understanding of the Greenhouse Effect. The research program had a number of quantitative components, which involved comparison of questionnaire scores by a control group and two intervention groups in a pre-test post-test sequence. In addition, audio taped responses from student interviews were undertaken with a view to providing deeper insights into students' understanding of greenhouse concepts.

The main data-gathering instrument was a written questionnaire, which was based on recorded interviews with focus groups, about global climate change principles. The interviews were held with three small groups of year six/seven students (15 boys, 14 girls) from schools that had had no prior contact with Greenhouse Lab. Students' responses were used to select and modify statements that were adapted from a 36-item instrument originally developed by Boyes and Stanisstreet (1993) for students in England. The preliminary questionnaire was pilot tested by year six students and a panel of four researchers in science and environmental education. The final version (the research instrument) comprised twelve of Boyes and Stanisstreet's original statements, ten of which were modified to better reflect Australian children's language and terminology.

A sample of 215 year 6 and year 7 children (120 boys, 95 girls) was randomly selected from the available year 6 and year 7 classes in three schools. One of the 9 classes was randomly designated a control group, the other 8 classes were randomly allocated to two experimental groups. The two experimental groups experienced different levels of intervention. The "Lab only" groups (4 classes) received two interactive class periods with Greenhouse Lab. During one of these sessions the researcher worked with half the group and discussed the Greenhouse Effect ideas that were illustrated on the information panels. Students were encouraged to complete worksheets and ask questions during the session. At the same time the class teacher worked with the other half of the class using worksheets to help provide specific learning experiences with the interactive exhibits. In the second session the groups changed over and received similar teaching. The researcher and teacher each attempted to carry out identical tasks with both halves of the class.

The second intervention groups designated the "Lab plus teaching" groups (4 classes), were provided with identical Greenhouse Lab activities to those received by the "Lab only" group. However these activities were complemented by three one-hour classroom teaching sessions. The complementary teaching/learning activities were developed from the associated classroom teaching ideas that accompany Greenhouse Lab and focused on ideas like the responsible use of energy in home and community, and addressing misconceptions that had been identified during initial taped interviews.

A pre-test questionnaire was administered to the eight experimental groups during the week before Greenhouse Lab was scheduled to visit their schools. An identical version of the questionnaire was administered as a post-test to the same groups, one week after the use of Greenhouse Lab. Twenty-two days later the same test was again administered to the same groups, under similar conditions. A ninth group (the control group) received only the pre- and post-tests, one week apart. They had no contact with Greenhouse Lab, nor were they formally taught about the global greenhouse effect or related environmental issues. Difference scores on the questionnaire were used to determine whether conceptual change had occurred and, if so, whether the change persisted. Children were not told that they would repeat the questionnaire.

Interviews were held immediately after the first post-test, with four different focus groups drawn from the intervention groups. Children's answers to seven questions, which were similar to those asked of the initial focus group students, were tape-recorded.

One way ANOVA was employed as the statistical procedure for analysis of questionnaire scores across the three different levels of intervention (control, Lab only and Lab plus teaching groups).

Results and discussion

Figure 1 illustrates the interaction pattern for group by time through a plot of mean scores for the three groups at pre- and post-test 1. A post hoc comparison (Scheffe) of the three groups at the pre-test found no significant difference between the mean scores. However, an identical post hoc comparison at the post-test found a significant difference between the groups (F (2 201) = 18.21, p<.001). Scores for each group were then compared at the two times using t-tests. No significant difference was found for the control group. The Lab only comparison indicated a significant difference following teaching with the Greenhouse Lab (t (85) = 13.01, p<.001). The Lab plus teaching group also showed a significant difference (t (92) = 8.28, p<.001). These data support the hypothesis that teaching that involves interaction with the Greenhouse Lab results in a change in students' conceptual understanding of the enhanced greenhouse effect.

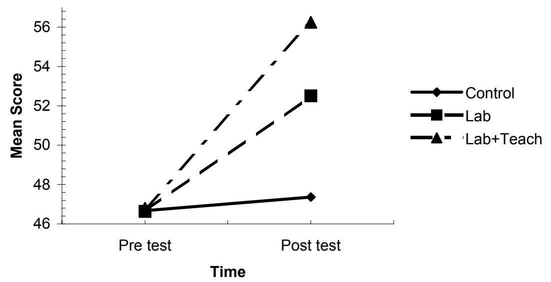

Figure 1

Mean scores for control and two experimental groups (N = 215) before and after intervention

An additional analysis examined the relationship between the two intervention groups. One way ANOVA for both group scores at pre-test, post-test 1 and post-test 2 (22 days after post-test 1) were run. Figure 2 illustrates the interaction pattern for group by time through a plot of mean scores for the two groups at pre-test, post-test 1 and post-test 2.

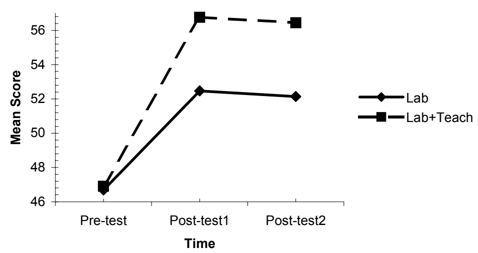

Figure 2

Mean scores for both intervention groups at the pre-test, post-test 1 (7 days after pre-test) and post-test 2 (22 days after post-test 1)

The interaction pattern between the two intervention groups at three different times is shown through a mean scores plot in Figure 2. The difference ($F(2,320) = 12.34$, $p<.001$) was significant. A post hoc comparison (Scheffe) of both groups at post-test 2 indicated a significant difference between the groups ($F(1,160)=12.53$, $p<.001$). T-tests for both groups at pre-test 1 and pre-test 2 were not significant. These results show that the students' level of understanding of the Greenhouse Effect was sustained and that neither level changed significantly during the 22-day period between the two post-tests.

Summary

The above findings suggest that:

- teaching of an environmental education unit involving the Greenhouse Lab led to change in the conceptual understanding of the Global Greenhouse Effect in year six and seven students;
- the change in conceptual understanding was more pronounced if students receive additional teaching as well as interaction with the Greeenhouse Lab; and,
- the change was sustained, at least in the short term.

B: Interactive web-based greenhouse curriculum materials

Greenhouse Lab remains a highly sought after resource but it can travel only to relatively close destinations. In order to help to satisfy growing numbers of requests from teachers and members of the public from many parts of Australia for greenhouse curriculum materials and renewable energy information, two sets of complementary resources have been developed. These have allowed us to considerably broaden our assistance to a much wider community than can be served by Greenhouse Lab alone.

The first of these complementary resources comprises print materials in the form of three booklets, each written for a different audience and each based on the research and development activities that originally led to the idea of the Greenhouse Lab. The first booklet entitled "The do-it-yourself solar energy project book" is written for the home handyperson. The booklet contains detailed instructions on how to construct a mini solar hot water heater, a solar swimming pool heater, a solar barbecue and a solar still (42 pages). The second booklet entitled "The global greenhouse effect: Ideas and activities for teaching in primary schools" (52 pages) was co-authored with a primary school science adviser who helped to ensure that the activities were suitable for primary school children. The booklet is highly rated for its practicality and suitability for the primary school and has been sold to many primary and secondary schools throughout Australia. The third booklet "Energy in society …and 101 ways of saving it" (16 pages) has been written for children of reading age of about 11 years. Many schools have purchased multiple copies of this booklet as class readers. All booklets were developed with the aid of small Federal Government or Griffith University grants. Therefore they can be sold on a cost-recovery basis. They are available for a nominal cost of about $5 each through the Griffith University EcoCentre, and the Mt Gravatt and Logan Campus bookstores.

The second complementary resource has the potential to assist educators and primary and secondary school children from many countries. In 2000 we were awarded a teaching grant from the Faculty of Education specifically to develop web-based interactive materials that promote understanding of science and social issues relating to global climate change. Stage one of this project was completed early this year and four of the interactive modules may currently be viewed through our Griffith University primary science home page. To the best of our knowledge there are no similar teaching materials on the Internet. This resource has the potential to reach a very large number of teachers and children. Preliminary evaluations from students rate these interactives highly.

Table 1

BEd Primary students' reaction to one of the web-based interactives (n = 48)
Data are reported as percentages

MODULE 1: THE GREENHOUSE EFFECT	SA	A	N	D	SD
It is more effective than traditional lesson format	10.4	45.8	31.3	12.5	
It would be better used as an addition to normal lessons	37.5	60.4	2.1		
It is more interesting than the traditional lesson format	22.9	54.2	16.7	6.3	
It would be suitable for primary age children	37.5	56.3	4.2		2.1
Operating instructions caused no problems	64.6	35.4			
Language used was easily understood	54.2	41.7		4.2	
Diagrams were effective in presenting the concepts	79.2	16.7	4.2		
There is an appropriate balance between text and diagrams	52.1	39.6	6.3	2.1	
Navigation within the site was easy	68.8	31.3			

Similar positive responses were obtained by different groups of students to identical questions asked about Module 2 - House design and the Greenhouse Effect, and Module 3 - Colour and the Greenhouse Effect.

Development of these web-based Greenhouse interactives is an expensive and time-consuming process. However, feedback from teacher trainees is positive and it would appear that these prototype materials are pitched at an appropriate level to be of value to upper primary school/lower secondary school students and their teachers. The next step will be to ask schoolteachers to test the modules with groups of students and to make suggestions for improving their effectiveness for use in classrooms.

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Research on Constructing Web-Based Courses in the Open University

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Instructors and learners are the main components in the traditional teaching setting. Whereas, modern learning includes the third element—scientific technology. A learner or an instructor must understand that learning is not restrained to books and instructors themselves. The role of instructors should have some changes and adjustments for the intervention of scientific technology. Domestic formal adult education was learned through the media of broadcast and television, however, it cannot produce the effects of interaction. Network teaching is using innovatory technology can improve the efficacy of learning and broaden the area of education. This research will be carried out on the adult learners of the Open University of Kaohsiung, in Taiwan, to collect information about viewpoints and requirements of learners of web-based courses. The purposes of this study are: 1. To understand the behaviours of network usage of adult learners; 2. To explore the attitude regarding web-based courses; 3. To use this information to plan and design web-based courses suited to the adult learners in the Open University. In this study, web-based courses mean E-learning.

Introduction

Distance learning is a traditional learning method of adult education, but it is not the most effective one. Adult learners usually have to make compromises in terms of the existed education system. Classified by different teaching media, there are four stages in developing distance teaching:

1. correspondence courses;
2. teaching by broadcasting;
3. teaching by television;
4. teaching by using network and multi-media.

The weakness of these first three teaching types is that the learner and instructor are in different places and using one-way communication. There are no interactions between learners and instructors. But teaching by television can transmit more abundant information than the one by broadcasting. The strength of teaching by using network and multi-media is that it can enhance the efficacy of teaching and learning, because there are direct interactions between learners and instructors. If learners have any questions about lectures they can ask their teachers and get answers immediately.

There are two open universities in Taiwan. One is the National Open University established in 1986. The other is the Open University of Kaohsiung established in 1997.

Both are adult higher education institutions in Taiwan.

Leung (1995) stated that the biggest problem met with by the learner of the National Open University was the schedule of the curriculum. These are too early (from 5:00 till 7:00 in the morning) or too late (from 22:00 till 24:00 in the evening). That affected the learning behaviours of learners and their daily life. If learners have any questions about lectures they can't ask their teachers and get feedback immediately.

In the beginning, the Open University of Kaohsiung planned to use the network as the main teaching media, but survey found that just a few learners were able to use computer and Internet. School authority decided finally to use broadcasting and television as the same time. When learners familiarised themselves with using computers and the Internet, the network would become the main teaching media. The Open University of Kaohsiung had set up its network broadcasting station and television station in 1999. If learners using the Internet can receive all of broadcasting and television teaching programs, they can carry on their learning activity at any time and place.

Constructing the teaching environment on the website requires that one should first understand the nature of teaching and then examine the functions of the teaching environment. Teaching means to teach and for learning to occur. Teaching is the process to find out the wants from learners and then design and deliver appropriate courses (Yang 1999). The purposes of the research described here is:

1. To analyse and inquire into learners using network courses.
2. Programming and designing network courses to suit for learners.

The questions of research:

1. What are ideal network courses.
2. What are ideal network courses to meet the requirements of adult learners.

Theoretical background

Throughout history, major technological advances have had the power to completely alter society. Often referred to as "restructuring" or "disruptive" technologies, even if the previous technology had been a mainstay of life for a very long time.

The history of using technology for learning is replete with promise and disappointment. In 1922, Thomas Edison predicted that the motion picture would replace textbooks (and perhaps teachers) in the classroom. Clearly, Edison was better at inventing than he was at predicting.

There was lots of work done on many campuses in the United States and around the world. In the sixties, early "teaching machines" and "programmed" texts paved the way for embryonic computer-based training. Instructional films became more creative. During the 1970s, Florida's Nova University (now Nova Southeastern University, www.nova.edu) stood almost alone as a pioneer in distance learning. Today Nova and almost all traditional higher education institutions are developing an Internet presence beyond simple promotional Web sites.

Due to development of communication technology, there are many different teaching types of distance learning, such as tapes, videotapes, CD-ROMs, network online learning. These not only affect learners but also change the role of traditional teachers.

There have been many terms to describe the use of technology for learning, but most are either antiquated or no longer appropriate for a digital world. We have used E-learning quite a lot already, so let's define it.

The Definition from Bank of American Securities: E-leaning is the convergence of learning and the Internet. Elliott Masie says that E-learning is the use of network technology to design, select, administer and extend learning. Cisco defines Internet as enable learning (Huang 2001). It is based on three fundamental criteria (Rosenberg 2001):

1. E-learning is networked, which makes it capable of instant updating, storage/ retrieval, distribution and sharing of instruction or information.
2. It is delivered to the end-user via a computer using standard Internet technology.
3. It focuses on the broadest view of learning, learning solutions that go beyond the traditional paradigms of training.

With e-learning, we're not just introducing new technology for learning, we are introducing a new way to think about learning. This is a key point.

The Open University of Kaohsiung co-operated with Chunghwa Telecom Co. to try to construct web-based courses in 2002. Chunghwa Telecom Co. is responsible for maintaining hardware facilities, providing the broadband network (512 K) to learners of the Open University of Kaohsiung. They can download the teaching programs very quickly. The initial stage focuses on the television and broadcasting programs. In other words, if learners missed the schedule of television and broadcasting programs, they can view the programs on-line. To learners, they can watch and listen repeatedly. In the second stage the Open University of Kaohsiung will depend on the needs and wants of learners to construct the web-based courses suitable for adult learners.

What is ideal web-based learning environment? Lin (1998) cited McGrea's viewpoints (1998), giving five main factors:

1. on-line courses: it is the most important part that learners to keep going on learning activities, depending on problem thinking and learning theories.
2. on-line evaluation : the instructors can understand learning process of learners.
3. virtual classroom: constructing a co-operative situation composed of synchronous and asynchronous communication media.
4. teaching management: recording the learning information of learners that instructors can catch learning behaviours of learners in details.
5. learning tool: helping learners to learn in web, by using the on-line notebook, search engine etc.

Lin (2000) also presented evidence to show that opinions, the degree of interaction between learners and learning organisation will affect the courses satisfaction. In other words, the more frequent interactions they have, the higher satisfaction they obtain.

Measurement of variables

The two independent variables being investigated are:

1. demographic variables: gender, age, education, marriage, income monthly , residence, school year, learner's purpose.
2. behaviours of using the Internet: how many years have you used the Internet , frequencies of using the Internet, how many hours do you surf the Internet, what's your main purpose using the Internet, what's your secondary purpose using the Internet, what's your main purpose when you enter the website in school, what's your secondary purpose when you enter the website in school.

The dependent variable proposed in this study is the learners' attitude on web-based courses. It was measured by a five-point Likert scale which is composed of twenty attitude statements. High scores indicate that subjects hold a favourable and positive attitude on web-based courses; whereas low scores indicate that subjects hold a negative attitude on web-based courses. Cronbach alpha was computed for the scale, the resulting Cronbach alpha based on the twenty items has a value of .8252.

Research method

Description statistics and Chi square test ($\chi 2$) were utilised in this study. First, subjects were asked to fill out a self-administered questionnaire in which questions on their attitude on web-based courses. The subjects participated in the study were primarily the learners of the Open University of Kaohsiung who co-operated with Chunghwa Telecom Co. In total, 44 completed questionnaires were collected and analysed. There are three parts on the questionnaire: behaviours of using the Internet, attitude on web-based courses, personal information. Chi square test ($\chi 2$) was run in examining the correlation of demographic variables and behaviours of using the Internet.

Data analysis

In total, 44 completed questionnaires were collected and analysed. *Male*: 21 persons (47.23%), *Female*: 23 persons (52.3%). *Age* (range): 20–39 years old: 16 persons (36.4%), 40–54 years old: 25 persons (56.8%), over 55 years old: 3 persons (6.8%). *Education*: senior high school: 4 persons (9.1%), high school: 23 persons (52.8%); college: 17 persons (38.6%). *Marriage*: married: 30 persons (68.2%); single: 14 persons (31.8%): *Income monthly*: under 30,000 dollars: 18 persons (40.9%); 30,001–60,000 dollars: 19 persons (43.2%); over 60,001 dollars: 7 persons (15.9%). *Residence*: Kaohsiung city: 31 persons (70.5%), other cities: 12 persons (29.5%). *Year (in school)*: sophomore: 19 (43.2%), senior: 15 persons (34.1%), junior: 10 persons (22.7%). *Part-time student*: 4 persons (9%), *full-time student*: 40 persons (91%). *Learner's purpose*: all included: 27 persons (61.4%), getting knowledge or skills: 17 persons (38.7%).

