Technology teacher education through a constructivist approach

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RESEARCH

Abstract

This paper reviews literature on constructivist learning theories relevant to and evident in teacher education in a New Zealand university. These theories are illustrated within an authentic technology education context which involves students from a primary teacher-education degree programme. It investigates how a practical activity, based on constructivist principles, successfully leads to the development of student teachers' understandings of technology education and technological practice within an initial teacher education programme. The paper describes the practical activity undertaken by final year students where a collaborative 'company approach' strategy is used. The data shows that while undertaking a constructivist based activity, students gain a rich understanding of theory related to technological practice and relevant links to learning in the classroom. Examples are presented of the higher level thinking obtained by the students as they participate in this collaborative and cooperative exercise and reflect on their learning.

Key words

constructivism, teacher education, technology education, collaboration, co-operation

Introduction

The *New Zealand Curriculum* (Ministry of Education, 2007, p. 12) currently implemented in New Zealand schools provides a clear directive for teachers to facilitate student independence and autonomy in learning, and to encourage students to work co-operatively and collaboratively. A 'front end' to the curriculum identifies the key competencies, principles and values students will need to succeed in twenty-first century society and to sustain life-long learning. Learning through constructivist approaches will more readily allow for the integration of key competencies and values with discipline knowledge and content in a way that will lead to more purposeful and meaningful connections.

This study illustrates how the constructivist based theory in teacher education facilitates reflective thinking and enables students' insight into teaching technology education in the primary classroom. In New Zealand, teacher education is currently experiencing considerable pressure to move teaching from small classroom based programmes to mass delivery of lectures. The current programme very successfully facilitates the modelling of activities and learning strategies that allow students to experience successful learning themselves through motivating and practical application. This paper clearly demonstrates the effectiveness of this method in developing students' deeper understandings of learning in technology education and presents an opportunity to appreciate how an activity can be utilised in the school classroom environment. Technology is a holistic and practically based curriculum, which is ideally suited to constructivist approaches to teaching and learning. The immigrant[1] biscuit activity demonstrates an approach that encourages students to think critically about technology and how to successfully implement it in the classroom.

The paper reviews three constructivist theories and discusses how these theories enhance learning for students who are undertaking, recording, and reflecting on technological practice. It briefly investigates learning in the 21st century, introducing two metaphors of learning (Sfard, 1998) and illustrates the effectiveness of constructivist based learning in technology teacher education.

Literature review

Constructivist theory

The acquisition of technological knowledge clearly aligns with several constructionist theories of knowing. These theories and theorists such as; Situated Cognitive Apprenticeship and Authenticity (Hennessy, 1993, Bereiter, 1992), Scaffolding and Modelling (Bruner, 1996, Vygotsky, 1978), and Integrated Inquiry (Murdoch, 2004, Blythe, 1998) among many, claim that people construct knowledge through interaction with others in the socio-cultural environment and as such, knowledge is socially constructed. In their discussion paper on the nature of technology, Compton and Jones (2004) state that technological knowledge is socially constructed. This is because the social and cultural values of particular groups of people influence the technological advances made at any one time. Technological activity accordingly is

[1] In New Zealand the term 'immigrant' is used widely to describe recent arrivals to our country. In reality all New Zealanders are either immigrants or decedents of immigrants. In this context the term refers to recent arrivals. The authors do not mean this term to be derogatory but use it to differentiate those who have either chosen or needed to make their home in New Zealand.

embedded in the 'made world' and is influenced by social, cultural, environmental, economic and political influences.

The relationship between societal and technological development is complex and inseparable (Compton & Jones, 2004). Hennessy (1993, p.11) clearly supports this notion: 'It is obvious that merely presenting children with new information and experiences in the classroom is insufficient to promote learning.' Within the context of technology education, giving students problems that allow them to work within a specific technological culture or practice motivates them as it has direct and perceivable relevance to their work (Fox-Turnbull, 2006; Hennessy & Murphy, 1999). This is because they are able, through activity and reflection, to make connections to real and authentic needs, issues and practices within society (Absolum, 2006; Turnbull, 2002). The activity 'Immigrant Biscuit' using the 'company approach' presented in this paper is a case in point.

