The Nature of Conversation of Primary Students in Technology Education

Implications for Teaching and Learning

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Abstract

Classroom conversations are core to establishing successful learning for students. This research explored the nature of conversation in technology education in the primary classroom and the implications for teaching and learning. Over a year, two units of work in technology were taught in two primary classrooms. Most data was gathered in Round 2 during the implementation of the second unit titled 'Props for the School Production'. It used qualitative methodology and an ethnographic approach using participant observations, Stimulated Recall interviews with autophotography, semi-structured interviews with participants and their teachers, and students' work samples, to develop a rich description of classroom conversation in technology.

Initial data identified four significant stages of learning within the second technology unit; these included Stage 1 Character and Function, Stage 2 Planning, Stage 3 Mock-up and Stage 4 Construction. Four over-arching elements of conversation, each with various sub elements, were identified as flowing through the classroom conversations. These were Funds of Knowledge, Making Connections and Links, Management of Learning, and Technology Knowledge and Skills. These elements describe the sources and the purpose of conversation. For example, conversations identified as Funds of Knowledge showed students brought knowledge and or skills learned from home and their community to their technology learning. In Making Connections and Links, students implemented knowledge from school based learning. Management of Learning included classroom conversations initiated by both teachers and students, which enhanced or managed students' learning in some way. In the fourth element, technological knowledge and skills learned were evidenced.

Further analysis of the elements identified three over-arching themes of conversations. The first, 'Deployment', describes knowledge and skills brought by students to their technological practice and included the elements Funds of Knowledge and Making Connections and Links. The second, 'Conduit', described techniques and strategies used by teachers and students to maximise learning

opportunities acting as a conduit between other knowledge and technological knowledge, and was mainly situated within the Management of Learning element. The third theme, 'Knowledge', showed the exact nature of technology learning obtained by the students though the bringing together of the first two themes, rather like a set of interconnected cogs.

The study makes a significant contribution to understanding how students learn in technology education. It develops current understanding of the nature of talk and the role it plays in learning technology. It also presents new findings on the Funds of Knowledge students bring to technology and it challenges existing findings on students' ability to transfer knowledge from one domain to other. Finally, it identifies a gap in existing research into students' abilities to investigate and select appropriate materials for intermediate and final outcomes.

The undertaking of this thesis has been a journey of a lifetime. The ongoing Christchurch Earthquakes from September 2010 until recently, and the death of my father in January 2011, have provided numerous challenges. I could not have undertaken such a journey without the unfailing love and support of my husband Mike Riley. I also wish to thank my children Lucy, Dougal and Jenny for their frequent inquiries and interest in my work and for being proud of their "Mum". Mike and Joan Forrett also require a special 'thank you' for their generous hospitability on my frequent trips to Hamilton.

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Wendy Fox-Turnbull
December 2012

Please Note: In reproducing quotations from research participants, some superfluous speech such as repetitions, speech disfluencies and fillers, have been deleted from the text to make the intended meaning clearer.

Publications from this Research

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Chapter 1. Introduction

1.1 Technology Education Introduction

Technology Education is a learning area that deals with the ways people develop their technological environment to better suit their needs (de Vries, 2009). The world today is technological; people engage with, and use technology from the minute they are born, some even before. Therefore, it makes sense that students are educated about technology, learn how it is developed and how it influences and impacts on their lives (de Vries, 2009).

The term technological literacy is defined in a number of different ways, but essentially means to acquire a level of literacy that is needed to understand and operate within today's technological world. Not only do people need to read and write (language literacy), engage with and use numbers (numeracy or number literacy), they also need to be able to engage with, critique and develop technology (technological literacy) (de Vries, 2009). Technology education deals with aspects of technological literacy that are unique to the discipline and where learning about technology is the main focus (de Vries, 2009).

The New Zealand Curriculum (Ministry of Education, 2007) was released in October 2007 with technology as one of the essential learning areas. It is defined as 'intervention by design, the use of practical and intellectual resources to develop products and systems [technological outcomes]' (Ministry of Education, 2007, p. 32). The three strands or components of technology education as stated in The New Zealand Curriculum - Technological Practice, Technological Knowledge and The Nature of Technology - allow for the considered and efficient development of culturally and environmentally situated technological outcomes.

> The general aim of technology education in The New Zealand Curriculum is to develop technological literacy through understanding:

Technological Practice

Technological Knowledge

The Nature of Technology (Ministry of Education, 2007, p. 32).