Behaviours of using the Internet

How many years have you used the Internet:

Within a year: 16 persons (36.4%), over 4 years: 12 persons (27.3%), 2–3 years: 8 persons (18.2%), 3–4 years: 5 persons (11.4%), 1–2 years: 3 persons (6.8%).

Frequencies of using the Internet everyday:
Below 5 times: 31 persons (70.5%), 6–10 times: 7 persons (15.9%), 1 6–20 times: 4 persons (9.1%), 11–15 times and over 21 times each one person (2.3%).
How many hours do you surf the Internet everyday:
1–2 hours: 14 persons (31.8%), under an hour: 12 persons (27.3%), 2–3 hours: 10 persons (22.7%), 3–4 hours (9.1%) and over 4 hours (9.1%), both are 4 persons.
What's your main purpose using the Internet:
Receive and send e-mails (38.6%) and download web-based courses (38.6%), both are 17 persons. Searching engines: 8 persons (18.2%), chat room, ICQ and reading e-news are each one person (2.3%).
What's your secondary purpose using the Internet:
Receive and send e-mails: 15 persons (34.1%), download web-based courses: 12 persons (27.3%), Searching engines: 10 persons (22.7%), reading e-news: 6 persons (13.6%).
What's your main purpose when enter the website in school:
Download web-based courses: 21 persons (47.7%), getting newer information about school authority: 11 persons (25%), term grade-checked: 9 persons (20.5%), Searching engines: 3 persons (6.8%).
What's secondary your purpose when enter the website in school:
Getting newer information about school authority: 19 persons (43.2%), download web-based courses: 13 persons (25%), term grade-checked: 10 persons (22.7%), searching engines: 2 persons (4.5%).

Demographic variables and behaviours of using the Internet

Gender

The gender of adult learners correlates with "What's your main purpose when enter the website in school." But it doesn't correlate with" How many years had you used the Internet", "Frequencies of using the Internet everyday", "How many hours do you surf the Internet everyday", "What's your main purpose using the Internet", "What's your secondary purpose using the Internet", and "What's your secondary purpose when enter the website in school".

Age

The age of adult learners correlates with "How many hours do you surf the Internet everyday". But it doesn't correlate with " Frequencies of using the Internet", "What's your main purpose using the Internet", "What's your secondary purpose using the Internet", "What's your main purpose when enter the website in school" and "What's your secondary purpose when enter the website in school".

Education

Education of adult learners correlates with" How many years have you used the Internet", "Frequencies of using the Internet", "What's your main purpose using the Internet". But it doesn't correlate with" How many hours do you surf the Internet", "What's your secondary purpose using the Internet", "What's your main purpose when enter the website in school" and "What's your secondary purpose when enter the website in school".

Marriage

The marriage of adult learners correlates with "What's your secondary purpose when enter the website in school". But it doesn't correlate with" How many years do you use the Internet", " How many hours do you surf the Internet", "What's your main purpose using the Internet", "What's your secondary purpose using the Internet" and "What's your main purpose when enter the website in school".

Learner's purpose

The learner's purpose of adult learners correlates with "Frequencies of using the Internet". But it doesn't correlate with " How many years have you used the Internet", "How many hours do you surf the Internet", "What's your main purpose using the Internet", "What's your secondary purpose using the Internet", "What's your main purpose when enter the website in school" and "What's your secondary purpose when enter the website in school".

Other democratic variables

The income monthly, residence and school year of adult learners doesn't correlate with" How many years have you used the Internet", "Frequencies of using the Internet", "How many hours do you surf the Internet", "What's your main purpose using the Internet", "What's your secondary purpose using the Internet" and "What's your main purpose when enter the website in school" and" What's your secondary purpose when enter the website in school".

Attitude on web-based courses

It was measured by a five-point Likert scale which is composed of twenty attitude statements. The basic design of this study is principal components analysis. The factor loading > 0.4. The four components are labelled: (1) courses assessment (2) learner autonomy, (3) quality & evaluation, (4) courses characteristics.

Table 1

Total variance explained

(Rotation sum of square loadings)

COMPONENT	TOTAL	% OF VARIANCE	CUMULATIVE %
1	5.822	29.112	29.112
2	3.475	17.377	46.489
3	1.877	9.386	55.875
4	1.645	8.226	64.101

Extraction method: Principal Components Analysis

Table 2

Reliability analysis

TOTAL CRONBACH α	COURSE ASSESSMENT	LEARNER AUTONOMY	QUALITY & EVALUATION	COURSES CHARACTERISTICS
.8252	.8634	.7922	.7398	.6238

Conclusion and suggestions

It is important to adult learning institutions and instructors to understand clearly the requirements of adult learners, especially in today's world where life-long learning is popular. When school authorities are planning and designing courses, the wants and needs of adult learners should be considered well. Adult learners choosing the way of distance learning to learn expect to get knowledge, skills, the bachelor's degree and new friends. More than that, it is convenient for adult learners who can go on learning at any time, anywhere. Every adult learner can adjust their speed of learning.

The suggestions are proposed in this study are as follows:

School authority:

- making the timetable of constructing web-based courses in detail.
- planning pre-courses of web-based , learners familiarised them with learning media.
- in addition to contents of web-based courses, school authority constructing positively "web-based classroom" and "web-based school".
- school authority offers every adult learner an individual e-mail address to connect himself with others.
- in order to reduce the anxiety about web-based courses, it should be used simply and easily by adult learners.

Instructors:

- professional knowledge.
- challenging new technology.
- individualised contents of web-based courses.

Adult learners:

- holding positive attitude on web-based courses.
- learning persistently.

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Breaking Down Barriers in Design and Technology: Recent Experiences in Hong Kong Gender Equity Initiatives

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This paper will present recent initiatives to increase gender equity in Hong Kong secondary Design & Technology (D&T) programs. First will be a short introduction on the history of D&T in Hong Kong and how gender inequities were manifested throughout the program. Next will be a discussion of the first Hong Kong Pupil's Attitudes Toward Technology study (PATT-HK) that helped lead to changes in program opportunities for secondary school students. This will follow with strategies being undertaken at The Hong Kong Institute of Education to encourage greater female participation in the D&T teacher preparation program. Finally, as a result of the first PATT-HK study, preliminary findings of the second PATT study (PATT2-HK) will be presented, examining the results of having girls now participating in D&T studies at secondary school level for three years.

Introduction

Reflecting its colonial past, the subject of Design & Technology in Hong Kong was influenced by the British system. Born out of the traditional subjects of woodworking and metalworking in the late 1970s, D&T was an attempt to move beyond the craft-based and skill-oriented programs that permeated most school programs (Volk, Yeung & Siu 1997). Unfortunately, factors such as a dated syllabus, inadequate facilities, poor public perception, and the inability of a large number of students to participate limited the subject's potential.

Design & Technology in Hong Kong has also been offered almost exclusively to boys, with girls taking Home Economics (HE). This was done because of traditional gender stereotyping, as well as administrative and scheduling convenience in schools. This gender imbalance not only exists in opportunities for girls taking D&T, it translates in inherent problems attracting female teachers who may later serve as role models. In recent years, some progress in gender equity has been made.

The first PATT-HK study

The first Hong Kong Pupils' Attitudes Toward Technology (PATT-HK) was administered to over 3,500 secondary three students. The results showed significant differences between boys and girls in all six attitude categories. Specifically, boys had significantly more positive attitudes toward technology in the five categories of "Interest", "Difficulty", "Consequence", "Curriculum", and "Career Aspiration". Girls had significantly more positive attitudes than boys for the attitude category of "Role Pattern", indicating girls thought they could/should participate in technology activities, while boys thought technology was more for boys. More importantly however was that at that time only one school in the study allowed girls to take D&T, with the analysis of data indicating some attitudinal differences disappeared when such opportunity exists.

In reality, the authors already suspected the results would be similar to most other PATT studies in other countries (Raat, de Klerk Wolters, de Vries 1987). However, armed with this evidence of differences, an Executive Summary of the results was sent to the Equal Opportunity Commission (EOC), with the suggestion they look into the matter. EOC soon began to conduct their own investigation and referred to Hong Kong's Sex Discrimination Ordinance that it is unlawful to discriminate against a student in the way it affords him/her access to any benefits, facilities or services.

In July 1999, the Equal Opportunity Commission published their own findings, looking at Design & Technology and Home Economics subject availability and opportunities (EOC 1999). Their conclusion and subsequent recommendations supported the earlier charge that D&T should be available to all students, regardless of gender. In consultation with the Education Department, some secondary schools immediately began to allow girls to take D&T in that academic year. In October of 1999, a forum was held with teachers, principals, Education Department representatives, EOC, and the authors to discuss the report and required changes to all D&T and HE program offerings. As a result of these initiatives, by the 2001-2002 academic year all schools offering D&T now allow girls to participate.

Changes in D&T teacher preparation

The Hong Kong Institute of Education (HKIEd) is newly-established, combining the four former colleges of education and the Institute of Language in Education that were located throughout Hong Kong. Prior to HKIEd's establishment in 1995, D&T and other technical subject teachers were prepared at the Hong Kong Technical Teachers' College. A most noticeable feature of the Institute is the new Tai Po campus opened in 1997, located north in the New Territories. This state-of-the-art campus houses all program areas and students formerly located at separate campuses.

The establishment of HKIEd enabled a sizeable number of new lecturing staff to be recruited in the department that prepared technical teachers. One major result of this change of staff was a re-examination of program philosophy, courses and facility needs. Soon, it was agreed that the new facilities for preparing D&T teachers should now reflect a philosophy based on subject integration, rather than segregation; new technology, rather than old; an exploration of design and creativity, rather than a simple mastery of skills; and a concern about attracting students from non-traditional sources. For the latter, this naturally included the need to bring women into the D&T teaching profession.

In order to attract women into the program, the facilities were designed to minimise as much as possible features that may be uncomfortable or threatening to individuals that have not been exposed to technical subjects. Some of the resulting facility changes include a 3-D Design Studio, combining wood, plastics and metals (a move away from woodshop originally planned by the Education Department) and an Exploring Technology lab, introducing a variety of "modular" activities for all HKIEd students as well as invited primary/secondary school children to utilise.

A new admission test was also put in place, which eliminated the high failure/frustration practice of requiring prospective students to demonstrate their hand tool skills through the making of a dovetail joint and sheet metal box. The new test now emphasised creativity, problem-solving skills and also served as a "recruiting tool" to familiarise those students who did not have the opportunity to take D&T in schools. So successful has been this change in emphasis and recruitment, that today the program has nearly 30 percent women. In the 2003–2004 academic year, our first cohort of new Bachelor of Education students majoring in D&T will graduate. Included in this group will be talented women with a repertoire of skills and strategies who will no doubt lead the way as role models for boys and girls in secondary school D&T programs.

Other gender equity initiatives undertaken at the Institute have been the encouraged expansion of Technology as a subject in primary grades and a biannual conference for primary and secondary teachers on Science and Technology. With the former, the introduction of Technology Education as a Key Learning Area in primary schools (CDC 2000) is seen as encouraging female participation and attitudes in the subject. The Science & Technology Education Conferences (STEC) have been a success in providing participants with a variety of teaching strategies. In each Science & Technology Education Conference, topics relating to gender needs, issues and instructional strategies have been of paramount importance.

The second PATT-HK study

It has now been three years since girls had the opportunity to take D&T, with some schools fazing-in the opportunity due to continued scheduling and/or staffing difficulties. In the 2001–2002 academic year, all schools offering D&T now allow girls to participate. The result is that some girls have now had D&T for three years, while others have just been introduced to the subject. In light of this change to D&T programs, the authors felt it was appropriate to duplicate the PATT study to ascertain whether D&T was having any influence on pupils' attitudes.

Methodology

Following a similar methodology and the same instrument used in the previous PATT-HK study (Volk & Yip 1999), the attitudes of secondary 3 students toward technology were again examined in a second PATT study (PATT2-HK). A list of schools offering D&T was first obtained from the Education Department. This list indicated whether boys and girls were taking D&T for three years or whether girls were just beginning to experience D&T for the first time in Secondary 3. Using a cluster sampling technique (Shao 2002), schools were randomly selected and sent a consent letter and the sample instrument. From the two categories, 14 out of 40 schools (35%) having girls just taking D&T for the first time (or about to take D&T that year), and 8 out of 24 (33%) schools that had girls going through three years of D&T agreed to participate. Using the population to determine sample size, the number of students estimated to participate was found to be sufficient (Bordens 2002). Co-operating teachers were then sent packages of questionnaires, directions to administer the questionnaire, and a proforma asking questions about their program and students. A follow-up telephone interview and site visits were also conducted to ascertain the type of D&T program in the school. Features such as the syllabus used, type of facilities, and type of activities were used to classify the programs as either Traditional or Innovative.

Like the PATT-HK study, the PATT2-HK questionnaire consisted of three parts. The first section requested the student to provide a short description of what technology is. The second section contained questions seeking information required for demographic data analysis. The third section contained 58 statements to assess respondents' attitudes toward technology. A five-point Likert scale, with 'strongly agree' to 'strongly disagree', was used for student responses. The attitude statements were broadly organised under the following six categories:

1. Interest in technology (Interest)
2. Technology as an activity for both boys and girls (Role Pattern)
3. Perception of the difficulty of technology (Difficulty)
4. Consequences of technology (Consequence)
5. Technology in the school curriculum (Curriculum)
6. Ideas about pursuing a career related to technology (Career Aspiration)

The PATT2-HK study would examine the following questions:

1. Are there changes in demographics since the 1997 PATT study?
2. What differences exist between boys and girls attitudes toward technology?
3. Are there any differences in girls' attitudes for those that participated in D&T for three years, compared with girls just starting?
4. Are there any differences in attitudes from programs that are classified as "Traditional" or "Innovative"?

Demographics

A total of 2876 usable surveys were returned in the PATT-HK study with 52.2 percent of the respondents were boys and 47.8 percent girls. This proportion corresponds closely with the 2001 Population Census with 51.5 percent in the 10–15 age group being boys and 48.5 percent girls (Hong Kong SAR Government 2001).

Technological climate in the home

Table 1 shows the results of the information gathered on the technological climate in the home. For the majority of students, the father's job had little or very little to do with technology. When students were asked about their mother's occupation, a higher percentage indicated that their mother's job had little or very little to do with technology.

In general, there appears to be a reduction in occupations relating to technology, having technical toys, and working space for modelling at home since the earlier PATT-HK study.

Table I

Cross comparisons of gender with student characteristics and home environment

	1997 (in %)		2002 (in %)	
	BOYS	GIRLS	BOYS	GIRLS
Extent father's job has to do with technology (n)	(1817)	(1444)	(1465)	(1348)
very little	30.5	33.8	41.0	48.7
little	37.4	38.8	38.6	36.6
much	25.0	21.3	15.4	10.8
very much	7.1	6.2	5.0	3.8
Extent Mother's job has to do with technology (n)	(1785)	(1399)	(1426)	(1311)
very little	59.6	62.1	64.4	69.7
little	25.8	22.7	24.5	20.6
much	11.4	12.2	8.0	7.6
very much	3.2	3.0	3.1	2.1
Is there a personal computer in your home? (n)	(1863)	(1471)	(1473)	(1361)
Yes	54.5	45.7	89.3	87.1
No	45.5	54.3	10.7	12.9
Do you think you will choose a technological profession? (n)	(1860)	(1471)	(1465)	(1347)
Yes	65.0	47.2	66.5	54.1
No	35.0	52.8	33.5	45.9

What was most interesting was the increase in the numbers reporting having a personal computer at home, with 50 percent having a computer in 1997 to nearly 88 percent in 2002. Also, although the percentage of boys indicating an interest in a technological profession remained nearly the same, girls appeared to have a greater interest than in 1997. The number of girls interested in a technology career increased from 47.2 percent to 54.1 percent. This seems to correlate positively with the increased rate of girls taking D&T or other technical subject having multiplied seven times since 1997. This increased interest by girls was encouraging to see, although the interest was still less than boys.

T-tests on student characteristics

T-tests were conducted on the six student characteristics and the six attitude categories of "Interest", "Role Pattern", "Difficulties", "Consequence", "Curriculum", and "Career Aspiration". The results are presented in Table 2.