Situated cognitive apprenticeship and authenticity

Situated cognition encompasses thinking as part of a culturally organised activity carried out within a community of practitioners. Procedural and conceptual knowledge is an active part of this process (Bereiter, 1992). Situated cognitive apprenticeship learning methods aim to enculturate students to authentic practices through activity and social interaction. Programmes of this nature develop students through situated learning, enabling them to observe, engage, and invent or discover strategies within contexts to facilitate the development of expert knowledge through the persistent solving of problems in relevant domains (Bereiter, 1992). Turnbull (2002) argues that technology education within the classroom needs to reflect authentic technological practice as much as is practical. She determines that if students are to understand technological process, they must be actively engaged in practice that reflects the culture of real technological practice. Hennessy (1993) reminds us that within our understandings of situated cognition: "Learning is most successful when embedded in authentic and meaningful activity, making deliberate use of physical and social context" (p. 15).

Modelling and scaffolding

In a constructivist approach, modelling and scaffolding are an integral approach to teaching and learning. The expert (usually a teacher) begins by modelling effective strategies and techniques and may make explicit their tacit knowledge. Scaffolding is the process whereby teachers guide learners through activity in a manner that gradually increases the confidence and competence of the learners (Hennessy, 1993). Bruner (1996) uses it as an umbrella term to describe a range of actions and strategies that an adult uses to help children's learning efforts. The form of these supportive interventions may vary but all aim to help the children gain goals that would be beyond them without the support provided. With gradual withdrawal of the scaffold, the learner becomes progressively independent.

Both these approaches relate to Vygotsky's (1978) notion of the 'zone of proximal development'. Within this zone, students and teachers engage in dialogue about knowledge students have and the knowledge they need. They also consider how teachers, 'as experts', can assist and guide students in a manner that has the teacher gradually withdrawing their support as students become more proficient at the task or learning at hand (McLachlan-Smith, 1998).

Learning

Learning in the 21st century needs to look significantly different to that of the past to equip students for their future lives in the information age. For this reason, educators face a huge challenge including the development of critical thinking and problems solving skills in our students, suggested skills vital for 21st century learning. Some critics, however, oppose the idea of developing these skills on the grounds that important 'content' will be lost (Bellanca & Brandt, 2010).

Sfard's (1998) identifies acquisition and participation as two metaphors that guide learning. The first of these, acquisition, is the more traditional model of learning in which the mind is a vessel, which needs filling with knowledge and concepts much of which is content related. She suggests in recent studies learning is dominated by the participation metaphor in which students learn through interaction with material and people. Learning through participation is more likely to facilitate critical thinking and problem solving as students work collaboratively and co-operatively to advance learning through doing.

> Moreover, ongoing learning activities are never considered separated from the context within which they take place. The context, in its turn, is rich and multifarious, and its importance is pronounced by talk about situatedness, contextuality, cultural embeddedness and social mediation
>
> (1998, p.6).

This latter model best exemplifies constructivist principles of learning and better aligns with skills needed for the 21st century. It also best typifies learning in technology education. One needs to be cognisant of concerns mentioned above about specific content. In reality learning will occur though a range of approaches and certainly through both of Sfard's complementary, not competitive metaphors.

Integrated inquiry learning

The inquiry approach reflects the belief that, for learners, active involvement in construction of their knowledge is essential for effective learning (Murdoch, 2004). Inquiry is guided and systematic learning that proceeds through a number of teaching and learning phases. It is very different from 'open' discovery learning in that the teachers have a major and continuing responsibility to structure a range of activities sequenced to maximise the development of skills and thinking processes of the learners. Inquiry uses a wide range of teaching approaches from teachers' exposition to independent student research (Murdoch, 2004). Inquiry methodology and integrated curriculum are also supported by Caine and Caine (1990, cited in Murdoch, 2004). They argue that the brain seeks pattern, meaning and connectedness; methods that move from rote memorisation to meaning-centred learning (Murdoch, 2004). Integrated inquiry involves students in developing deep learning through the process of self-motivated inquiry that strives towards development of 'big understandings' and 'rich concepts' (Murdoch, 2004) about the world and how it functions (Blythe, 1998). Inquiry is deeply centred on both process and content (Murdoch, 2004).