Technology education explicitly deals with the technological processes of investigating, designing, making and appraising technological solutions for identified problems or recognised opportunities within any given social and cultural context. Programmes using authentic learning offer models for inquiry-based learning, facilitating the integration of numerous curriculum areas. Compton and France (2006) recognise that technology is increasingly interdisciplinary and requires technologists to work in an integrated manner. Fleer and Jane suggest that it has a symbiotic relationship with a number of other curriculum areas meaning that, through technological practice, students will deploy knowledge from a range of other disciplines in meaningful contexts thus enhancing understanding of technology and other curriculum areas. (1999, p. 73).

Technology education requires students to design and develop solutions for identified problems or to meet specific needs. To do this they are involved in technological practice which ultimately leads to the development of the product or system (Ministry of Education, 2007). Technology topics are generally '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).

1.2 Motivation for the Study

As a teacher educator, the Researcher has considerable contact with children from a range of schools and regularly interacts with student teachers about concepts and knowledge in technology. The story below briefly outlines the awakening moment for the Researcher. One incident, a conversation with a child, triggered the motivation for this study as it left her wondering how much teachers don't know or miss about their students' knowledge and learning, through not having quality conversations with them while they work. This story is told in the 'first person' by the Researcher for effect.

1.2.1 Reuben's Story

In 2004, a Year 4 class with a varied ethnic mix from a low decile school was sought and selected by me in my role as the Professional Studies co-ordinator at the then Christchurch College of Education School of Primary Teacher Education. The class was videoed undertaking a unit of work as a resource for teacher education students. Later that same year, in appreciation of work they had done for us I offered to take the class through a technology unit. The classroom teacher willingly agreed and requested a Christmas theme. At my suggestion, the classroom teacher bought a Christmas tree for the class and we posed the problem that the tree had no decorations and there was no money to buy them. The children were asked to design and develop chocolate Christmas tree decorations to adorn the tree.

Over a period of a week the students undertook a number of activities to enhance their understanding of Christmas decorations, symbols of Christmas, of physical and functional features of moulds and the vacuum forming process used to construct the plastic moulds for the chocolates. We subsequently asked the students to sketch three possible ideas for their decoration, select one and create a copy of the design in ceramic dough, cooked for hardening. During the sketching process, I circulated around the room looking at the students' options and preferred designs. I noticed that one boy, Reuben, had three sketches on his paper; two tradition Christmas designs and one that looked like a sausage with a face rather like a papoose. I asked him which one he was going to develop into the actual decoration. He pointed to the papoose. 'A strange choice', I thought and wandered on to the next child.

Later that week when the students had completed their moulds I noticed Reuben carefully cradling his 'papoose' in his little hand. I stopped and asked him to tell me about his design. He explained to me that his design was for his mother. He went on to say that two years previously he had had a baby brother, born prematurely, who lived only two days. Every year the family hung a decoration on the Christmas tree to remember him. Reuben had designed a representation of his little brother that he was going to give to his mother to hang on their tree at home.

The story still moves me every time I read it or retell it. On reflection, I realised how easily I could have missed this conversation with Reuben. From my perspective, his design could have just been a sausage with a face. On hearing his story, I had a much better appreciation of the thinking and reasoning that had gone into Reuben's technological solution. I began to wonder how much teachers miss when they don't or can't have these conversations with their students and what insights these conversations give us into learning in technology.

1.3 Context of this Study

The study took place in an urban New Zealand primary school. It consisted of two rounds, each involving the planning and implementation of a different technology unit based on whole school themes. In the first round, the Researcher's main aim was to establish positive relationships with the students and their teachers. In the second round the Researcher focused on twelve students, six in each of Years 2 and 6, all of whom were willing participants. The school was a mid-decile, state funded school with families from a range of socio-economic backgrounds and representative ethic mix. The classrooms selected were single level or non-composite classes, one at each of Year 2 and Year 6.

This was a qualitative study concerned with socially embedded action and took place within a sociocultural framework. It followed a qualitative methodology. An interpretive paradigm was employed to answer the research questions. An ethnographic research design facilitated the use of participant observation and oral recording, interviews and work samples to develop rich descriptions of the nature of classroom conversation in technology education. The study aimed to understand the nature of conversation, and how it enhanced students' learning in technology education.

In this research, the culture of the classrooms and the particular groups of children being studied were a clear focus point. The Researcher, clearly present in the classroom during data gathering, was in a role clearly articulated to all participants. The students' ability and willingness to tell their stories to and share their ideas of technological practice with their peers, their teachers and the Researcher depended, among other things, on the culture of their classroom and their relationship with the Researcher.