Table 2

T-test on demographic characteristics

Characteristics	Interest in technology	Role Pattern	Technology is difficult	Consequences of technology	School Curriculum	Career Aspiration
Gender						
Boy (1502)	2.57	2.72	2.81	2.43	2.51	2.62
Girl (1374)	2.80	2.69	2.81	2.49	2.61	2.77
Significance	**			**	**	**
Personal computer						
Yes (2502)	2.66	2.70	2.80	2.43	2.54	2.67
No (332)	2.82	2.78	2.85	2.61	2.68	2.83
Significance	**	**	**	**	**	**
Girls who have taken D&T or technical subject in school						
Year One (378)	2.79	2.73	2.83	2.55	2.64	2.71
Year Three (745)	2.82	2.67	2.80	2.46	2.60	2.80
Significance				**		**

**significance = $p < .01$.

As in the 1997 PATT-HK study, the PATT2-HK found that when examining the characteristic of "Gender", boys continued to have more positive attitudes than girls in categories of "Interest", "Role Pattern", "Difficulties", "Consequence", "Curriculum", and "Career Aspiration". Although girls continued to have more positive attitudes about "Role Pattern", it was not significant. One other interesting observation was that when only girls had D&T as an initial experience (Year One) and those having it for three years (Year Three) were compared, two significant differences appeared for the categories "Consequence" and "Career Aspiration". This led to a need to examine differences in the way programs were taught as potential factors influencing this outcome.

T-tests on program type

With programs classified as "Traditional" or "Innovative", T-tests were conducted on the Year One and Year Three girls. The results are presented in Table 3.

Table 3

T-test on School Type

Characteristics	Interest in technology	Role Pattern	Technology is difficult	Consequences of technology	School Curriculum	Career Aspiration
Year One						
Traditional (172)	2.73	2.65	2.76	2.49	2.54	2.65
Innovative (151)	2.86	2.81	2.90	2.67	2.76	2.77
Significance	**	**	**	**	**	
Year Three						
Traditional (398)	2.80	2.67	2.79	2.46	2.62	2.79
Innovative (347)	2.84	2.67	2.81	2.74	2.58	2.80
Significance						

**significance = $p < .01$.

The girls studying D&T in Secondary 3 for the first time (Year One) showed significant differences between Traditional and Innovative programs in five of the six categories, with those in Traditional programs having more positive attitudes toward technology. Those having three years (Year Three) did not show differences. This may point out that the approach, activities and facilities used to introduce technology to girls may initially be more appealing or less threatening in traditional programs, and after three years of experiences, these differences are gone.

Discussion

The Design & Technology programs in Hong Kong have gone through considerable changes in recent years. With the results of the first PATT-HK study that helped convince educators that D&T should be made available to girls, and the changes in recruitment and course content that helped attract women to become D&T teachers, some progress has been observed. Gender equity is beginning to be a reality, and as evidenced in the PATT2-HK study, the difference in attitudes between boys and girls for the categories of "Role Pattern" and "Difficulty" are now gone.

However, one interesting observation can be made about both boys' and girls' attitudes since the 1997 study. That is, there now appears to be less positive attitudes toward technology across all six categories. History can possibly be used to explain this phenomenon, as Hong Kong's (and the world's) current economic, social and political landscape has changed a great deal since then. With recent events such as the World Trade Centre terrorist attack, increased regional pollution, and an unemployment rate in Hong Kong hitting record levels, attitudes toward technology would be expected to be different then during less traumatic times. As the study of technology is not only about the present but also about the future, concerns must be raised about the expected prospects and current attitudes students have as members of this ever-changing technological world.

Questions and concerns also exist for the way D&T is taught in schools. It appears that in early experiences with Design & Technology programs, girls in more traditional programs have more positive attitudes toward technology. This may suggest that as girls are introduced to the subject, a more traditional program may be a better initiation before moving on to more innovative approaches, including those with high technology.

The future of D&T in Hong Kong

In Hong Kong, debate over the future of education has taken centre stage, with a new government, the introduction of several major policy initiatives and a new Secretary for Education and Manpower under a new Ministerial system. Like many other places in the world, the subject of Design & Technology (Technology Education) as being a necessary and valuable part in students' curriculum has to be convincing to educators and the public. Unfortunately in Hong Kong, it has become even more urgent that educators, the public and the Minister need to be convinced of the necessity to even continue D&T programs, with the existence of the programs at stake. To help in this matter, the results of the PATT2-HK study will be disseminated to policy makers in order to explain the impact D&T can have on girls' attitudes.

Also will be the suggestion that because of the technological world all students live in, and the influence programs such as D&T have on students' attitudes, all secondary schools should include such programs as a necessary part of the curriculum. Currently only around half of the secondary schools do. This will obviously require a monumental effort to convince the public and the government during these trying economic times. But perhaps again armed with convincing evidence, the once "unimaginable" of having girls in D&T programs that were a result the first PATT-HK study can again be achieved, this time for all boys and girls to have the opportunity in all schools. This is the hope of the authors.

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Technology Education and Higher-Order Thinking

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Technology Education as an evolving subject area is approaching a pedagogic crossroad. That is, the instructional strategies of lecture and demonstration traditionally associated with the industrial arts subjects of the recent past are being superceded, but perhaps will never be totally replaced, by more student-centred informal teaching and learning strategies. Curriculum documents (United Kingdom), standards statements (America) and syllabus documents (Australia) are now emphasising the life-long learning and higher-order thinking benefits of students' exposure to student-centred Technology Education learning environments. Students are expected to accept responsibility for their own learning, and teachers are required to facilitate a learning environment that supports students during independent and group learning experiences. Many researchers have been prepared to support this notion of the technology learning environment as one which increases students' use of higher-order thinking skills. However, empirical research examining the technology learning environment and student higher-order thinking, is limited. In response to this lack of research evidence, a pilot study (Walmsley 2001) was initiated in a number of Queensland state and independent high schools to examine the influence of current Technology Education teaching practices on students' use of different types of thinking. This paper presents and discusses the findings of this study.

Introduction

The subject of Technology Education is in transition throughout the world (McCormick 1996; Linnell 1994; Fritz 1996; Lewis 1999). Curriculum reform is requiring the subject's adjustment to meet the needs of the world's current post-industrial technological societies (Lauda 1988). Zubrowski (2002, p.48) argues that, "…there is an on-going debate about the nature of technology education and that current practices may be seen as transitional in nature, there are shortcomings in these practices that need to be addressed." Various modifications to curriculum documents (QCA 1999), standards statements (ITEA 2000) and syllabus documents (QSCC 2002; QSA 2002) are currently being formulated in recognition of the need to redefine the pedagogy of Technology Education. What these documents have in common is a commitment to developing students' higher-order thinking skills, so that ultimately students as future citizens may have the cognitive ability for critical and creative interaction with an exponentially developing technological society.

However, the instructional focus of the industrial arts subjects of the recent past has been more on students acquiring prescribed industrial hand and machine skills, than on students' use of higher-order thinking skills. The change of pedagogic emphasis towards thinking skills in preference to industrial skills has placed pressure on technology teachers to alter their teaching strategies (Fritz 1996; Linnell 1994; Lauda 1988). Industrial arts teachers have traditionally used lecture and demonstration strategies, "show and follow" (Fritz 1996, p.212) to instruct students in the use of particular industrial skills. The dilemma for these teachers is that current curriculum reform in Technology Education is prescribing the use of a technological design process in their teaching programs. This designing process requires that teachers and students depart from their traditional teaching and learning roles (Fritz 1996). That is, teachers are no longer to be considered instructors of hand and machine skills, but rather facilitators of student initiated design activities, which require students' use of higher-order thinking skills, such as problem-solving and critical and creative thinking (Winek & Borchers 1993). Students are to become more active with, and responsible for, their own learning (Deluca 1992). In essence, the technology learning environment is experiencing a fundamental shift from incorporating predominantly teacher-centred teaching and learning strategies, to a learning environment that now incorporates those strategies that are predominately student-centred (Deluca 1992; Johnson 1996b; Wicklein & Rojewski 1999).

The significance and need for the study

There exists a body of Technology Education related literature (e.g. Eggleston 1992; Herschbach 1995 1998; Johnson 1996a 1996b; Lee 1996; Mahlke 1993; Pucel 1992; Foster 1996; Williams 2000) that lays claim to an increase in student higher-order thinking potential, in unique technological problem-solving orientated technology learning environments (Williams 2000). However, these claims are made with limited acknowledgement of the lack of substantive empirical research evidence concerning the cognitive activities of students in Technology Education (Johnson 1997) and in "particular of what teachers and students actually do in classrooms" (McCormick 1996, p.72). Technology Education classrooms in Queensland, as in other parts of the world, should be of particular interest to researchers at this time. This is because these classrooms offer the opportunity for examination of the initial transition process from industrial arts to design in Technology Education. That is, how does the transition process effect the cognitive activities of technology students? An understanding of how students' react cognitively to certain types of instruction is important in terms of the instructional strategy teachers' employ. The current literature and curriculum documentation relating to Technology Education requires that teachers should aim to use instructional strategies which encourage students to use higher-order thinking skills (Lee 1996). This study (Walmsley 2001) was initiated in acknowledgement of the lack of empirical research into the cognitive activities of technology students during different methods of instruction.

Research approach

Walmsley's (2001) study focused on student perceptions of their own learning activities. Aspects of cognitive theory in the form of Cognitive Holding Power (Stevenson 1998; Stevenson & Evans 1994) were used to examine the relationship between students' use of procedural knowledge and the task environment in various technology classrooms. The Cognitive Holding Power (CHP) concept is defined as the press exerted by an educational learning environment, which causes students to utilize certain levels of procedural knowledge (See Stevenson & Evans 1994 for details).

Stevenson and McKavanagh (1992) interpret procedural knowledge in terms of hierarchies or orders. First order procedural knowledge is defined as knowledge of how to perform specific skills, much the same as the industrial skills, which students in industrial arts type technology learning environments would be expected to perform. Second order procedural knowledge is defined as knowledge of how to apply problem-solving skills, which assist with the application of previously acquired first order skills and conceptual knowledge to new and unusual situations. Second order procedural knowledge would be expected to be evident during students' technological problem-solving activities (higher-order thinking) in design process based Technology Education classrooms (Garcia 1994). Third order procedural knowledge is defined as knowledge that judges as to the appropriateness of all other levels of knowledge in specific circumstances. Of particular significance for Technology Education, is the ability of the CHP construct to differentiate between learning environments that press for either first order procedural knowledge, that is learning environments that have first order cognitive holding power (FOCHP) or learning environments that press for second order procedural knowledge, that is learning environments that have second order cognitive holding power (SOCHP) (Stevenson 1998).

The Cognitive Holding Power Questionnaire (CHPQ) is an instrument developed to assess learning environments relative to students' perceptions of the press for different levels of procedural knowledge (Stevenson & Evans 1994; Stevenson 1998). The CHPQ seeks students' responses to 30 questions, which each relate to the amount of control students' perceive they or their teachers have over their learning activities. Each question in the CHPQ requires students to respond to a five-tiered Likert scale, ranging from *almost never* to *very often*. Questions such as, "I ask questions to check my results" and "I try out new ideas," require responses that indicate the students' perception of a learning environment that presses for student control (SOCHP). Questions such as, "I copy what the teacher does" and "I feel I have to work exactly as I am shown," require responses that indicate the students' perception of a learning environment that presses for teacher control (FOCHP).

A modified version of the CHPQ (i.e. title change only – Technology Education Response Form "TERF") was used to collect data for this cognitive examination of technology classrooms.

Subject selection

After receiving approval from Education Queensland to proceed with the research, 800 year nine and ten students in a total of nine Queensland state and independent high schools were chosen to participate in the study. 480 students of the original 800 provided consent, a response rate of 60%. These schools were approached in February 2001 as they had prior knowledge of the Years 1–10 Technology Syllabus, which at this time was on trial in these and other schools throughout Queensland. Knowledge of the syllabus enabled each school to provide a description of the instructional strategies being used in the delivery of their technology curriculum. The teaching strategies at each school were described as being orientated towards either a design based, an industrial arts based or a combination of design and industrial arts based. A brief informal interview with those in authority in the technology subject area of each school provided the researcher with consistency across school instructional descriptions.

Strengths and limitations of the study

Research instrument

The CHPQ as developed and validated over previous studies (Stevenson & Evans 1994; Stevenson 1998) provides this study with both a reliable and valid research instrument. A principal component analysis with Varimax rotation, and Cronbach's α reliability scores (Bryman & Cramer 1997; Field 2000) for the tested variables were used to interpret the reliability of the scales FOCHP and SOCHP, and the validity of the CHPQ construct in this current study. The results of the α reliability and principal component analysis mirrored those found in previous studies (e.g. Stevenson & Evans 1994; Stevenson 1998). This further supported the reliability of the two scales FOCHP (α = 0.76 to 0.81) and SOCHP (α = 0.78 to 0.82) (Walmsley 2001, p.64).

Sampling method

The purposive sampling method (Bernard 2000) used in this study provided an approximately equal number of students from various high schools, which represented each of the three teaching orientations under examination. Table 1 (Walmsley 2001, p.60) shows student response numbers per variable.

Data collection

Teachers were required to administer the questionnaire to their own class. Each teacher was provided with an introductory dialogue to present to students before they responded to the questionnaire. This provided a consistency of introduction for students across schools and teachers. The researcher had no control over when during the school day each class was administered the CHPQ. The response process was totally dependent on school class timetables. However, each class group did respond to the questionnaire in the same four-week period. All the data was returned to the researcher by late March 2001. The researcher did not observe classroom activities during the data collection period.

Data

The data was tabulated and recorded using SPSS 10.1 for Windows. Means and standard deviations of student responses regarding FOCHP and SOCHP were analysed with reference to school teaching orientation. Analysis of variance F – test (ANOVA), Univariate analysis of variance using type III sum of squares and Scheffe *post hoc* comparisons were conducted to establish the significance of between and within category responses (Field 2000; Bryman & Cramer 1997). A Shapiro-Wilk Tests of Normality (Field 2000) was used to ascertain the distributions of responses for both FOCHP and

SOCHP. The Responses for FOCHP were normal for all categories. However, there was some deviation from normal for SOCHP and the industrial arts based category. The category that violated normal distribution principles were included in the parametric analysis after consultation with the literature (Bryman & Cramer 1997). Table 2 (Walmsley 2001, p.67) shows the distributions with deviations below 0.05 (not normal) highlighted.

Research results

The results of this study indicate that students interpret an increased press for SOCHP relative to the extent of design based teaching orientation in their technology learning environment (Walmsley 2001). That is, technology subjects with a design orientated teaching strategy exhibited a superior mean result for SOCHP than did both industrial arts and the combined categories. However, the mean results for FOCHP were consistent across all three teaching orientations (Walmsley 2001). Table 3 (Walmsley 2001, p.70) displays the mean results and standard deviations for FOCHP and SOCHP across teaching orientations.

Table 1

Response numbers per variable

TEACHING ORIENTATION	TOTAL
Design Based	161
Industrial Arts Based	171
Combination Ind Arts & Design	148
	480

Table 2

Shapiro-Wilk Test of Normality for CHP across data categories

(Deviations from normal shown highlighted)

DATA CATEGORY	SIG. FOCHP	SIG. SOCHP
Design Based	0.852	.123
Combined Design & Ind Arts	0.464	.294
Industrial Arts	0.082	**.005**

Table 3

Mean results for cognitive holding power and teaching orientation

(Standard deviations in brackets, N = number)

SUBJECT TEACHING ORIENTATION	FOCHP	SOCHP	N
Design Based	3.08 (0.56)	3.12 (0.52)	161
Combined Design Ind Arts Based	3.09 (0.54)	2.96 (0.52)	148
Industrial Arts Based	3.07 (0.68)	2.92 (0.58)	171
Total	3.08 (0.60)	3.00 (0.55)	480

Walmsley's (2001, pp.69–71) investigations of this data using a one way analysis of variance (ANOVA) (Field 2000) for the effect of technology subject teaching orientation on CHP, found that the relationship with SOCHP to be significant (F = 6.322; p = 0.002) but insubstantial (adjusted R squared = 0.022). Further analysis (ANOVA) of the SOCHP means between the design based and industrial arts based learning environments only, indicates that the variation is more significant (F = 11.093; p = 0.001). However, the effect of teaching orientation on SOCHP between design and industrial arts based learning environments only, accounts for just 3% of the variance (adjusted R squared = 0.03). The relationship between FOCHP and technology subject teaching orientation was found not to be significant (F = 0.025; p = 0.98). A Scheffe *post hoc* test of comparison between teaching orientations and SOCHP revealed that design based learning environments were significantly superior to both, industrial arts based and combined design & industrial arts based environments (p = 0.003 and p = 0.035 respectively). However, no significant difference was discovered between industrial arts and the combined categories (p = 0.79).

Discussion

The results of Walmsley's (2001) examination of the cognitive activities of technology students in different types of technology learning environments, indicates that students do experience an increased and significant, yet insubstantial press for second-order procedures (higher-order thinking; e.g. technological problem-solving) in design-based technology classrooms. Also, the study's results indicate that students are equally pressed for first-order procedures (skill development) throughout all forms of technology learning environment, regardless of that environments design component. This empirical research evidence regarding students' perceptions of their own learning activities, provides support for the argument that design based technology teachers are currently mixing teaching strategies (i.e. teacher support (FOCHP) and student autonomy (SOCHP)). It appears that students do perceive significant control over their learning in design based classrooms. However, the study indicates that the extent of this student control was not substantial. That is, the norms or expectations (Talbert & McLaughlin 1993) of current technology curriculum practice (e.g. teacher demonstration and exposition), which flow on as a possible result of Technology Education's craft traditions (McCormick & Davidson 1996), may be causing design based teachers to emphasise teacher control during their instruction (Wiske 1994).