Quality technology education programmes which use authentic learning offer an excellent model for inquiry-based learning because they allow the integration of numerous curriculum areas and will incorporate key competencies, principles and values in meaningful contexts (Caine and Caine, 1990, cited in Murdoch, 2004). Compton and France (2006) recognise that technology is increasingly interdisciplinary and requires technologists to work in an integrated manner. Technology topics can become 'vehicles' for learning from which students can engage in 'worthwhile exploration of meaningful content that relates to and extends [their] life experiences and understanding of the world' (Murdoch & Hornsby, 2003, p 19). Within this sphere of learning, in technology education, students are given authentic opportunities to measure, speak, write reports, discuss and consider all manner of issues (e.g. social, health). During the process of participating in technology and learning technological concepts, other areas of the curriculum become more accessible (Lewis, 1999). Inquiry learning is clearly a teaching approach that lends itself to the authentic delivery of technology in the classroom.

Methodology

The study uses qualitative methodology within a constructivist framework. Fraenkel & Wallen (2006), Cohen, Manion and Morrison (2001), Neuman (2000) and Lichtman (2006) all cite a number of characteristics or critical elements of qualitative research. Those relevant to this study include that:

- people construct their own meanings (direct link to social constructivist theory);
- meaning arises out of social situations and is handled through interpretive situations;
- words and often direct quotes rather than numbers are used to illustrate a certain point; thick description is desirable;
- concern with context, researchers go into the natural setting to observe and collect their data and use everything from pen and paper to sophisticated audio and video taping equipment to gather data;
- the researcher plays a pivotal role in the research as it is through the researcher's eyes that the data is collected;
- bias can be a problem however; it can be eliminated or controlled through triangulation.

Qualitative research has an emphasis on holistic description, that is, describing in detail what is going on in a particular activity (Fraenkel & Wallen, 2006). It allows for multiple perspectives on reality and ways of knowing, these being interpreted by the observer. A degree of subjectivity is expected by the researcher. Interpretations of data are based on and influences by the researcher's background and experience (Bogdan & Biklen, 2007; Fraenkel & Wallen, 2006; Lichtman, 2006).

This research draws on an interpretive approach, using participant observations, reflections and analysis of student work samples. It aims to understand how students construct meaning of and in technological practice through participating in a practical activity and making links to relevant theory.

Data

Data consisted of reflective quotes taken from the students' assignment work, illustrations, drawings, students' technological outcomes, quotes and photographs from students' technology portfolios and images of their actual practice. This data was triangulated with direct observations from one of the researchers, the class lecturer. Lecturer observation and discourse increased validity of the study by providing authentication of students' work. Researcher observations were in the form of field notes and post class reflections and evaluations, duly followed up with specifically targeted conversations, feedback and clarification with students.

Participant sample

Study participants were initial teacher education students undertaking a collaborative and cooperative task completed in one of their technology education compulsory courses. The course was a part of their three-year Bachelor of Teaching and Learning degree for primary teacher training at the University of Canterbury, New Zealand. The class had approximately 30 adult students from a range of ages and backgrounds, with half constituting the research sample. This study investigates one of the constructivist learning activities undertaken by the students and represented approximately half the course content.

The sample was selected using every second student on an alphabetical class list from one class. All but one of the original sample were willing participants. The student who did not wish to be in the research group swapped before the project began. Once in their company, the students were given a specific immigrant group in this case Hungary, and asked to appoint a chief executive officer (CEO). The CEO facilitated the division of the company into three roughly even teams. Under the guidance of the CEO each team then worked co-operatively to develop the biscuit, its packaging or marketing and promotion. All teams collaborated to gain the information required to complete their outcome. Self-selection of teams within the company allowed students to work in an area of interest or where they might be motivated to develop new skills and practices. Due to tight time constraints and, as all participants were adult, specific teaching of collaborative and co-operative skills were not covered in the course.

Course content for the participants covered a mix of technology theory and practice with many opportunities for students to be actively involved in practical activities. The activity took place in a specialist room including six large hexagonal tables with chairs for written and group work, a food preparation area with two ovens, several microwaves and general cooking facilities, and a 'workshop' area which included a range of tools and equipment. The room represents facilities that are typical of primary or intermediate schools' technology facilities in New Zealand.

The 'immigrant biscuit' activity

The activity described illustrates how a constructivist approach can be used in tertiary teacher education and is predicated on the understanding that students' practice must be as close as practicable to authentic technological practice (Turnbull, 2002). Under the leadership of a chief executive officer (CEO) using a 'company approach' (http://www.techlink.org.nz/teaching-snapshot/multiple/CanterburyCoECompanyApproach.htm) students develop and market a packaged biscuit product, meeting legal requirements, and that could be given as a gift to a predetermined immigrant group. It serves to welcome them through the New Zealand custom of biscuit giving and at the same time giving them a nostalgic feel of home. It is not intended that the biscuit outcome be one that the immigrant could purchase at home but something that presents authentic flavours, shapes, colours or symbols of the immigrant in a New Zealand styled biscuit.

This 'company approach' places students in a mock company of three teams (four to five students per team). Teams take responsibility for the development of either the biscuit, the package or advertising. The target market, in this case was charitable organisations that in turn, gift the biscuits to immigrants. Students were required to complete this activity in a culturally sensitive manner and are directed to thoroughly research their immigrant group to avoid offence and stereotypes.

Once informed of their particular immigrant group the students are required to research information that will give them a full understanding and appreciation of the people encouraging them to develop a sense of empathy. Suggested headings given to the students include tastes, flavours, sights, sounds, images, colours associations, religions, affinities, and adversaries. The sharing of this information with other members of the company helps to foster initial cohesion in the group and consistent understanding of the immigrants' culture.

Each team then researches information about their specific roles as bakers, packagers, or marketers and develops a short list of key tasks to be completed. These lists then allow the CEO to complete a critical path to establish and communicate workable time frames for task completion. The teams then set out to complete their practice. The activity culminates with the CEO planning and leading a product launch to peers. Students individually record their technological practice in a portfolio, submitted for assessment purposes on completion of the activity. The students also submit reflections on their technological practice indicating how their practice links to given theories and primary classroom practice.

The immigrant biscuit activity particularly relates to aspects of the strand 'technological practice' as set out in *The New Zealand Curriculum (Ministry of Education, 2007)*. It engages the students in all three components of practice related to this strand: brief development, planning for practice and outcome development and evaluation. This strand requires students to research, plan, implement and reflect on their own technological practice within the broader aim of developing and evaluating a specific technological outcome.

One purpose of the Immigrant Biscuit activity is to introduce and model the 'mock company' approach to student teachers as a classroom learning strategy emulating as much as possible authentic practice in the real world. Another is to give students the opportunity to work in a situation that requires co-operation and collaboration in order to meet identified needs, as suggested in *Technology in the New Zealand Curriculum* (Ministry of Education, 1995, p. 16, p.16) and *The New Zealand Curriculum* (Ministry of Education, 2007, p.12). It is this notion of learning through participatory and collaborative thinking processes that is the root of situated cognitive apprenticeship and underpins the practice of many modern manufacturing companies (Daniels, 1996; Hennessy, 1993).

The activity allows modelling of an experience student teachers could use directly or modify for use in the primary classroom. It further allows them to experience the authentic technological practices of planning for practice and product development (biscuit, package, and marketing campaign). It facilitates engagement in reflective practice by making links between theories of social constructivist ways of learning, theories of technological practice, and their own learning. During the activity, the students are taught task and time-management strategies, and they experience the use of the portfolio as an assessment tool within technology education.

Analysis and results

Students' reflective comments and their portfolios were analysed for themes. Coding was used for this analysis. Following the coding and theme identification, researcher observation, photographs, and student outcomes were then examined for evidence to further support the identified themes. Table 1 demonstrates the coding process using students reflective comments and photographs taken of their work.

Four themes were identified in the analysis of the data and these will become the focus of discussion in the paper. The themes are:

1. the place of and importance of working cooperatively and collaboratively, seen as significant because it clearly links to authentic technological practice as technologists frequently work in teams rather than in isolation;
2. insightful connections between the students' practice and the theoretical models of technological practice taught in the course: Kimbell and Pacey (cited in Burns, 1997) and Gawith (2000);
3. connections made to classroom practice from the perspectives as a teacher and as a learner;
4. the place of scaffolded learning demonstrating how examples of scaffolding have improved students' learning.

In the following section, each of these themes is discussed in detail.