The changing emphasis within all forms of technology curriculum documentation from industrial skill development to cognitive skill development, dictates that the balance between teacher-centred and student-centered learning should now favour the direction of the latter. It appears that design based Technology Education teachers are currently adopting a more learner-centred approach to curriculum delivery, but are doing so while still maintaining a certain level of teacher control over students' learning. These technology teachers may be placing more importance on the making (doing) phase of the design process in preference to (but not excluding) the thinking and planning stages (McCormick & Davidson 1996). At this point, in the subject's evolving history, it appears that students perceive the balance between teaching strategies, as being only marginally weighted towards the student-centered strategies of the design process. The lecture and demonstration strategies of industrial arts education still appear to have considerable influence concerning how students' perceive control over their learning.

Conclusion

Walmsley's (2001) study of Technology Education learning environments has provided a starting point from which others in the field (teachers and researchers) can examine how different instructional strategies influence students' perceptions of learning control. Instructional reform in Technology education is requiring a shift from the industrial arts focus on hand and machine skills to a technological problem-solving focus on higher-order thinking skills.

For both teachers and students in Technology Education the traditional norms associated with teaching and learning are now required to change. That is, students are expected to become more autonomous towards their learning and teachers are expected to facilitate this type of student learning activity. The results of Walmsley's (2001) study provides some encouragement for those who argue favourably for the higher-order thinking benefits of students' exposure to design based technology learning experiences. However, regardless of the subject's transition towards instruction that is more student-centred, there is still and perhaps should always be, the necessity for teachers to demonstrate for students the safe and proper use of a range of hand and machine skills, as well as model for students a range of technological problem-solving skills. These skills ultimately provide students with the opportunity and facility to fulfil the various requirements of the technological design process. Therefore, Technology Education as a subject area should not necessarily devalued the traditional hand and machine skills of workshop industrial arts type subjects, but rather it should revalued these skills in conjunction with higher-order thinking skills to have particular significance within the subject's technological design process.

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Multimedia in Technology Teacher Education

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At the department of "Technology and Didactics of Technology" (University of Essen) a project that addresses the problem of "multimedia" in technology teacher education has been launched. As part of these projects, computer based "objects" are developed, which can be used in lectures and seminars (university), technology courses (general educational schools) and by the students themselves for self-study. A specially developed database (**M**ulti**M**edia**D**ata**B**ase, MMDB) gives users access to interactive learning of technology contents. The MMDB is structured along technological, scientific, and methodological criteria and forms the centrepiece of the multimedia package. The MMDB is part of an **INT**egrated developing Environment for the Gen**ER**ation of modules (INTEGER) and is therefore much more than simply a database with a multimedia focus. The ability of INTEGER to generate so-called "learning modules" on the basis of objects provides the opportunity to test and evaluate these modules. The online use of modules generated by INTEGER makes it possible for students to have access to all the material that is used during lectures and seminars at any given time and place. This is a necessary condition for the use of learning platforms where these modules could be used as an important task at various different stages of E-Learning.

Introduction

At the faculty of Technologie und Didaktik der Technik TUD (Technology and Didactics of Technology [1]) at the University of Essen, the education for Sek II (secondary stage of education) technology teachers at general education schools is clearly focused on information technology. This emphasis is enforced by a new set of regulations for the Conditions of Study [2] and the field of Transformation of Information has been extended to include further courses such as Data Processing III and IV in the Advanced Study Stage (Hauptstudium). The structure of these two courses [3] embraces the focused use of and practice with *New Media* (*New Media* can appropriately be described using the acronym TIME: Telecommunications, Internet, Multimedia, Electronics). The primary goal here is to advance and broaden media proficiency working on the foundations of a basic education in information technology, which include: the operation of different network-based computer systems, the creation of applications that are not dependent on the operating system, and Client-/Server-programming [4]. In addition to those technologies that relate to the Internet, there is also a strong emphasis on the area of Multimedia.

Multimedia in technology teacher education

To define Multimedia, the Encyclopaedia provides three interrelated definitions: 'concerning many media', 'designed for many media', and 'consisting of many media'.

Hence, using a whiteboard and an OHP could be considered to be multimedially oriented teaching! At this stage, however, an unmistakable connection to *New Media* (the central part of which is amongst other multimedial elements) needs to be made. A multimedial element is an element which can be reproduced in picture or sound via different network based systems. For instance this could include a website, an animation/simulation, an interactive application, a video, a sound, or any other a meaningful combination of single multimedial elements.

New Media must not be excluded by either teachers or students, as they are a system immanent part of technology: **the use of contemporary media must be part of contemporary technology teaching!** In order to use *New Media* in a meaningful way it is absolutely necessary for all participants to broaden their media-proficiency.

The multiplicity of multimedial elements determines the complexity of the field of Multimedia. Basic tuition on creating websites is not nearly sufficient. Every multimedial element assumes very specialised knowledge in its creation and its implementation within a certain context. A network-based, multimedial preparation of a lecture or sequence of classes, for instance, is a very costly venture. Not only does it require a selected choice of certain multimedial elements (e.g. a sound-supported, vector-oriented animation in Flash-Format or a video-sequence in MPEG-4-format), but also a specialist and methodologically-supported presentation. It needs to be clearly focused on the subject and, if necessary, also take into account psychological issues.

Multimedial learning can be rendered into one coherent concept linking together three essential steps:

- Creation of multimedially oriented (study-)objects
- Combination of (study-)objects (MMDB and INTEGER)
- Use of study-objects (modules) in study platforms.

Creation of multimedially oriented (study-)objects

The contradiction that not everybody is an expert in all fields but that at the same time there is demand for an expert in every field can only be resolved by giving experts the opportunity to make their knowledge available in a structured way via a comprehensible interface. It follows that every potential user, even without any particular background knowledge, should be able to use this interface. The only requirement would simply be a basic education in information technology. Such an interface can be established using a modular approach.

This approach is currently being developed within the framework of different projects within the faculty of TUD and the website Lernplattform LPF (study platform [5]) provides information on the current state of related project work. The requirement for the project-initiation is a project-co-operative PT-NMB (*Supporter of the Project New Media in Education* [7]) between the University of Essen [8], represented by the faculty TUD, and, the Technical University of Braunschweig [9], represented by the Institut für Allgemeine Technikpädagogik ATP (*Institute for General Technical Pedagogy* [10]); which is promoted by the Bundesministerium für Bildung und Forschung BMBF (*Federal Ministry for Education and Research* [6]). The central issue here is the development of teaching- and study-modules for the faculty of technology. The notion of a module, within this context, is defined as follows:

> A *Module* consists of at least two *Objects* which have been joined together into one coherent unit in any one subject. An *Object* is the smallest and an undivisible coherent unit (e.g. a picture, a closed text on any one subject, an applet, an animation, etc.). A *Teaching*- or *Study-Module* is designed for technology-specific broadening, which allows for specialist integration into technology-specific areas and into engineering or natural sciences. Below, it is also referred to as *Study Object*.

This modular approach has been accomplished in a structured way within the faculty of Technology and Didactics of Technology with the MultiMediaDatenBank für den TechnikUnterricht MMDB-TU (*MultiMediaDataBase for TechnologyTeaching* [11]).

The combination of (study-)objects (MMDB-TU, INTEGER)

Qualified students of information technology from the faculty and educated teachers provide objects of very different types with a variable focus and accordingly associated formats (specialist texts, animations, simulations, interactive elements, videos, sounds, etc.). Such objects can only be entered in a structured way into the MMDB-TU. An important basis for it is the classification with the approach of DCMI (*Dublin Core Metadata Initiative* [12]) which can be found in the RFC 2731 (*Request for Comment* [13]).

The conventions of DCMI are supported by the W3C (*WorldWideWeb Consortium* [14]). The IEEE LTSC (*Institute of Electrical and Electronic Engineers, Learning Technology Standards Committee*) specifies this framework (see *also E-Learning takes important step forward* [16]) in the standardisation IEEE 1484.12 [15] of the LOM-Working *Group (Learning Objects Metadata*). With metadata from educational sciences [18] the European Initiative ARIADNE [17] is currently working on an extension of the above mentioned scheme.

DCMI provides a vital set of 15 basic elements (*title, creator, subject, description, publisher, contributors, date, type, format, identifier, source, language, relation, coverage* and *rights*) in order to make it easier to find accordingly classified data. These basic elements can be integrated into HTML-documents in the form of metadata, or, can be recorded via simply structured RDF-based data (*Resource Description Framework*).

Every object that has been entered into the MMDB-TU, regardless of which type of format it has, must be described in a data record according to DCMI. The MMDB-TU has templates and various input masks available in order to instruct the user correctly. He is responsible for entering the data record which describes the respective object in as much detail as possible. The object is entered into the MMDB-TU exclusively on the basis of these details. Changes to object descriptions that have been entered are possible at any time. Otherwise, the user can call an integrated help function which holds detailed examples and descriptions ready for entering objects and formulating basic elements according to DCMI. Once the objects have been entered, they can be joined in modules (study objects) via the Integrierte Entwicklungsumgebung für eine Generierung von Lernobjekten INTEGER (*Integrated developing Environment for the Generation of Modules* [19]) which allows for different or even completely new focuses.

The integrated developing environment INTEGER, on the basis of the MMDB-TU, provides the opportunity to create modules (study objects) of a simple or complex kind from existing objects, regardless of which type of format they are in. Further, study objects that have previously been generated can be re-entered into the MMDB-TU at any time. Within this context, an extended classification of the basic elements according to DCMI is used.

The arrangement of this extended classification follows a scheme of technical devices according to G. Ropohl [20]. And here the notion *of technology* is exclusively regarded in terms of its natural definition. In addition to the general criteria of order (attributes) such as *substance, energy and information*, technology-specific extensions (functions) are also possible: *conversion, transport and storage*. The resulting attribute-function-matrix describes four fields of use which allow for a more refined classification of the details. The fields of use are: *supply and disposal, transport and traffic, information and communication, automation*. For instance the item optical wave guide [21] can be found in the field of *use information and communication* and the attribute *information* is assigned to the function *transport*.

In addition to its ability to generate study objects, INTEGER also provides selective query options for the MMDB-TU. Controlled by query masks and based on a search term or phrase it is possible to search certain attributes, functions and fields of use. The results will then be displayed according to a pre-adjustable weighting. With every found object (as for instance gif-animations, flash-simulations, java-applets, MPEG-files, HTML-texts) or study objects (HTML-files which have been composed by the above mentioned objects) the user is able to see the contents and its description. In this way he can decide carefully which (study)objects he needs in order to generate a new individual study object with a focus of his choice. After this he has the opportunity to enter the generated learning object into the MMDB-TU and a new description, corresponding to the newly chosen focus, can be made. When viewing the search results, the user can make an evaluation of (study-)objects. He thereby makes a contribution to a simple evaluation of the database.

New study objects that have been generated by the user are retrievable online at any time with the appropriate search criteria. Moreover, there is the possibility to have study objects sent to yourself by e-mail attachment.

It needs to be mentioned that the MMDB-TU together with INTEGER does not serve only as an online system for self assessment study. However, both provide study objects which can be entered into existing E-learning-study platforms: Integriertes Lern-, Informations- und Arbeitskooperations-System ILIAS (integrated study-, information-, and work co-operation-system [22]) or OpenUSS (Open University Support System [23]). The MMDB-TU together with INTEGER thereby fill the gap between mere contents and structured study objects which are necessary for the use of study platforms.

The use of study objects (modules) in study platforms

The Ministerium für Schule, Wissenschaft und Forschung des Landes Nordrhein Westfalen *MSWF (Ministry for Schools, Science and Research of the Bundesland North Rhine-Westphalia* [24]) has accepted the faculty of TUD into the new support programme Studienreform 2000plus (*Reform of Study 2000plus* [25]) since 2001. In addition to the promotion of innovative Reform of Study projects and didactic training concepts the programme guidelines also include assessment measures which are tied into quality assurances. Within the framework of this project, the two CampusSource-study platforms ILIAS and OpenUSS mentioned above are being tested in the presence courses as a meaningful complement for the use of study objects via the MMDB-TU and INTEGER. For this purpose, a radio-network of 15 laptops (supported by Reform of Study 2000plus) is used which enables teachers and students to access any documents that are used in the courses at any time and any place using the Internet. In this way, the use of the two study platforms in technology teacher education enables multimedially oriented studying to be realised in light of the issue of broadening information technology based media-proficiency.

Summary and outlook

In this way, within the faculty of technology and didactics of technology, the three principles of multimedial studying have not only been realised but also combined: the *creation of multimedially oriented (study-) objects or modules, the variation of (study-) objects* (*MMDB-TU and INTEGER*), and the *use of study objects (modules) in study platforms*. As far as it has been possible, parts of the project results have been introduced to a broad section of the public at various different education fairs (Lerantec Karlsruhe [26], Bildungsmesse Köln [27]). Conception and outcome of subject related and finished multimedia projects [28] supported by the Universitäts Verband Multimedia UVM (*University Group Multimedia* [29]) have been presented at the international PATT-11 Conference (*Pupils' Attitude Towards Technology*) of ITEA (*International Techology Education Association*) in Haarlem (Netherlands) [30], e.g. under the topic *New Media in Technology Education*. In Cape Town, South Africa, the intermediate outcome of the project work described above has been introduced under the topic *Technology Education, Optimal Use of Resources* [31] in collaboration with the PATT Foundation of Eindhoven and the Cape Technicon to an international specialist audience. Around the end of 2003 all work on the projects and above mentioned plans will be completed. All activities will then be accessible to the public. In respect of forthcoming pan-European projects, all contents will eventually be available in two languages. However, work still needs to be done in terms of legal arrangements regarding the right of use concerning objects and modules.

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Issues in the Delivery of International Technology Education

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This paper examines issues concerning the delivery of international technology teacher education programs from both an institutional and student perspective. Analysis of the issues is based on experience in the delivery of local and off shore international programs over several years and current research into the experiences of graduates teaching in various contexts within Botswana. Both institutional and student issues will be discussed with particular focus on aspects of cultural, contextual, technological and pedagogical difference. Institutional issues range from the pressures associated with marketing education internationally, correlations between international technology education and general technology transfer, and pragmatic concerns such as modes of delivery and political contexts. Issues for students include the contextualisation of appropriate technology and the cultural transferability of content, methodology and pedagogy.

Introduction

A significant development in technology education in recent years has been the extent of change in educational programs, and the similarities in the direction of that change.

Many countries are developing technology education through challenges to traditional characteristics of schooling–the decontextualisation of knowledge, the primacy of the theoretical and secondment of the practical, and the organisation of the curriculum along disciplinary lines. Technology education's response to these characteristics include an emphasis on the context of the technological activity, the achievement of learning through the interaction of theory and practice and it is interdisciplinary nature.

The tradition has also generally been gender biased. The new technology education is moving away from narrow vocational preparedness and from gender specificity. The culture of school technology (Puk 1993; Layton 1993) is developing, though still in its infancy, into beliefs about values, practices, content, methodologies and capability.

Some of the trends in technology education, which are obvious in a number of countries, include a movement from:

- teacher as information giver to teacher as facilitator of learning
- teacher controlled learning to teacher learner partnership
- teacher centred learning to student centred learning
- time age and group constraints to individualised learning

- materials based organisation to needs based activity
- product centred to process centred
- elective area of study to a core subject
- social irrelevance to socially contextualised.

Given the identification of these types of common trends, there is also a great degree of diversity throughout the world in technology education (Williams 1996). This diversity ranges from the absence of technology education (Japan) to its compulsory study by all students (Israel), an instrumentalist approach (Finland) to a basically humanistic approach (Scotland), a focus on content (USA) to a focus on the process (UK), an economic rationalist philosophy (Botswana, China) to a more liberal philosophy (STS in the USA), a staged and well supported implementation of change (as proposed in South Africa) to a rushed and largely unsuccessful implementation (England), integrated with other subjects (science in Israel) or as a discrete subject (Australia). The derivation of current programs varies as well, for example in some countries it has derived from vocational programs such as in Taiwan, and in others it is influenced by craft subjects such as in Sweden.

Both the commonalities and the diversity are appropriate. The type of technology education developed within a country must be designed to serve that country's needs, and build upon the unique history of technical education resulting in a unique technology education program. This paper will address the development and implementation of both offshore programs and the delivery of onshore programs to International students. It will also identify issues relating to the delivery of such programs through experiences with their establishment and delivery, and through research of graduate experiences. An approach is described that has been developed and implemented in Mauritius, Seychelles and Botswana to meet the need of technology teacher education in these countries. It will outline the principles of course design, modes of delivery, some of the issues of course delivery and the cultural dynamics of the student experiences in one of the programs.

Technology teacher education

The corollary of implementing a new curriculum is the teachers required to deliver it successfully. When a technology curriculum is revolutionary in that it departs significantly from the trends and traditions preceding it, as many technology education curriculum are, then traditional teachers become a barrier to its successful implementation. The dichotomy between a revolutionary curriculum and the evolutionary understanding of teachers can only be reconciled over time with professional development and education.

There is evidence of a shortage of technology teachers in many countries (Ritz 1999; Banks 2000; Williams 2000), the reasons for which vary from country to country.