Co-operation and collaboration

Students in this activity worked very successfully as a group to produce a high quality outcome. Very clear evidence of collaboration and communication within and between the teams is presented. The production team

Collaboration	Theory links	Classroom perspectives	Evidence of scaffolded learning
	Pacey's (cited in Burns, 1997) model identifies the skills and tools available to the restricted meaning of technology, the technical aspect of the process. (Female Student C)	"At every step we are asking ourselves questions. Is this appropriate? Does it have good design qualities? Are people going to want to purchase our product by seeing the ad? How can we make it better?" (Female Student A)	"I think this [critical path] is useful to be aware of, amongst all the creativity that goes with this task. There are certain skills and resources that have to be used to achieve the desired outcome". (Female Student C)
	The production team are using their reflective capability to create a biscuit that will be enjoyed by Belgium taste buds". (Female student A)	"The first try of making the plastic insert for the box according to our plans failed as the cardboard box patterns collapsed in the vacuum former. We then had to change the resources and apply this knowledge to the problem at hand" (Female Student D)	This [critical path] is quite useful in the classroom for the children to be aware of the time frames available. "According to Gawith (2000), the technologists must organise their resources such as time" (Female Student B)

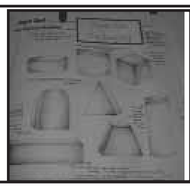
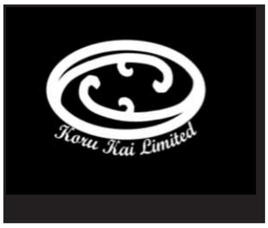
	"This is an excellent example of Kimbell's Reflective Active Capability Model of technological practice" (Female Student B)	"In a class situation, most children would understand the concept *[refers to Herringbone Time Line]* and be able to see what they need to do to contribute to the final outcome" (Male Student E)	"I really like this timeline process, as it clearly displays what I need to do in order to complete my task within the rest of the company. The times are not as specific for this model, which gives the necessary scaffolding while allowing some flexibility" (Female Student A)
	"This is a useful brainstorm to narrow down the vast range of resources and skills available to us. Gawith (2000) states that technologists need to organise materials and resources as well as the process" (Female Student C)	"In a class situation, most children would understand the concept *[refers to Herringbone Time Line]* and be able to see what they need to do to contribute to the final outcome" (Male Student E)	"In a class situation, most children would understand the concept *[refers to Herringbone Time Line]* and be able to see what they need to do to contribute to the final outcome" (Male Student E)
As a teacher I think it is important to provide opportunities for students to work individually and groups (Female Student G)	"This [critical path] is quite useful in the classroom for the children to be aware of the time frames available According to Gawith (2000), the technologists must organise their resources such as time" (Female Student B)	"This [critical path] is quite useful in the classroom for the children to be aware of the time frames available. (Female Student C)	
	Gawith's Models looks at techniques playing a big role in technology. With this I extended my knowledge by looking at different techniques used for packaging currently and applied these to my own packaging designs (Female Students G)	"This is a useful brainstorm to narrow down the vast range of resources and skills available to us" (Female Student A)	
"This *[critical path]* was completed by our CEO. It is a great overview of the whole process and allows you to see where you are up to and how far you have to go" (Female Student B)		"For children's understanding, it is important to think about the skills they need, and have, to complete the given task. It would need some guidance from the teacher to complete this brainstorm" (Female Student C)	"This *[critical path]* was completed by our CEO. It is a great overview of the whole process and allows you to see where you are up to and how far you have to go" (Female Student B)
		"The value for me is in my turning this back to the classroom and my role as a technology teacher. Having a realistic situation, authentic context and technological area, I am able to see how this practice relates to the curriculum document. It's not just what I teach but an insight into how I will teach it" (Male Student E).	
		I believe that this would be a terrific activity in the classroom as it could be integrated with a number of curriculum areas, e.g. art and maths. (Female Student G)	

Table 1. Examples of populated analysis framework evidence within each of the four identified themes



1.1: Company logo

1.2: Marketing campaign

1.3: Marketing campaign

1.4: Marketing poster

Figure 1. A selection of slides from marketing PowerPoint

needed to complete the biscuit so that the packaging team could photograph it for their label, and find out the biscuit's size and shape. The packaging team needed to liaise with the marketing team about the logo and colour themes so they could coordinate their package with the marketing direction. The marketing team needed to understand the 'flavour' of the biscuit and package so that they could accurately represent these products in their advertising PowerPoint. The marketing team also needed to know the colouring of the package so that continuity between packaging and marketing could be maintained.