Nielsen (1997) has identified a number of reasons for insufficient numbers of trained teachers including a shortage of qualified candidates, the length of time required for certification, the expense of teacher education programs, difficulties in student access to teacher education sites and the scarcity of student places. In addition to these factors, an outcome of the renewed interest in technology education in smaller countries is that it is not well catered for in the higher education sector, including teacher-training institutions. One of the reasons for this is the limited number of higher education institutions, typically one or two, and the resulting limited flexibility and resources. This situation exists for example in a number of southern African countries, where technology teachers are trained to a certain level, for example a two-year diploma, and the provision is not generally available within the country to train beyond that, say to a bachelors degree level.

Forms of distance education

There are many different forms of distance education ranging from traditional text based to online structures. The main defining feature of all forms of distance education is the separation of the learner from the instructor, by distance and often by time. Placing technology education into a distance education context raises particular issues because of the essentially practical nature of technology. It is not possible to satisfactorily teach technology in any form of distance mode.

It is difficult to find current research about text-based distance education, this having been overtaken by online and Internet modes of delivery. Of the 558 articles on Technology education searched for this paper, and the 526 full-text online journals accessed through WilsonWeb, a number of searches revealed no research since 1990 on text-based distance technology education.

A comparison of this emphasis with the state of the world's population in terms of computer availability, phone lines and arguably that portion of the population in most need of education, indicates a significant imbalance. In low-income countries (40% of the world's population) there is 1 computer for every 250 people, in high-income countries (14.9% of the population and generally the origin of on-line distance education) there is 1 computer for every 3 people. In low-income countries there is 1 telephone line for every 37 people, in high-income countries there is 1 for every 2 people. There are about 400 million computers in the world and 300 million of them are owned by 15% of the world's population.

Table 1

Telephone line and computer ownership by income category

CATEGORY OF COUNTRY	% OF WORLD POPULATION	PCs/1000	TLs/1000
Low Income	40%	4	27
High Income	14.9%	346	583

One cannot help but conclude that the current direction of distance education research is not serving the interests of the majority of the population who need an education. This is compounded by the high proportion of untrained and unqualified teachers in low income countries (Nielsen 1997), and reinforced by the evaluation of distance education reported in this paper.

Course design

The courses reported and evaluated in this paper have either been delivered or are currently operating in Mauritius, Botswana and Seychelles.

A teacher education course in technology education derives its content from three main sources. One is the educational system for which the teachers are being trained. Information from this source includes syllabi, methodologies, school contexts, etc. The second source is the technological activity that takes place in society, and the third source is from the discipline that is being studied, in this case technology education. The research and literature of the discipline gives guidance on content, structure, learning patterns and methodologies.

These are all vital sources for the design of a teacher-training course in technology education. Graduates need to be suited to the system in which they are going to work, be able to relate their teaching to the technology context around them and to be up to date and informed by research. Their tertiary studies should be more than a repetition of the secondary syllabus at a deeper level.

Each course was designed to accommodate the above characteristics in the context of the appropriate education system. This meant significant local input with regard to the local educational system and the social/technological context. It was found that it is difficult to do this at a distance and requires face-to-face negotiation by someone who has both content knowledge and university authority to negotiate the course, answer questions, and evaluate the environment in which the course would be delivered. Important information related to facilities and equipment, prior experience and education of the potential students, cultural and regional considerations, local co-ordinators and living conditions.

The broader contextual goal of the courses is also the sustainable development of the country. This applies to individual teachers who, as a result of their course, will develop relevant and current content knowledge in technology education, incorporate contemporary pedagogical skills into their teaching, and have a defensible rationale for what they do.

Typically, at the early stages, courses had to be designed quickly. The identification of a market opportunity was followed by the development and submission of a proposal to the key people in the market. A lengthy delay at this stage could have resulted in missed opportunities. The initial proposal was clearly identified as a flexible starting point for discussion and negotiation about the structure and content of the course, then the specifics were modified later.

Initial proposals were not specifically costed, but a range of delivery options were outlined, with an indication of the relative expense of each option. Sponsors do not necessarily choose the least financially expensive option, as other factors such as ease of administration and perceived quality of delivery are important factors. In one country the most expensive delivery option was selected because that was the traditional approach to upgrading teachers in that country.

As a result of these initial visits and communication, a specific and costed proposal and course design was developed and signed by the appropriate parties. Responsibilities of all involved were specifically detailed. This detail is essential, and can significantly impact on course success. For example in a course that was delivered in Mauritius, student consumables were the responsibility of the local sponsors. This proved to be a greater expense than was anticipated and would have impacted significantly on university revenues.

Course delivery and structure

The Design and Technology Bachelor of Education (Secondary) program is designed to prepare students to teach Design and Technology at all year levels in the secondary school. The award is granted after the successful completion of four years of full time study (or equivalent), that is 8 semesters at 4 units each semester, or 32 units. The remainder of the suite of undergraduate courses available in this area include a 3-year Bachelor of Arts, a 2-year BEd upgrade for diploma holders and a 1-year BEd upgrade for BA holders. These are all subsets of the 32 units of the Bachelor of Education, which provides a pool of units from which to select the most appropriate for the specific market. So for example, the 16 units of a 2-year BEd upgrade offered in one country may be different from that offered in another because they are selected and matched to the specific needs of the market.

The courses are delivered through a combination of distance mode and intensive workshops/lectures over a period of up to four years. Students study part time, and enrol in two units per semester. The part time study involves readings, assignments, assessment and examinations being forwarded to the students, in concert with a period of intensive lectures/workshops in their country. This provides about 30 hours of face to face interaction for each unit in the middle of each semester. So students do some study both before and after the on-site classes.

The advantages of this mode of delivery include:

- No disruption to schools through the absence of teachers;
- Education activities and discussions can be based on current practice;
- The opportunity for collaborative teaching and research between local staff and university lecturers.

The upgrade course consists of three types of units:

- Education Studies: studies in the theory of education, educational psychology and teaching studies and practice.
- Curriculum Studies: studies of relevant curriculum resources and related teaching.
- Content Studies: appropriate specialisation content.
- The balance of these units varies depending on the local context and needs.

Costs and responsibilities

The sponsor's responsibilities may include:

- Nomination and resourcing of a locally based program co-ordinator;
- Recruitment of the cohort of teachers into the program;

- The provision of an appropriate venue for the on-site teaching;
- Funding time off for course participants, for example 1 day/fortnight during semesters;
- The provision of consumables and technical support for the on-site teaching;
- Organisation and funding of mentors;
- Organisation and invigilation of examinations.

The University's responsibilities include:

- All costs associated with university or local staff conducting the in-country teaching;
- Provision of all distance education materials;
- Implementing enrolment and recording procedures;
- Reasonable remediation of failing students;
- Setting and marking assignments and examinations;
- Granting the relevant degree.

If the government sponsors the program, it is funded on the basis of a specific number of students being the minimum in the cohort. If the number of students drops below that level, the cost will be maintained. It is generally agreed that a specific number of students above that level can be enrolled for no extra cost.

Researching international technology education

Since 2000 a research project has been underway to examine the experiences of teachers returning to teach in Botswana after spending two years upgrading their qualifications in Australia under a government sponsored program. This ethnographic study focuses on the relationships between technology education and the cultural contexts in which it occurs. It examines the experiences of graduates as they reflect on their studies abroad and function in their local contexts.

The following brief narratives articulate the contexts in which two recent graduates now function as Design and Technology teachers. Their inclusion is intended to establish a brief understanding of the diversity of contexts in which various issues related to the delivery of international technology education have been recognised.

Mokobeng CJSS

Mmarati is now the deputy head and one of two design and technology teachers at Mokobeng Community Junior Secondary School in a village several hundred kilometres north of the capital Gaborone. The village has around 3000 people. By most Western conceptions, this village is relatively impoverished. The village has been without running water for several years after floods destroyed bore holes, water is trucked in daily to service three stand pipes which the village shares and which often run for only a couple of hours a day. Village dwellings range from thatched rondavels to Red Cross tents and unemployment, or subsistence employment is the norm rather than the exception.

The village has both a primary school and junior secondary school. The CJSS caters to forms 1-3 (years 8-10 equivalent) and has around 300 students. The school day begins around 6:45 am and for many of the students ends at 6:30-7:00 pm. Students are provided with meals throughout the day and the kitchen is the focal point and physical centre of the school complex. The kitchen is an open structure with large cast iron cauldrons and open fires for preparation of meals for students. The school has significant issues related to student welfare. In 2001, one third of the three hundred students in the school were living without parents. This figure has risen in 2003 to a half. Various factors contribute to this, including HIV/AIDS deaths, inability to care for children due to sickness and poverty and inability to facilitate education through rural isolation. Few students are fluent in English, despite it being the official language of the school system and the language of all examinations. The exceeding majority of all students will fail exams and never have the opportunity to progress to a senior secondary school. Examinations are all in English and correct answers in Setswana are marked as incorrect. Students' exposure to life outside of the village is very limited, if at all. Some younger children had never seen a white man.

St Josephs SSS

In contrast to Mokobeng, St Josephs Senior Secondary School is on the outskirts of the capital, Gaborone. Development in and around Gaborone has been extensive in recent years. The city now hosts shopping malls, cinemas, Internet cafés, developed infrastructure and a vastly different general standard of living than in rural areas. Botswana was officially graduated from the UN (ECOSOC) list of least developed countries (LDC's) in 1994 (United Nations 2001). Despite the wealth that has been generated from mining, tourism and agriculture, the distribution of this wealth has yet to impact the poorest citizens of Botswana in significant ways, for instance there still remains no social security for the unemployed

The facilities at St Josephs are relatively good, students live in and around the capital and are generally the children of working parents living and working in the capital–they are amongst the most affluent of Botswana's citizens. Students have progressed through CJSS examinations and are fluent English speakers, despite Setswana being the popular language. The general contemporary nature of the school culture demonstrates students' access to media and information that is not accessed by students in Mokobeng CJSS. Students watch South African television and embrace icons of international popular culture.

The school has attracted the most qualified and experienced teachers and the facilities provide a standard of education not possible in more isolated areas of the country. The design and technology department has 7 staff, workshops have powered machinery and the contexts in which technology education is taught and learnt are broader than that of Mokobeng.

The impact and incidence of HIV/AIDS in the city is thought to be greater, but less overtly visible, than in rural areas (UNAIDS & WHO 2000). Awareness and education of the pandemic is recognised within the school and has been a context for work in technology education.

Issues

These narratives demonstrate the disparity of contexts in which graduates can be placed upon their return from study abroad. They also highlight what would usually be circumstances in which very different approaches to technology teacher preparation might be appropriate. Whilst specific in nature, the objective of these narratives is that broader issues in the delivery of international education would become apparent.

Analysis of research data, mechanisms for the review of programs, and the experience of establishing and delivering international technology education programs have all contributed to the identification of issues pertaining to their delivery. Issues covered include; political, practical, social and cultural dimensions.

Managing local disparities and levels of technology

Technology education in teacher training serves the dual role of providing experiences and activities which teachers can model in their schools when they begin teaching, and experiences which enhance their understanding of technology. Both are important because teachers need starting points for their teaching, but also need a sophisticated awareness of the nature of technology. In extending educational experiences across cultures, the correct balance, and the justification of the balance between these two goals is imperative. The principles of appropriate technology become relevant in the selection of technological activities.

With such dramatic disparities often occurring in the local context in which graduates are placed, preparing teachers for such differences is an issue. Balancing the technology education preparation for the future and the reality of the present is a difficult but not insurmountable task. Consideration of the appropriateness of technologies for various contexts and the nature of technological problems that exist in those contexts are important features of a sensitive international program. Likewise, exposure to technologies not available in the graduates own context is often viewed as an important element in the future technological development of the country. In this sense, the nature of a program can either be seen as both inappropriate for the current context but appropriate for the goal of educating about technology in the more developed world.

Staffing programs and Lecturer education for local contexts

The contexts in which many students have and will be working are often so removed from the experiences of lecturing staff that it may be difficult to successfully adapt or broaden teaching and learning experiences. An understanding of learners' prerequisite knowledge, skills and prevailing cultural context is an important element of course delivery. Being adequately briefed enables staff to factor cultural nuances, appropriately contextualise course content and assist students to feel less distanced from their experience abroad.

> "I had no idea what he was talking about when he started talking about left mouse button and right mouse button" An international student.

For some Botswana students for example, the concept of left and right are foreign. Alternative ways are used to communicate orientation or direction. This example highlights some of the potential pitfalls associated with a lack of understanding of local contexts. What may be perceived as inferior capabilities are quite often accounted for with a better understanding of aesthetic cultural influences, local contexts, general cultural differences such as conceptions of time and other cultural sensitivities.

For offshore programs, staffing presents other issues. It takes some time interacting with a class for a lecturer to develop a rapport with students, and when they spend 30 hours together over two weeks the relationship seems to become quite strong. Students do not want to go through this 'getting to know the lecturer' period with a new lecturer for every unit. However, if the 'expert' in each unit is the person sent to do the teaching, then many different people are involved in a course. It has been necessary at times to restrict the number of people involved in course delivery in order to help ensure student comfort.

It is appropriate to occasionally localise course material to the extent that a local person is involved in presenting to the students. This can, however, be perceived negatively by the students, who consider they are paying for an overseas course, and that is what they want, not local lecturers.

Political issues

Both on and offshore programs a fraught with political issues. Politics exist at the source university in the tension between local and international programs in terms of staffing, resources and income generation. The increasingly competitive nature of international education does not always sit well with academics who are more inclined toward collaboration and consultation, but international students is now a significant criteria of success.

The occasional student who does not want to return home after completion of a course in Australia, or the student who, after gaining an Australian qualification, accumulates enough points to emigrate to Australia inevitably creates tensions between the course provider and the student sponsor.

There is invariably a political dimension involved in the context in which the course is delivered. A local course co-ordinator is invaluable in steering through the potential pitfalls of teaching site selection and dealing with local institutions and authorities, which may respond to a variety of ethnic, religious and political agendas. This can nevertheless be a source of frustration as the sense of urgency felt at the source institution is not always replicated in going through the protocols in the local delivery context.

Affecting local change

Onshore upgrade programs for diploma level International teachers have generally not included professional teaching practice. Approaches to technology education predominating in courses of study often conflict with dominant and historical modes of delivery. One of the implications of excluding professional practice has been the lack of teaching and learning pedagogical models to support new approaches to technology education. The power of existing school pedagogy often dominates and prevails in the post-graduation delivery of technology education. Developing ways of incorporating teaching and learning experiences and a general awareness of different school cultures in the host country could be an important characteristic of the program.

Offshore programs where teachers are studying part time provides the opportunities for them to experiment with different pedagogical models in their teaching, and report on those experiences in their assignment work. This implementation of new ideas coupled with feedback loops in course structures ensures a more lasting paradigm shift in practice. In some instances, program sponsors (Ministry of Education) specifically insist on the assurance that the changes in current practice that are advocated are in line with concurrent curriculum developments and that graduates, in turn, become change agents within their regional context.

Supporting students

For local onshore programs, the majority of students travel abroad leaving spouses, children and often extended families that they support behind. This, compounded by the dramatic cultural experience, can be an unsettling experience for many students. Various modes of supporting international students is an important factor in the successful delivery of international education and an often recounted experience for graduates. The nature of this support includes general pragmatic and administrative support to more targeted support related to courses of study. Students often have different prerequisite experiences relating to technologies, aesthetic influences, and general competencies that the course demands. These differences need to be acknowledged, appreciated and valued, whilst deficiencies need to be supported.

Supporting offshore programs involves a different set of difficulties and issues. The difficulties associated with reliable and convenient communication are issues not confronted by countries with more developed infrastructure and access to information and communication technologies. Reliable communication with developing countries poses some unique challenges. Because standard means of communication such as mail, Internet and fax can be unreliable or non-existent, communication with both students and co-ordinators in the host country can be frustrating. Typically only a few students have Internet connections, and mail and fax are unreliable. This means forward planning is critical, and normal processes may sometimes need to be circumvented. For example an unreliable mail system resulted in a batch of exam papers going missing and alternative strategies had to be devised; and assignments, both to and from students, are express mailed together rather than individually.

Adequate facilities for the delivery of offshore programs are another issue. In some countries the facilities are not available to offer units that would normally be considered core units. For example in technology education these could relate to computer assisted drawing and machining, advanced materials, electronics and a range of computer based units. In some countries the units cannot be offered, in others the unit content can be modified to enable it to be offered in an appropriately contextualised way.

Re-assimilation

Returning to teach in their home country after a significant time abroad has also proven a difficult experience for graduates. Students are at the mercy of the system in terms of placement after graduation and have experienced professional conflict with regard to the cultural, pedagogical and physical differences between their current situation and previous studies.

> "We've had a computer lab building for ten years but have never had a computer, we don't even have power machines"

> "I spent all that time working with CAD and I get placed in a school that doesn't even have one computer"

Strategies for managing and negotiating change in the classroom and preparation for dealing with professional change are other issues for program delivery.

Course duration

Some students, both on and offshore, have been dissatisfied with the duration of the courses. They would have preferred for example to study for three semesters per year and complete a two year full time course in under three years part time, than study for two semesters each year over four years. Students who are studying part time in their own country generally meet with lecturers during their school holidays, and this commitment becomes a burden for both students and their families when it continues for up to four years. Students studying in Australia are removed from their immediate and extended families, and for some, for example mothers with young children they have left behind, this is a significant distraction from their studies.

Conclusion

The benefits and rewards of international programs in technology education have become more apparent over time. The cultural exchange presents enlightenment and education for both students and staff. For international students, the experience is often recounted as valuable and life changing. It naturally facilitates broader conceptions of technology for both local and international students. The interplay and collaborative nature of technology education presents both inherent difficulties and fruitful experiences for students and staff.

The delivery of international programs is complex. Issues and dimensions that require consideration, management and sensitivity relate to:

- philosophical diversity and various interpretations of technology education across cultures,
- various historical traditions that underpin local school technology programs,
- political issues relating to the establishment and delivery of programs,
- cultural awareness and understanding that leads to specific adaptations of programs,
- practical creativity in overcoming the obstacles of delivery.

For many students, text-based distance education represents their only source of educational opportunity. In the area of technology education, a successful mode of delivery incorporates a period of intensive face-to-face interaction with a lecturer. Detailed planning is vital, but flexibility in the implementation of those plans is just as important in order to overcome unforeseen barriers.

Each international program is delivered in a unique context and so, while there are certain common principles that have been discussed in this paper, specific issues vary.

These authors have found that the most significant principles for success are cultural sensitivity and flexibility.

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Crisis in Technology Education in Australia

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After promising initiatives in the last few years, the development of national support for technology education in Australia has stalled. It seemed that there were a number of significant concurrent developments which could positively impact on technology education in the future. At the national level these included a study into the status of technology education, the promotion of Information and Communication Technologies (ICT), Vocational Education and Training (VET), and a range of enterprise initiatives including the Innovation Summit. At the state levels, most states are implementing a contemporary technology education framework or curriculum, and the trend is to make technology education a compulsory lower secondary level subject and to recognise the parity of its contribution as a year 12 subject for university entrance. Significant Commonwealth funding is available for the development of Technology Education but there is no clear idea about what to do with it, despite the obvious problems currently confronting the area. These include an increasing teacher shortage and an ageing teacher population, an ineffectual national professional association, a dissipation of focus on the core technology business, a developing curricular diversity across states and a significant lag in implementing new curricula at the school level for a range of reasons.

Introduction

After promising initiatives in the last few years, the development of national support for technology education in Australia has stalled. It seemed that there were a number of significant concurrent developments which could positively impact on technology education in the future. Many of these are both opportunities and challenges, and if the opportunities are not capitalised upon then the challenges will prevail. At the national level these included:

- a study into the status of technology education,
- confirmation of technology as a key learning area in the Adelaide Declaration,
- elements of the Quality Teacher Initiative program,
- the promotion of Information and Communication Technologies (ICT),
- Vocational Education and Training (VET),
- and a range of enterprise initiatives including the Innovation Summit.

At the state levels, most states are implementing a contemporary technology education framework or curriculum, and the trend is to make technology education a compulsory lower secondary level subject and to recognise the parity of its contribution as a Year 12 subject for university entrance.

Some of these developments presented a window of opportunity for technology education which has now just about closed. The links that could have been forged with technology education and the resultant increase in its status and general awareness of its potential would have served the development of technology education well.

History

Technology education as a learning area in Australian schools is relatively new. In 1987, the Australian Education Council (AEC) began a series of initiatives that led to the publication in 1994 of nationally agreed curriculum statements and profiles related to eight learning areas, one of which is technology. In 1990 the K-12 Technology Curriculum Map (Australian Education Council) revealed a shift in emphasis in many schools toward gender equality, flexible outcomes and a variety of teaching and assessment strategies. The 1994 documents extended this trend.

The declaration of technology as a learning area had profound implications. Firstly, all subject areas in secondary schooling from which technology education developed were located within the elective areas of the curriculum. The implication was that these subjects provided specific learning experiences relevant only for specific groups of students with particular interests or career destinations in mind. Indeed, some of these subjects were regarded by students and the community as relevant only to a particular gender. Secondly, in the case of primary education, technology had not generally been part of school programs, and primary teachers have little experience to draw on to develop programs. The challenge for technology education was to determine the learning experiences that are essential for all students, and are unique to technology education or best undertaken within the area.

The literature is generally in accord that a clear philosophy for technology education should be articulated (Gardner 1994; Ihde 1997). However, there is less common ground on what that philosophy should be (Gardner 1994; De Vries & Tamir 1997). De Vries argued that the philosophy of technology could be used to develop a philosophy of technology education. Gardner suggested the historical and philosophical origins of science and technology as fertile ground for the development of a philosophy of technology education. Others (Jones 1997; McCormick 1996) have inferred a philosophy in terms of the research direction taken, being concerned with learning about technological concepts and processes, which also involves an understanding of the structure of technological knowledge.

The most significant rationales for the development of technology as a discrete learning area were related to the technological nature of society and equity of opportunity for students. Australian culture was rapidly becoming highly technological, and all students needed to have the opportunities to develop, experience and critique a range of technologies as part of their core education. This rationale aligned with concerns for gender equity in technology education, with more flexible, open ended and collaborative approaches to delivery, and with a range of key competencies for all students.

Prior to the 1990's school curricula addressed technology in a very limited way. In the main, technology was referred to in elective or optional syllabuses. Most often students' perceptions of technology were developed from a very restricted range of learning experiences, for example, students might learn about the tools and machines used to work with timber. Invariably learning focused on an established body of technical 'know-how'. In some courses students learnt about designs that characterised past eras.

The technology classroom activities of today have developed out of these traditions. At the primary school level technology education practices tend to have developed out of art and craft and science. Technology and Science still tend to be bracketed together for primary education as illustrated by recent government reports (ASTEC 1997) and some learning area documentation.

Probably the most significant aspect of the change to technology education is the concept that as a learning area it contributes to all students' general education and therefore should be studied by all students in the compulsory years of schooling.

Since it is a new learning area, the status of technology in the curriculum is not well established and is therefore variable across the states and systems in Australia. In some states for example, technology subjects are compulsory and in others they are elective, though it is offered in some form in 95 percent of schools (Williams 2000).

Technology education in the curriculum

Since the publication of *A Statement on Technology for Australian Schools* (Curriculum Corporation 1994) all the states and territories have established technology learning areas through the development of frameworks, curriculum and support material. Various titles have been adopted in different states (Technology Education, Technological and Applied Studies, Technology and Enterprise) but they contain similar elements. There is a significant degree of consistency in the definitions of technology used by education systems in Australia. Technology is defined broadly, and key common elements of the definitions include 'the application of knowledge and resources' and that it is used 'to extend human capabilities'. There is strong general agreement that technology involves a process, that is, there is an identifiable method used in the development of technology. This process is most commonly referred to as design, but it is not defined or described in detail. Similarly the relationship between the concepts or knowledge of technology and the processes of technology is not explored.

In the titles ascribed to subjects, technology is commonly linked with other concepts, for example 'materials, design and technology', 'science and technology', 'technology and enterprise'. This may suggest that existing notions or definitions of technology are inadequate to describe the scope of the intended learning, and this is an emerging area of the curriculum still in the process of definition.

There are few curricula in technology that describe an accompanying body of knowledge, though in some instances new subjects have been developed with the introduction of technology as a learning area. This has left teachers to modify existing subjects to conform to the new approach. Those that use the United Nations Education Scientific and Cultural Organisation (1985) definition express technological knowledge as 'know how', presumably knowledge of how to do technology.

In primary schools, technology education is generally delivered through an integrated approach with other learning areas. At the secondary level it is delivered through a range of technology related subjects–Home Economics, Industrial Arts, Design and

Technology, Agriculture, Business Studies, Computing Studies, though 25% of secondary schools surveyed indicated that they integrate some of these areas. This is in contrast to some of the other learning areas such as Science, Mathematics and English, which are often delivered via a subject with the same name as the learning area they support.

While states have or are establishing clearer directions for technology education through curriculum frameworks, its implementation has been problematic. This is partly because there is a conflict between the curriculum, which is quite revolutionary in nature, and its implementation, which cannot be revolutionary but is developmental and must build on past practice. Teachers have to develop their understandings of technology education and implement new strategies over time. But the technology education curriculum does not incrementally develop from what has existed in schools in the past, it is revolutionary in both knowledge and associated pedagogy.

The Adelaide Declaration

In April 1999, State, Territory and Commonwealth Ministers for Education, at the 10th Ministerial Council on Education, Employment, Training and Youth Affairs (MCEETYA), endorsed new National Goals for Schooling in the Twenty-first Century as the Adelaide Declaration (1999). The new goals replaced the Common and Agreed National Goals for Schooling in Australia which were endorsed as the Hobart Declaration in 1989, and changed only slightly from then, confirming the 8 key learning areas.

Education Ministers also affirmed their commitment to national reporting on comparable educational outcomes and agreed that the new National Goals for Schooling in the Twenty-first Century provided the appropriate framework for such reporting. The areas for initial national outcomes reporting were identified as literacy, numeracy, student participation, retention and completion, vocational education and training, science and information technology. The ministers also noted the need to develop performance indicators for civics and citizenship, and enterprise education.

There are a number of areas within the National Goals Statement that could potentially impact on Technology Education including information technology, vocational education and training and enterprise education. To the extent that these areas exist within the technology education curriculum provides an opportunity to capitalise on their focus and promote technology education in achieving relevant and common goals. The alternative is a focus on these areas without the context of technology education, resulting in not only lost opportunities for development but the potential relegation of technology education to a superfluous context and a more narrow interpretation.

Teachers for the 21st Century

The Quality Teacher Initiative, *Teachers for the 21st Century* (CDEST 2000), provides for $80m over 3 years including $74 to support quality teachers. This is to lift the skills of teachers in the 'key priority areas' of literacy, numeracy, mathematics, science, information technology and VET, and to work with teacher associations to develop professional teaching standards in science, literacy and mathematics.

This initiative also provides both threats and opportunities for technology education.

Opportunities lie in the development of skilled technology teachers who specialise in IT and VET. The threats are more numerous and relate to the possible fragmentation of the learning area by focusing on IT and VET, and, in the absence of a teacher association, the development of standards that exclude the unique characteristics of general technology education.

The chance to change

Australia's Chief Scientist, Robin Batterham, produced a report in November 2000 addressing Australia's science engineering and technology (SET) capability called The Chance to Change (Batterham 2000). Its thesis was that 'science, engineering and technology underpins our future as a thriving, cultured and responsible society' (p.9). Its focus is on innovation, higher education and research and development, but it does recognise schooling as an important basis.

In August 2000 Batterham released a preliminary discussion paper which was typical of the discussion related to SET in Australia in that science was assumed to encompass technology, and technology education was accorded no status. For example: 'Excellent teachers are the key to exciting and sustainable interest in science in schools', and 'The curriculum needs to focus on educating students to be more scientifically literate' (Section 2.4.3)

Despite feedback in response to the discussion paper, the final report is little better in terms of recognising the potential of technology education. For example:

> Australia needs to provide advanced science education so that all our children have the opportunity to better understand the rapidly changing world around them and have the option to pursue as career in science, engineering or technology. Australia's success as a knowledge economy is dependent on a highly skilled, informed and scientifically literate workforce (p.49).

Public recognition of technology education at this level seems to be regressing rather than progressing. Take for example the following statement from the 1996 ASTEC study Developing long term strategies for science and technology in Australia:

> For many years literacy and numeracy have been the cornerstones of western industrialised education. Yet there are basic skills in technology and problem solving which are required to support a technological lifestyle. ASTEC considers that technacy provides a sound framework for developing a new vision of the role of the S&T system in achieving national goals and improving understanding of S&T in the Australian community (p.62).

Innovation Summit

An Innovation Summit was held in Melbourne in February 2000 with more than 500 participants, organised by federal and state governments, the research community and industry. The report produced as a result of the summit, Innovation: Unlocking the Future (DISR 2000) made 24 recommendations related to:

- intellectual capital
- research funding
- tax incentives

- minimising regulations, and
- education.

Some of the recommendations related to education include:

Recommendation 2

… develop a program to support young entrepreneurs who demonstrate an interest in enterprise, design and innovation ($25m over 5 years).

Recommendation 3

To build business and enterprise skills in schools, support a new program of Enterprise and Innovation Scholarships for teachers to take up structured workplace learning opportunities with innovative businesses ($100m over 4 years).

Recommendation 4

To ensure that students have access to innovative learning environments, develop innovative online curriculum materials to support a number of curriculum areas, especially science and technology and business education ($200m over 4 years).

It was clear to technology educators that Technology Education, through its constructs related to enterprise, design and innovation, had a role to play in the development of the government agenda in the promotion of a resourceful, ingenious and creative population to help ensure Australia's competitiveness. The hurdle is that many people do not understand the nature of technology education and so cannot make this link.

Innovation: Unlocking the Future (DISR 2000) and the recommendations therein, together with The Chief Scientist's Report, *The Chance to Change* (Batterham 2000), formed the basis of another report, *Backing Australia's Ability* (Commonwealth of Australia 2001). *Backing Australia's Ability* is 'a practical approach to innovation that is focused, funded and producing real results' (p.2). The report recognises the need to 'educate for innovation' (p.5) in a context where 'the knowledge economy and increasing influence of ICT are two areas driving a growing demand for workforce that is adaptable, creative, entrepreneurial and highly skilled' (p.6).

The report is replete with references which could relate to technology education, including the following funded initiatives:

- $130m to foster scientific, mathematical and technological skills and innovation in government schools
- $34m over 5 years to help develop online curriculum content in schools
- $35m over 5 years to implement a National Innovation Awareness Strategy to raise the understanding of the importance of science and technology, particularly among the young.

Again, the opportunity is there for technology education, but the key to capitalising on that opportunity is the promotion and development of an awareness of the capability of technology education.

Enterprise education

Coming from the state where the relevant learning area is Technology and Enterprise, the opportunities for technology education within the government's Enterprise Education programme seem obvious.

The definition of enterprise education under consideration by the Ministerial Council on Education, Employment, Training and Youth Affairs (MCEETYA) is as follows:

> Enterprise Education is learning 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.

In 1998 Enterprise Education was funded for $3.4m over 3 years; the package Enterprise Education in School (EES) was launched by the Curriculum Corporation, but it mainly operated through the business studies area of schools and has not been effectively implemented across the broader technology education area.

The current Enterprise and Career Education program was announced in 2001 and provided funding of $25m to 2004. Components of this programme include a Foundation to develop capacity for school-industry engagement, an action research project and professional development. There are opportunities within each of these components for technology education to be active, but because the link between technology education and enterprise is not explicit for many people, the input from technology education is not sought for this type of programme.

Current opportunities

Review of teaching and teacher education

A discussion paper*, Strategies to attract and retain teachers of science technology and mathematics* was released in September 2002 as a precursor to a review of teaching and teacher education. The discussion paper seems to indicate an intent to seriously deal with issues related to each of these three areas, both through the commonalities and the unique aspects of each. However this does need to be emphasised through responses to the discussion paper because of the relative complexity of the technology education area. For example Table 1 in the discussion paper: Students in selected first year subjects within secondary teaching courses, deals with students under the headings of Science, Mathematics and Computing and Humanities – a classification that would seem to be seriously flawed in a discussion of Science Technology and Mathematics, but is explicable given the complex nature of the technology education area.

Technology Education Action Plan 2012

As a result of a national investigation into technology education in 2000 and a conference in Melbourne in July 2002, a draft Action Plan for technology education has been released in September 2002. This draft maps a series of integrated strategies for the development of technology education grouped around strategies related to a technology education network, research, promotion and advocacy, inservice and preservice teacher education and curriculum. The plan has potential because the commonwealth government has funding available to support the initiatives. It will however require considerable effort and dedication by technology education professionals to implement the plan.

Challenges

While many of these initiatives present opportunities for the development of technology education, there are some areas in which they represent challenges.

Teacher shortages

A shortage of technology teachers confounds efforts to move the profession forward. Messages about teacher shortages are mixed. MCEETYA (2001) assessed the teacher labour market as broadly in balance in both primary and secondary, and teacher graduations were expected to be sufficient to meet demand for new teachers until 2003.

A report commissioned by the Australian Council of Deans of Education, "Teacher Supply and Demand to 2004" (Preston 1998) painted a different picture, indicating that the demand for secondary and primary teachers would exceed supply to 2004. It was predicted that supply as a percentage of demand for primary teachers would reach 81% in 2004, and for secondary teachers, the estimates generated revealed a greater shortage of 66% in 2004.

The evidence in many states however is of significant shortages in areas of technology education. There is some room for optimism, with rising numbers of preservice education courses and targeted strategies for rapid training.

Vocational education and training and information and communication technologies

While these two areas are different, they are similar in that elements of them are components of technology education.

The focus on VET and ICT in some of the initiatives (outcomes reporting in the Adelaide Declaration, Quality Teacher Initiative, Standards) has the potential to segregate the breadth of technology education to a focus on its subsets rather than its holism. This could lead to the dominance of these areas over the broader goals of technology education to produce technologically capable individuals.

Professional association

The absence of a vibrant active representative professional association inhibits the development of technology education in a number of ways. It means there is no conduit between the government or other organisations and technology teachers, and advocacy opportunities are not taken advantage of as they arise.