Figure 1, showing a selection of slides from the marketing team's PowerPoint advertisement, provides evidence of collaboration between the packaging and marketing teams through the use of the packaging team's logo by the marketing team and with the consistency of the colours used by the different teams. It also illustrates links to immigrant research through the use of colour and image.

Figure 2, showing the packaging illustrates the liaison between the packaging and production teams to get an accurate list of ingredients to produce a nutritional information panel using the Australia New Zealand Food Standards Authority (ANZFA) nutritional panel calculator (www.foodstandards.gov.au/npc). They also needed to know the size and shape of the final biscuit quite early in their practice so they could determine the best type and shape for the package. Also required for the package was a photograph of the final biscuit.

Both Figures 2.1 and 2.2 show consistent use of the colour of the immigrants' home flag. Figure 2.1 illustrates use of the mock company's logo. Figure 2.2 displays the nutritional information panel developed by the packaging team using information gathered from the production team.

The researchers observed an anecdotal link between the quality of the outcome produced and the quality of

2.1: The biscuit package

2.2: The nutrition information panel

Figure 2. The biscuit package and the nutritional information

relationships within each team and across the whole company. Students recognised the value of collaboration in the development of their company critical path, a task and time management tool taught, modelled and scaffolded for the students as a part of their preparation: "This [critical path] was completed by our CEO. It is a great overview of the whole process and allows you to see where you are up to and how far you have to go" (Female Student B).

Connections to theoretical models of technological practice

Students were able to make insightful and relevant links between their practice and relevant theory presented in the course. The following quotes illustrate how students have gained an understanding of Pacey's and Kimbell's Models of Technological Practice (cited in Burns, 1997). "The production team are using their reflective capability to create a biscuit that will be enjoyed by Hungarian taste buds" (Female student A) and "This is an excellent example of Kimbell's Reflective Active Capability Model of technological practice" (Female Student B,).

Like Female Student A, Female Student C also made a link to another model in another aspect of her practice.

"Pacey's (cited in Burns, 1997) model identifies the skills and tools available to the restricted meaning of technology, the technical aspect of the process."

Student B was also able to link another aspect of her practice to another of the models of technological practice taught in the course, Gawith's Model of Student Technology Practice (Gawith, 2000). "This [critical path] is quite useful in the classroom for the children to be aware of the time frames available. According to Gawith (2000), the technologists must organise their resources such as time" (Female Student B). Female Student C also made insightful links to Gawith (2000), "This is a useful brainstorm to narrow down the vast range of resources and skills available to us. Gawith (2000) states that technologists need to organise materials and resources as well as the process" (Female Student C).

Connections to classroom practice

The students' reflection also facilitates links between authentic technological practice undertaken by the students and classroom practice as both a learner and a teacher. The following examples of students' reflections illustrate links to individual technological and classroom practice.

Many of the students gave some insight into what it is to be a learner in technology. "At every step we are asking ourselves questions. Is this appropriate? Does it have good design qualities? Are people going to want to purchase our product by seeing the ad? How can we make it better?" (Female Student A). "The first try of making the plastic insert for the box according to our plans failed as the cardboard box patterns collapsed in the vacuum former. We then had to change the resources and apply this knowledge to the problem at hand" (Female Student D). "This is a useful brainstorm to narrow down the vast range of resources and skills available to us" (Female Student A).

Others were able to make insightful connection to what this would mean for them as teachers of technology in the classroom. "In a class situation, most children would understand the concept *[refers to Herringbone Time Line]* and be able to see what they need to do to contribute to the final outcome" (Male Student E). "For children's understanding, it is important to think about the skills they need, and have, to complete the given task. It would need some guidance from the teacher to complete this brainstorm" (Female Student C). "The value for me is in my turning this back to the classroom and my role as a technology teacher. Having a realistic situation, authentic context and technological area, I am able to see how this practice relates to the curriculum document. It's not just what I teach but an insight into how I will teach it" (Male Student E).

Scaffolded learning

Throughout the activity the course lecturer used modelling and scaffolding to guide the students as they participated in this integrated inquiry. Students were taught three different planning for practice strategies for technological practice task and time management: Key Task List, Critical Path and Herringbone Timeline. Students were shown examples of completed strategies and were guided through an exercise involving the development of a critical path. Most students were able to successfully engage with and complete these strategies independently after the structured class work.