Standards

The move toward standards seems to be inevitable. It is promoted by the Federal government and advocated by professional associations. *Standards of professional practice for accomplished teaching in Australian classrooms* is being developed by a consortium of AARE, ACE and ACSA. Curriculum standards are being developed by the professional associations in the areas of English, mathematics and science. The USA and UK have content standards for technology education, and New Zealand is conducting research in that direction.

The predicament in the development of standards for technology education in Australia is reflected in the questions:

Who would develop them?

Why provide limitations to technology when there is strength in diversity?

Can standards be process related?

How would technology standards relate to VET and ICT standards?

Conclusion

While some opportunities for the development of technology education have arisen and passed, others remain. In the current context of state curriculum diversity and the absence of national leadership, there is little encouragement that technology education will strengthen its position nationally as a core learning area.

Not only are there few powerful advocates for the learning area, many do not understand the nature of technology education, and with a focus on areas such as ICT and VET, there is the very real danger that these areas will come to represent the learning area.

Nevertheless, much progress has been made in the last 8 years to provide a solid foundation of sound practice in many schools. With the continued commitment and dedication of technology education professionals, the potential is there for technology education to become a valued core component of all students' education.

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A Study of Implementation of Teaching Thinking Skill in Junior-High Technology Education in Taiwan

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The purpose of this study was to identify the implementation of thinking skill teaching in junior-high technology education in Taiwan. The objectives of this research were to explore technology teachers':

1. Ability to teach thinking skills
2. Attitude toward teaching thinking skills
3. Strategy for teaching thinking skills

The investigation research method was applied to this study. The research steps were listed in following.

1 Literature review
2. Design research tool
6. Pilot test
4. Expert evaluation and modification
5. Conducting formal investigation
6. Data collecting and statistic analysis
7. Discussion and conclusion.

Based on the literature review, the draft research tool was designed. Through pilot test, modification, and expert evaluation, a questionnaire development process was established for this research. According to statistical analysis of results, research questions were discussed and then concluded.

Introduction

Technology education is much more than just knowledge about technology and their application. It involves educational programs where learners become engaged in critical thinking as they design and develop products, systems, and environments to solve practical problems. Both ability and belief of teaching were considered important for an efficient technology teacher (Yang 2001). Especially, high level thinking skill was the core goal of education reform in Taiwan during these years. Clarke, J. (1990) argued that it was possible to integrated thinking skill into content area of teaching. Thinking skills are important for students to fit into the technological world. The purpose of this study was to identify the implementation of thinking skill teaching in junior-high technology education in Taiwan.

Objective

The objectives of this research were to explore technology teachers':

1. Ability to teach thinking skills
2. Attitude toward teaching thinking skills
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Samples of this study

The population of this study was junior-high technology teacher. The total amount was around twenty thousand. The random sampling procedure was applied and 200 objects were selected. The return rate was 78% (156).

Research tools

There were four parts to the questionnaire. The first part was profile information. The second part was ability of teaching thinking skill. The third part was attitude toward thinking skill. The fourth part was strategy of teaching thinking skill.

There were three question in the first part, those were:

1. Gender (Female/Male)
2. Years of teaching Technology Education (1-5,6-10,11-15,16-20,>20-25)
3. Academic background (Bachelor / Master)

There were 52 questions in the second part. Those questions were two crossed factors of four ability levels and thirteen thinking processes.

Ability of teaching a thinking skill

1. Introduce the skill
2. Explain mental processes and model the process
3. Let students practice the skill
4. Put the skill into the content of technology education.

Thinking skill processes

1. Abstracting
2. Analysis
3. Classifying
4. Compare
5. Constructing support
6. Decision making
7. Deduction
8. Error analysis
9. Experimental inquiry
10. Inductive reasoning
11. Invention
12. Investigation
13. Problem solving

The reliability alpha value was 0.83 of this section. There were nine statements of attitude toward teaching thinking skills in the third part. The reliability alpha value was 0.79 of this third section. The fourth part also included nine statements of thinking skills teaching strategy. The reliability alpha value was 0.73 of this fourth section.

Implications in the reported research

Findings, discussion and conclusion were assembled in this section.

Findings

This section divided into descriptive analysis and statistic test analysis. Mainly, the data was organised in tables and discussed in following sections.

Descriptive analysis

Technology teachers' profile information was listed in cross tabulation, Gender * Years of Teaching * academic background Cross tabulation. The number in the cell was the value of object count. There were two types of table in this descriptive analysis. The first one was frequency count, such as table 1. The second type was listed with the N, range, minimum, maximum, mean, standard deviation, and variance as those in tables 2, 3, 4.

Statistical test analysis

Tables in this section showed the statistical test result. One-sample T test result was listed in tables 5 and 6. One way ANOVA test result of those items with significant difference caused by one of those three factors was shown in table 7 under accordingly column.

Table 1

Cross table of objects' profile information

			YEARS OF TEACHING					TOTAL
ACADEMIC BACKGROUND			1-5	6-10	11-15	16-20	>21	
bachelor	Gender	Female	6	9	8	9	4	36
		Male	8	18	31	12	19	88
	Total		14	27	39	21	23	124
master	Gender	Female	0	2	1	3	3	9
		Male	4	6	9	1	3	23
	Total		4	8	10	4	6	32

Table 2

The N, range, minimum, maximum, mean, standard deviation, and variance of the profile items

DATA ITEMS		N	RANGE	MIN.	MAX.	MEAN	STD. DEVIATION	VARIANCE
		STATISTIC	STATISTIC	STATISTIC	STATISTIC	STATISTIC	STATISTIC	STATISTIC
I. Profile Information	Gender	156	1.00	1.00	2.00	1.7115	.4545	.207
	Years of Teaching	156	4.00	1.00	5.00	3.0769	1.2626	1.594
	academic background	156	1.00	1.00	2.00	1.2051	.4051	.164

Table 3

The N, range, minimum, maximum, mean, standard deviation, and variance of items of the part II

DATA ITEMS		N	RANGE	MIN.	MAX.	MEAN	STD. DEVIATION	VARIANCE
		STATISTIC	STATISTIC	STATISTIC	STATISTIC	STATISTIC	STATISTIC	STATISTIC
I. Ability of Teaching Thinking Skill	1	156	4.00	1.00	5.00	3.9103	1.0678	1.140
	2	156	4.00	1.00	5.00	3.8654	1.0416	1.085
	3	156	4.00	1.00	5.00	3.8269	1.0846	1.176
	4	156	4.00	1.00	5.00	3.8654	1.0661	1.137
	5	156	4.00	1.00	5.00	3.8269	1.0043	1.009
	6	156	4.00	1.00	5.00	3.9936	.9193	.845
	7	156	4.00	1.00	5.00	3.8462	1.0665	1.137
	8	156	3.00	2.00	5.00	4.0128	.9638	.929
	9	156	4.00	1.00	5.00	3.9038	1.0823	1.171
	10	156	4.00	1.00	5.00	3.8718	1.1286	1.274
	11	156	4.00	1.00	5.00	4.0256	.9364	.877
	12	156	4.00	1.00	5.00	3.7051	1.1372	1.293
	13	156	4.00	1.00	5.00	3.9103	.9796	.960
	14	156	4.00	1.00	5.00	3.9038	1.0018	1.004
	15	156	4.00	1.00	5.00	3.7115	1.0955	1.200
	16	156	4.00	1.00	5.00	3.8013	1.0187	1.038
	17	156	4.00	1.00	5.00	3.8333	1.0213	1.043
	18	156	4.00	1.00	5.00	3.8013	1.1038	1.218
	19	156	4.00	1.00	5.00	3.8590	1.0125	1.025
	20	156	4.00	1.00	5.00	4.0000	.9367	.877
	21	156	4.00	1.00	5.00	3.8205	1.1100	1.232
	22	156	4.00	1.00	5.00	3.8013	1.1608	1.347
	23	156	4.00	1.00	5.00	3.7885	1.1473	1.316
	24	156	4.00	1.00	5.00	4.0513	.9284	.862
	25	156	4.00	1.00	5.00	3.7436	1.1295	1.276
	26	156	4.00	1.00	5.00	3.9487	1.0336	1.068
	27	156	4.00	1.00	5.00	3.8974	1.0108	1.022
	28	156	4.00	1.00	5.00	3.8269	1.0726	1.150

DATA ITEMS		N	RANGE	MIN.	MAX.	MEAN	STD. DEVIATION	VARIANCE
		STATISTIC	STATISTIC	STATISTIC	STATISTIC	STATISTIC	STATISTIC	STATISTIC
	29	156	4.00	1.00	5.00	3.7500	1.0932	1.195
	30	156	4.00	1.00	5.00	3.7628	1.1252	1.266
	31	156	4.00	1.00	5.00	3.8974	1.0422	1.086
	32	156	4.00	1.00	5.00	3.8590	1.1497	1.322
	33	156	4.00	1.00	5.00	3.8974	1.1024	1.215
	34	156	4.00	1.00	5.00	3.6538	1.0264	1.054
	35	156	4.00	1.00	5.00	3.8526	1.1573	1.339
	36	156	4.00	1.00	5.00	3.8462	1.1139	1.241
	37	156	4.00	1.00	5.00	3.9423	1.0731	1.151
	38	156	4.00	1.00	5.00	3.7115	1.1014	1.213
	39	156	4.00	1.00	5.00	3.9359	1.0697	1.144
	40	156	4.00	1.00	5.00	3.9295	1.0961	1.201
	41	156	4.00	1.00	5.00	3.8654	1.1077	1.227
	42	156	4.00	1.00	5.00	3.9231	1.1161	1.246
	43	156	4.00	1.00	5.00	3.9295	1.0356	1.072
	44	156	4.00	1.00	5.00	3.8910	1.0133	1.027
	45	156	4.00	1.00	5.00	3.9295	.9910	.982
	46	156	4.00	1.00	5.00	3.8141	1.0943	1.197
	47	156	4.00	1.00	5.00	3.9103	1.0184	1.037
	48	156	4.00	1.00	5.00	3.7179	1.1848	1.404
	49	155	4.00	1.00	5.00	3.8839	1.0126	1.025
	50	156	4.00	1.00	5.00	3.9744	.9568	.915
	51	156	4.00	1.00	5.00	3.8333	1.0524	1.108
	52	156	4.00	1.00	5.00	3.8333	1.1741	1.378

Table 4

The N, range, minimum, maximum, mean, standard deviation, and variance of items of both part III and IV

DATA ITEMS		N	RANGE	MIN.	MAX.	MEAN	STD. DEVIATION	VARIANCE
		STATISTIC	STATISTIC	STATISTIC	STATISTIC	STATISTIC	STATISTIC	STATISTIC
II. Attitude toward Teaching Thinking Skill	1	156	4.00	1.00	5.00	4.2179	.9037	.817
	2	156	4.00	1.00	5.00	4.2179	.8136	.662
	3	156	4.00	1.00	5.00	4.1282	.9819	.964
	4	156	4.00	1.00	5.00	4.2500	.8697	.756
	5	156	4.00	1.00	5.00	4.1923	.8880	.789
	6	156	4.00	1.00	5.00	4.1218	.9322	.869
	7	155	4.00	1.00	5.00	4.2065	.9376	.879
	8	156	4.00	1.00	5.00	4.2115	.8425	.710
	9	156	4.00	1.00	5.00	4.3269	.8588	.738

DATA ITEMS		N	RANGE	MIN.	MAX.	MEAN	STD. DEVIATION	VARIANCE
		STATISTIC	STATISTIC	STATISTIC	STATISTIC	STATISTIC	STATISTIC	STATISTIC
IV. Strategy of Teaching Thinking Skill	1	156	4.00	1.00	5.00	4.4679	.7985	.638
	2	156	4.00	1.00	5.00	4.3205	.9571	.916
	3	156	4.00	1.00	5.00	4.3910	.7584	.575
	4	156	4.00	1.00	5.00	4.3590	.7783	.606
	5	156	4.00	1.00	5.00	4.5192	.6473	.419
	6	156	4.00	1.00	5.00	4.4167	.7358	.541
	7	156	4.00	1.00	5.00	4.5000	.7405	.548
	8	156	4.00	1.00	5.00	4.4679	.6855	.470
	9	156	3.00	2.00	5.00	4.5641	.6136	.377

Table 5

One-Sample Test of items of part II with test value three

DATA ITEMS	TEST VALUE = 3							
	ITEM	T	DF	SIG. (2-TAILED)	**ITEM**	T	DF	SIG. (2-TAILED)
II. Ability of Teaching Thinking Skill	**1**	10.647	155	.000	**27**	11.089	155	.000
	2	10.377	155	.000	**28**	9.629	155	.000
	3	9.523	155	.000	**29**	8.569	155	.000
	4	10.138	155	.000	**30**	8.468	155	.000
	5	10.284	155	.000	**31**	10.755	155	.000
	6	13.499	155	.000	**32**	9.331	155	.000
	7	9.909	155	.000	**33**	10.168	155	.000
	8	13.126	155	.000	**34**	7.956	155	.000
	9	10.431	155	.000	**35**	9.201	155	.000
	10	9.648	155	.000	**36**	9.488	155	.000
	11	13.681	155	.000	**37**	10.968	155	.000
	12	7.745	155	.000	**38**	8.069	155	.000
	13	11.606	155	.000	**39**	10.928	155	.000
	14	11.269	155	.000	**40**	10.591	155	.000
	15	8.112	155	.000	**41**	9.758	155	.000
	16	9.825	155	.000	**42**	10.330	155	.000
	17	10.191	155	.000	**43**	11.210	155	.000
	18	9.067	155	.000	**44**	10.983	155	.000
	19	10.596	155	.000	**45**	11.715	155	.000
	20	13.334	155	.000	**46**	9.292	155	.000
	21	9.233	155	.000	**47**	11.164	155	.000
	22	8.622	155	.000	**48**	7.568	155	.000
	23	8.584	155	.000	**49**	10.867	154	.000
	24	14.144	155	.000	**50**	12.719	155	.000
	25	8.223	155	.000	**51**	9.890	155	.000
	26	11.464	155	.000	**52**	8.865	155	.000

* Significant at 0.05 level.

Table 6

One-Sample Test of items of both part III and IV with test value both three and four

DATA ITEMS		TEST VALUE = 3			TEST VALUE = 4		
	ITEM	T	DF	SIG. (2-TAILED)	T	DF	SIG. (2-TAILED)
III. Attitude Toward Teaching Thinking Skill	1	16.833	155	.000*	3.012	155	.003*
	2	18.698	155	.000*	3.346	155	.001*
	3	14.351	155	.000*	1.631	155	.105
	4	17.951	155	.000*	3.590	155	.000*
	5	16.770	155	.000*	2.705	155	.008*
	6	15.031	155	.000*	1.632	155	.105
	7	16.019	154	.000*	2.741	154	.007*
	8	17.961	155	.000*	3.136	155	.002*
	9	19.297	155	.000*	4.754	155	.000*
IV. Strategy of Teaching Thinking Skill	1	22.960	155	.000*	7.319	155	.000*
	2	17.233	155	.000*	4.183	155	.000*
	3	22.909	155	.000*	6.440	155	.000*
	4	21.808	155	.000*	5.761	155	.000*
	5	29.315	155	.000*	10.019	155	.000*
	6	24.048	155	.000*	7.073	155	.000*
	7	25.299	155	.000*	8.433	155	.000*
	8	26.746	155	.000*	8.526	155	.000*
	9	31.838	155	.000*	11.482	155	.000*

* Significant at 0.05 level.

Table 7

One way ANOVA table of items with significant difference

ITEMS			GENDER					YEARS OF TEACHING					ACADEMIC BACKGROUND				
		Profile Factors	Sum of Squares	df	Mean Square	F	Sig.	Sum of Squares	df	Mean Square	F	Sig.	Sum of squares	df	Mean Square	F	Sig.
II	26	Between Groups	4.270	1	4.270	4.076	.045*										
		Within Groups	161.320	154	1.048												
		Total	165.590	155													
	27	Between Groups						11.683	4	2.921	3.007	.020*					
		Within Groups						146.676	151	.971							
		Total						158.359	155								
	31	Between Groups						12.347	4	3.087	2.987	.021*					
		Within Groups						156.012	151	1.033							
		Total						168.359	155								
	33	Between Groups						11.599	4	2.900	2.477	.047*					
		Within Groups						176.760	151	1.171							
		Total						188.359	155								

ITEMS			GENDER					YEARS OF TEACHING					ACADEMIC BACKGROUND				
		Profile Factors	Sum of Squares	df	Mean Square	F	Sig.	Sum of Squares	df	Mean Square	F	Sig.	Sum of squares	df	Mean Square	F	Sig.
	38	Between Groups	5.294	1	5.294	4.462	.036*										
		Within Groups	182.726	154	1.187												
		Total	188.019	155													
	40	Between Groups											4.981	1	4.981	4.233	.041*
		Within Groups											181.243	154	1.177		
		Total											186.224	155			
	41	Between Groups	6.973	1	6.973	5.862	.017*										
		Within Groups	183.200	154	1.190												
		Total	190.173	155													
III	6	Between Groups	2.267	1	2.267	2.636	.107						5.565	1	5.565	6.637	.011*
		Within Groups	132.419	154	.860								129.121	154	.838		
		Total	134.686	155									134.686	155			

* Significant at 0.05 level

Discussions and conclusions

Ability to teach thinking skills

Technology teachers showed significant ability to teach thinking skills. There were two factors in the statement. The first factor, teaching depth, was with four levels such as introduction, explaining, making learner practice, and putting into the content of technology education. The second factor, thinking process, was with thirteen levels. When consider only one factor, neither of them showed significant difference. The significant difference caused by interaction of both factors in certain level combinations. According to the test result listed in table 5, all 52 statements of teaching thinking skill ability showed significant higher than neutral. Technology teacher showed capable to teach thinking skill of all different levels and processes.