3.1 Critical path

3.2 Herringbone timeline

Figure 3. Examples of newly introduced technological practice task and time management strategies

Figure 3.1 shows an example of the successfully completed critical path by the CEO. It demonstrates how modelling and scaffolding has helped the student to complete a new and complex task. "I think this [critical path] is useful to be aware of, amongst all the creativity that goes with this task. There are certain skills and resources that have to be used to achieve the desired outcome". This quote gives insight into Female Student C's understanding of the need to actually teach specific skills (e.g. time management) required by students as they participate in technological practice.

Figure 3.2 shows the herringbone time management strategy. This includes the tasks of the whole company above the diagonal timeline and below allows each team to develop highly specific tasks that will need to be completed. Individuals can highlight their tasks to identify their contribution to the team. “I really like this timeline process, as it clearly displays what I need to do in order to complete my task within the rest of the company. The times are not as specific for this model, which gives the necessary scaffolding while allowing some flexibility” (Female Student A).

The data presented in this section was organised around four themes: collaborative and cooperative learning, links to theoretical models of technological practice, connections to classroom practice and scaffolded learning. All have been identified as significant to understanding and teaching technology education as demonstrated by the individual student reflections and work samples.

Discussion

In the above section four themes were presented as significant in relation to student teacher learning and understanding of technological practice. Sfard’s (1998) metaphor that best describes this learning would be participation, however is it important to note that the acquisition metaphor could be used to describe some of the scaffolded material that preceded this practical activity and some of the more formal teaching that occurred throughout the student’s practice. The data presented demonstrates that although the activity undertaken by the students was collaborative and practical in nature, significant learning, and understanding of technological practice and classroom application has been achieved. It also demonstrates that students were engaged in 21st Century learning (Bellanca & Brandt, 2010) as they were clearly engaged in problem solving and critical thinking.

Learning was contextualised, and culturally embedded through the incorporation of significant immigrant cultural aspects. It is an authentic opportunity because New Zealand is currently seeing the arrival of immigrants from many countries. Social mediation occurred through the students’ research of cultural aspects of the immigrant culture and as teams cooperated and collaborated in an ongoing fashion. Researcher observation suggests that teams demonstrating effective co-operation and collaboration were likely to work more efficiently, and produce higher quality outcomes.

Through the evidence, the researchers determined that the company approach is particularly useful in allowing students insight into learning in and about technology education. Although students may work on different tasks within the same project, they are still able to gain the necessary understanding. This approach can cause difficulties for teachers because of the need for a wide variety of skills, knowledge and processes; however this can be successfully managed with careful planning of ‘just in time’ or ‘just in case’ skills sessions, careful use of modelling and scaffolding, and formative assessment that focuses on process and next step learning. Teaching skills and knowledge to small groups of students as a need is determined is motivating and makes learning meaningful and authentic (Hennessy, 1993).

This immigrant biscuit activity, while not necessarily totally authentic, is a valid approximation of a *technologically* authentic context for children. Working collaboratively and co-operatively in teams to develop aspects or all of a technological outcome is authentic to the world of technological development. Throughout their technological practice, students’ reflections clearly articulate and demonstrate the learning that is occurring during this activity. The Immigrant Biscuit activity encourages students to behave and act like technologists (Turnbull, 2002). Students were able to see the link between their own practice and that of three theoretical models of technological practice. Theories of situated cognition and cognitive apprenticeship (Hennessy, 1993) highlight the issue of the disjunction between traditional classroom learning and cognition in practice. This activity minimises this disjunction by allowing the participants a freedom to discover new and exciting possibilities, often taking learning in unexpected directions and well beyond ‘teacher’ expectations, thus modelling real world technological practice.

Authenticity is also evident in that the student teachers, before being able to teach children to model *authentic* technological practice, need to understand what technological practice looks, feels and sounds like. During this activity, students continued to build their understanding of technological practice by being fully immersed in and reflecting on their own practice and that of their fellow company members. They experienced a modelling of classroom practice.