In the sixth process, decision making, significant different showed between depth level 4 and 3. Teachers were more capable to put decision making process into technology education content than to make students practice decision making.

In Table 6, gender caused significant difference in item 26 and 38. Both explaining deduction and induction displayed gender difference. Under teaching-year factor, item 27, 31, and 33 showed significant difference on teaching ability level. Both item 27 and 31 were let students practice deduction process and error analysis process. Item 33 was related to introduce experimental inquiry process. Under academic background factor, item 40 showed significant difference on putting induction reasoning into the content of technology education.

Attitude toward teaching thinking skills

According to table 6, all nine items were significant at .05 level. The positive attitude was revealed from this result.

In table 7, gender factor caused significant difference on item 6. There existed different level of agreement of teaching think skill in the traditional way between female and male teachers. Male teachers showed a higher degree than females. Attitude toward teaching thinking skills had no significant influence from different teaching-year factor.

Feasibility of teaching strategy

According to table 6, all nine items were significant at .05 level. All nine strategy statements were considered feasible. There existed no significant feasibility difference among different strategies. In figure 2, dialogue showed higher potential in teaching thinking skill, especially the process of creative. Questioning was good for practical thinking. Text based lecturing was fit into analysis thinking.

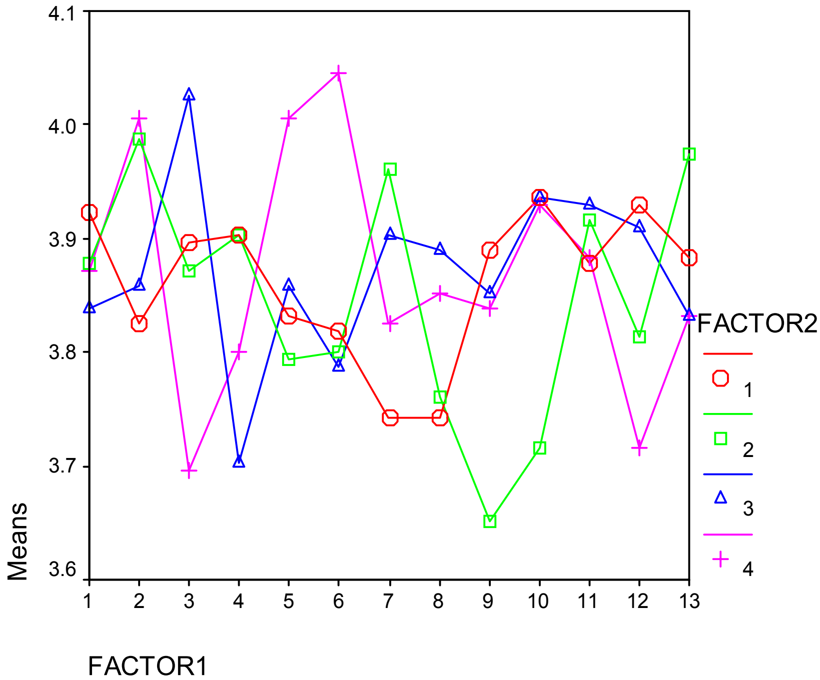

Figure 1

Estimated means of teaching ability of thinking skill

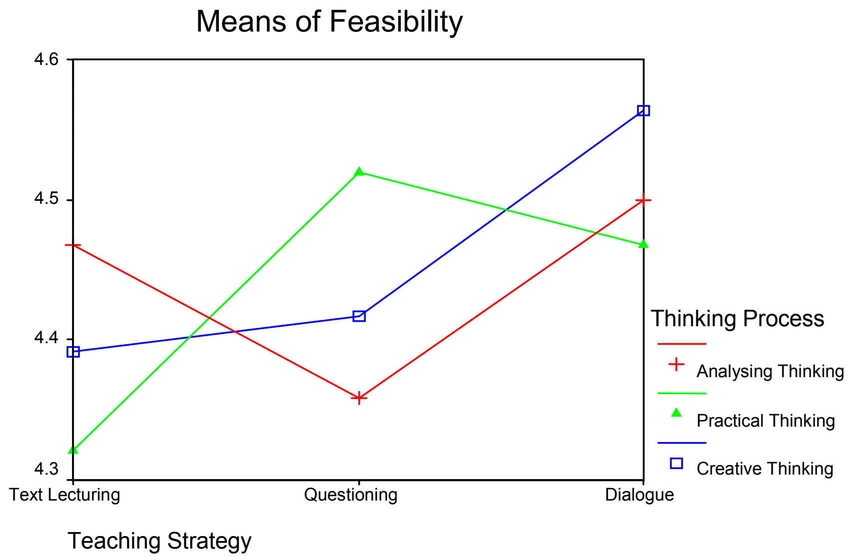

Figure 2

Estimated means feasibility of thinking skill teaching strategy

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The Effects of Computer Networks on Education

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Many advocates of using computer network in school emphasise its positive aspects and understate the kind of work that it requires for students, teaches and administrators. This study presents an interpretive case study of assessing the effects of using computer network upon administrative management in a selected senior high school, National Lo-Tung Senior High School (LTSH), in Taiwan. By employing the methods of document analysis, interview, and observation, the study examined the construction process of computer network infrastructure and the effects upon the campus after the network was implemented in administrative management. It is found that, at LTSH, a successful computer network infrastructure is established in three interrelated stages: preliminary plan, infrastructure preparation, and implementation. It is concluded that the factors that contribute to the successful network construction include the strong leadership of the principal, well-planned computer infrastructure, sufficient staff development and training, co-operation among teachers and administrators, and a perfect teamwork in the Information Group. All of these made up a successful network campus at LTSH. From the effectiveness aspect, it also showed that administration network system had a positive impact upon administrators and improved working efficiency and accountability.

Introduction

Exponential growth in the number of Internet users and hosts connected to the World Wide Web has created a gold rush mentality among schools. Computer network has opened up a new arena for educational development, especially, in the process of managing administration affairs in schools. The use of computer network in school administration, drawing attention to differences between network-based administration and manual systems are widely discussed in many institutions (Schofield & Davidson 1997; Morris 1998). Network technology is an attractive target for exploration when some educational institutions are faced with declining resources and are looking for ways to reduce costs, to promote working efficiency, or to expand their visibility (Murphy & Andrews 1996). As computer technologies enter school administration system, they affect working places and paces of teachers, administrators, and even change whole nature and structure of organisation.

In general, the factors that affect the adaptation of computer network technology may be divided into two parts. The first part is inside the organisation such as the leader's acknowledgement and support on computer technology, the level of the information department, the involvement of the leader in information department, the management skills of information personnel, and the possible resistances from administrators. The other is from outside environment such as the changes in the markets, the need of searching outside information, and the regulation of government's policy (Visscher & Spuck 1991; Gallo & Horton 1994). From the review conducted by Doyle and Levinson (1993), it also indicated that school systems that used technology effectively should take the following steps: (1) link measurable educational purposes with technology; (2) manage organisational and instructional changes to support technology; (3) create a long-term infrastructure plan for the entire school district; and (4) establish a technology-management team.

The role of school leader has also been addressed in many studies (Cusack, Gurr & Schiller 1992; Hallinger 1992; Gurr 2000). School leaders are key elements of the successful use of information and communication technology in education. Therefore, leaders of school are now working in a very different environment comparing to that of a few years ago, with many new challenges. On the other side, school administrators and teachers are increasing reliance on sophisticated technology systems to provide support and service in completing their daily tasks in school (Clark & Denton 1998). School administrators are now facing the sudden change and have little time to prepare for this new influx of skills. The attitude of an effective administrator is not battle with technology, but prepare for it and use it for work collaboration (Schrage 1995; Ross 1996).

Over the past several years, computer network studies have demonstrated that the network promotes administration accountability among various levels of educational institutions (Benzie 1997; Oblinger & Rush 1998; Weidner 1999). The emergence of network technology is gradually reshaping the process of administrative management. Today, an increasing number of high schools in Taiwan are establishing connections to the Internet. This study examined LTSH as a case study subject to analyse its approaches of implementing computer networks on promoting school administration affairs and to examine how computer network influenced upon high school campus. Furthermore, interest was also given to analyse any performance efficiency presented after the usage of computer network in campus.

Purpose of the study

This study was to investigate and analyse the process and approach of network construction and the effects that have brought on campus. More specifically, the purposes of the study were as follows:

1. Analyse the process and approach of network construction at LTSH;
2. Examine the effect and impact upon LTSH after implementing network in campus; and,
3. Analyse the effect upon LTSH administrative management after computer network is implemented.

Method

The setting

The setting for this study was a grades 10–12 high school located at the northeastern part of Taiwan. The high school's campus, as is similar to many high schools in Taiwan, consists of several buildings, including several classroom buildings, administration building, library, gymnasium, science building, art building, and technology education building. The selection of this particular high school was opportune. Within the past eight years, LTSH had undergone a renovation in computer network infrastructure. This infrastructure used fibre-optic cable to interconnect all the school's buildings and classrooms. Classrooms, offices, and labs all had data faceplates mounted on walls and all school staff were equipped with personal computers. Furthermore, these computers were connected to the data jacks in the rooms, thereby forming a local area computer network with all staff and students accessing to the Internet and having their own personal e-mail addresses.

Data collection

Document analysis

This was to examine documentations that had been established during the time of network construction at LTSH. The document includes school policy, infrastructure schedule, investment plan, staff training plan, and technical support plan.

Interviews

Fifteen teachers and ten administrators were interviewed at both of the beginning and end of study in order to collect their applications, attitudes and feedbacks of using computer network and to investigate the effects upon the administrative management in campus. These interviews were held individually in each individual's office and the results of these interviews were also analysed.

Observation

Participated office and classroom observation was held four times during the study. This was to help the researchers understand how administrators and teachers managed their daily administration and instructional affairs by using computer network and the effects that had on their works.

Results and discussion

It was found that the computer network infrastructure at LTSH was established in three interrelated stages: preliminary plan, infrastructure preparation, and implementation.

The preliminary plan stage

The original idea of the network construction in campus was based on the integration of message transferred among all school buildings. The idea was first proposed by the principal in 1992. Then the "Computer Network Infrastructure Plan" was immediately developed by the Information Group which was appointed by the principal. The "Computer Network Infrastructure Plan" includes all necessary elements, such as hardware, software, curriculum, staff development, and control, as suggested by Ross (1996). Under the leadership of the Information Group, all of the administration offices started planning their need assessments. These included the software and hardware required, content presented on Web, and functions needed.

The Librarians played the leading actors in the first stage of the network construction. They recruited a "Seed Group" which was formed by the teachers with speciality in computer network. The responsibilities of the group were to arrange and provide computer training for all the teachers and administrators in campus. As for the purchase of hardware and software, the Office of General Affairs was responsible for managing all details, and the Office of Academic Affair was responsible for equipment maintenance and management.

The infrastructure preparation stage

The problems occurred in this stages are mainly from the perception difference between planners and users. At the beginning, most teachers and administrators had merely no motivation to learn and use computer. In the meantime, the working pace between each office was not in concordance. Also, some system planned by the contractors was not compatible with one another.

The difficulty of recruiting people to maintain the network has also been troubling LTSH since the Information Group was unable to provide all services needed at the beginning. They tried to leave these to outside companies, but it cost too much. As for the budget issue, LTSH was unable to set-up a thorough evaluation at first. The renewal of the hardware was too fast to catch. Every time the software updated, the older equipment would not work functionally. As a result, LTSH has to spend more to buy parts upgrading the equipment to meet the need.

With all the difficulty in front, the principal of LTSH decided that a small scale of tryout was needed to prevent facing all the problems without any experience. The library was chosen to build its own computer network. This strategy was proved to be a correct movement since the school could take the opportunity to foster its own manpower and learn any possible experiences. Took the advantage of success at library, LTSH was capable to move further step by step.

The implementation stage

When LTSH decided to use computer network to manage administrative affairs, the facing difficulty was short of capable person that could perform computer efficiently. The Information Group was the only manpower that could help the school to execute this automation task. In order to attract more computer users, LTSH started to take all possible opportunities to conduct computer activities sponsored by the government. As a result, it raised overall staff's capability. One other strategy was to make competition between offices. When one brilliant idea has shown from an office, the result can stimulate others to follow. All of these made the use of computer prevailed. As for teachers, the Seed Group offered some on-job training to induce them to participate. The group held many actions such as studying group, home pages design contest, and windows application workshop during summer and winter vacation.

It took LTSH five years to construct a successful computer network environment. The following factors show changes shown in campus.

The role of the Principal

The changes at LTSH have shown the challenges that the principal was facing. One of the enduring features of school structure is the role of the principal. The principal of LTSH believes technology is changing administration operation. The construction of network systems allow school to collect, store and manipulate most of the data related to the running of the school. He has the following responses:

> "I often use school network to get everything done – the school management, the financial management, tracking leave by the end of the year, and so on. I also encourage our staff to use available data to get things done. So, I believe the effect has been very profound in terms of providing us with information but also requiring us to do all the data input".
>
> "School leaders and administrators have had to become knowledgeable about the development and maintenance of networks. They have not had to be network experts, but they have had to ensure that their school is developing appropriate networks".

Changes in teachers

Most teachers were willing to use network as a major teaching resource. By surrounding of network, there was another influence upon teachers. It was found that majority of teachers used Internet to collect information for teaching and inspiring the students' interests in learning. As the use of interest was raised from students, it also encouraged teachers to use more Internet as a source of instruction.

> "The Internet evidently has some usefulness in my work. I find it worth my while to spend about three to four hours per day online doing instructional work", said a teacher.

Changes in administration offices

All administration Offices could share the same database of students'. This increased working efficiency and communication channel among administrators. It was found that computer network simplified the work process and increased the quality of service. Although some believed that the communication through the net was not as convenient as face-to-face communication, especially in a high school environment. However, the use of network did provide administrators to access more not only the database of school, but also the rich resources in the Internet. This offered administrators the chances to learn more and widen their visions. Furthermore, computer networks provided the opportunity for administrators to collaborate widely with students and teachers at school, and to query expert and remote databases from other schools.

> "It is important that the administrators of our schools have a depth of information about technology," said a teacher. "Administrators are welcoming the opportunity for information changes because they already have devoted so much. I would hope they would continue to weave this into what they're already doing".

> "Administrators do not need to learn everything in technology. They don't have to do everything, but they need to understand the role of technology in education. I believe our administrators did it. " "Administrators are absolutely key to accomplishing integration of technology. They provide the funding, the planning and the release time for teachers to get trained. The administrators really are key to getting the whole plan going", said another teacher.
>
> "In some instance the adoption of network technology is increasing some administrative complexity because it is allowing things to be done that could not be done before. However, they are all contributing to greater efficiencies", said an administrator.

Conclusions

Principal must be the soul of the whole project when constructing the network in school. From the observation at LTSH, it was found that the principal's leadership and persistence was the key factor that made the whole work successful. The principal of LTSH believed that his involvement in using computer technology should act as a model to administrators and teachers. However, principal does not have to be expert on all aspects, but he/she has to be able to seek help and to be able to make informed decisions. The most important factor is that a strong leadership is always needed when the process of communication and decision-making is involved. In this study, it was found that the principal of LTSH had strong beliefs that his job was continuously to re-educate himself, procure necessary resources, understand technological implementation in classrooms, provide training opportunities, and mobilise staff to create a technology culture as Ritchie (1996) indicated.

From the experience at LTSH, it was found that negative atmosphere among staff members was also happening during the time of the network construction in campus. All faculty members usually took it for granted that there would be increasing works when adopting new network system. Under the constant communication and insistence of the principal, it then gradually showed primary outcomes. After several years of hardworking, the successful outcomes have caught the eyes from the public. The increasing visiting from other schools built the confidence of staff and also increased the willingness to continue. All these made a positive effect on the further development of network system.

It was also found that, at the beginning of network construction, there was little teacher voluntarily involved. Teachers were always concerned and questioned whether the network technology could achieve the goals that they planed to do. Or the network system was only to increase an incomplete communication between teaching and administration. However, from the experiences at LTSH, it can be concluded that the co-operation of teachers, a sufficient hardware, complete training courses, a sound network environment, and a positive supporting from community all form the main frames of the teacher fusion in network.

In conclusion, there are several factors that can be included to answer the question: How did the LTSH successfully construct his network system and implement it in administrative management? These factors include the strong leadership of the principal, well-planned computer infrastructure, the sufficient training courses provided for faculty in campus, co-operation among teachers and staff, and a perfect team work from the Information Group. All of these made a successful network campus at LTSH.

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