The immigrant biscuit activity required the students to use and reflect on three different types of task and time management models. The first of these was a simple listing of the required tasks, identifying who was responsible for each one and determining when it needed to be completed. A useful tool because it enabled students to comprehend the scope of the activity. The other two methods were more complex in nature and were specifically taught using a 'modelling through scaffolding to independence' method of teaching (Bruner, 1996). They were explained and modelled in class, and fully explained in course notes. Students were then presented with an exercise to help them work through the process of developing each model (scaffolding of the process) before they used the process independently in their technological practice on the templates provided. This theory and practice worked particularly well as student teachers immediately saw a need and then a use for their new skill (Turnbull, 2002).

Use of a template, a guide or pattern that leads the user towards the achievement, is a particularly useful scaffolding strategy within technology education used in this study. The portfolio template document, in which students keep a detailed record of their technological practice, was provided for the students. This gave the students guidance in the recording of their practice. Scaffolding of the portfolio has proved a very useful tool because it very clearly sets explicit expectations and guidance from the lecturers through activity in a manner that increases the confidence and competence of the learners (Hennessy, 1993). Many students have subsequently modified their portfolio templates when teaching technology in the primary classroom. This indicates not only an increasing independence but also an ability to adapt and design solutions to meet individual needs.

During the process of participating in technology and learning technological concepts, other areas of the curriculum become more accessible (Lewis, 1999). Inquiry learning is clearly a teaching approach that lends itself to the authentic delivery of technology in the classroom. In a recent case study report on quality teaching in technology by the New Zealand Education Review Office (ERO), teachers in all case-study schools mentioned the value of authentic, real-life problems or situations selected for study (Education Review Office, 2006). One school specifically mentioned that students' inquiries and interests played a major role in directing learning.

The Immigrant Biscuit activity is clearly an example of inquiry learning. The activity begins with a series of lessons to teach the students a range of skills they need to conduct the activity. There is a clear structure and purpose to the learning, and students have the freedom to research and take their product in a number of different directions. Inquiry methodology and integrated curriculum (Caine and Caine, 1990, cited in Murdoch, 2004) are clearly illustrated. Throughout the practice, students were engaged in authentic opportunities in a range of other disciplines, among them; science, social sciences, visual and oral English, art and mathematics. This is illustrated in Figures 1, and 2, where the marketing team who developed the poster seen in Figure 1.4 were involved in a number of inquiries in order to achieve an effective visual outcome. The students who developed the PowerPoint used nostalgic music to accompany it and created a voice over about the product. Research included such things as: investigating the immigrant culture to identify the difference between truth and stereotype, taking into consideration Māori protocol when sourcing and selecting suitable pictures, and investigating potential possibilities when using PowerPoint. These included layering pictures, incorporating voice over, adding music, adding text, inserting photos, and locating and isolating a picture of a family and inquiry involving effective visual layout. The production team used weights and measures in the production of the biscuit and the packaging team also used mathematics while calculating the nutritional panel and designing the box layout. Caine and Caine argue that the brain seeks patterns, meaning and connectedness; methods that move learning from rote memorisation to meaning-centred. This integrated inquiry involved students in developing deep learning through the process of self-motivated inquiry that fostered the development of 'big understandings' such as: inclusion, empathy, challenge of immigration and human cultural commonalities and differences.

Conclusion

Through their participation in collaborative authentic technological practice that clearly employed the principles of constructivism through integrated inquiry, students demonstrated a high level of engagement, understanding of technological practice theory, and the associated implications in the classroom. Presentation of their outcome to peers and visitors at the conclusion of the activity promoted a high degree of accountability and intrinsic motivation. Student reflections within their portfolios provided an unequivocal indication that this was a meaningful and purposeful learning activity that had significant bearing on their understanding of technology curriculum and authentic technological practice.

This paper has investigated an activity used within a primary initial teacher education programme to develop aspects of learning theory relevant to technology education and to teacher education in the tertiary sector. It shows how it can significantly help meet the Ministry of Education's directive within the context of an evolving technology curriculum. It has shown how a number of theoretical underpinnings of this practice are modelled and applied in the tertiary sector though teacher education but particularly in technology education. As an added bonus it has also given students an experience that they can take forward to their classrooms in the future.

The researchers suggest two areas for further research in this field. The first being the undertaking of a bigger study with a larger sample using a variety of constructivist based activities possibly across a number of institutions. The second would be a project following student teachers, post graduation, into their classrooms to ascertain the effectiveness and transfer of this learning.

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