1.4 Aims of the Research

There is very little New Zealand and international research on the nature of students' conversation in technology education. Classroom conversations are core to establishing successful learning for children for two main reasons. The first, being dialogue between teachers and students, assists teachers by giving them insight into student thinking and understanding. This enables them to adjust planning and teaching to meet specific needs of their students. The second is that the literature suggests that, through engagement in dialogue with peers and teachers, students are able to expand their understanding and knowledge. This research explores the nature of conversation in technology education in primary classrooms and the implications for teaching and learning. The aims of the study were to:

1) gain an enhanced understanding of the learning that influences students when developing technological solutions;

2) understand the nature of conversation most beneficial to students and how and when these conversations are best undertaken to effectively enhance students' learning;

3) illustrate the value and influence of focussed conversations between teacher and student to give teachers clear insight into students' learning and achievement in technology.

The aim of this research was to understand and describe the meaning of social action embedded in the context of fluid social interactions. Analysis of conversation transcripts, students' autophotographs, and participant Researcher observations of behaviour were used to describe the nature of classroom conversation. Neuman succinctly describes the extent of social action in the following quote: "Not just the external or observable behaviour of people. Social action is the action to which people attach subjective meaning; it is activity with purpose or intent" (Neuman, 2000, p. 71).

Classroom conversation is considered from two perspectives: strategy and knowledge. Strategy refers to the strategy used to ignite and facilitate the conversation and in this study includes three elements: Funds of Knowledge, Making Links and Connections, and Management of Learning. Knowledge refers to the actual technological content knowledge of the conversation and is discussed in the Element of Technological Knowledge and Skills.

This study advances research in the area of students' learning in technology by studying students from two primary year levels working in the same or very similar technological practice. This allowed insight into how previous experiences, background and culture impacted on and contributed to students' understanding in technological literacy and practice and the types of conversation that facilitated this process. It also allowed a comparison between students in the two year groups.

1.4.1 Main Research Question

What is the nature of conversation in Technology Education?

Sub Questions

1) What types of conversations enable students to participate in collaborative technological practice?

2) How do students' prior and concurrent experiences influence their technological practice?

3) What happens in the classroom to increase the likelihood of students deploying knowledge and skills from other areas into technology?

4) What insights into technology education can be gained through an analysis of students' conversations with their teachers and peers while participating in technology education?

1.5 Overview of Chapters

This thesis is organised into seven chapters outlined below.

Chapter 1	Introduction: a brief overview of the study and thesis document.
Chapter 2	Literature Review: there are four aspects to the literature review. The first investigates literature relevant to technological practice and technology education; the second considers sociocultural learning theory, the learning theory underpinning this study and also includes Funds of Knowledge (Gonzalez, Moll, & Amanti, 2005) and learning theory in technology education. The third investigates literature on the nature of conversation and its place in classroom-based, problem solving learning. The fourth section of the chapter draws together technology education, learning theory and the theory of language, identifying connections and issues. This chapter concludes with an outline of the significance and rationale of the study, the research aims and questions.

Chapter 3 Research Methodology and Methods: this chapter discusses the theoretical framework and methodology for this study. It also outlines the methods and process used for data analysis and identification of themes. This chapter concludes with the framework identified and used in the following discussion chapters.

Chapters 4 & 5 Results: these chapters use the developed framework to investigate the nature of conversation during a technology unit undertaken in both Years 2 and 6 in a New Zealand urban primary school. The data in this study was divided into four distinct categories, which coincide with the four stages of the unit of work implemented during the study. It evidences the nature of students' conversation while undertaking technological practice. There are four distinct sections, one for each stage of the unit taught. The first two stages make up Chapter 4 and the second two, Chapter 5. Each stage is, in turn, discussed through the four elements identified through data analysis.

Chapter 6 Discussion: this is the chapter in which the results and literature are synthesised to develop understandings about the nature of conversations in the primary classroom. This chapter is organised around the research questions.

Chapter 7 Conclusion: a conclusion of the study findings with implications for teachers and researchers with potential future areas of study identified.

1.6 Conclusion

This chapter introduced this study by giving a brief overview of the study. It also outlined the context and methodology used to frame the study. It briefly discussed the rationale for the study and gave a brief outline of the contents of each chapter. The next chapter, Chapter 2 gives a detailed review of relevant literature in the study and outlines the research questions.

Chapter 2. Literature Review

2.1 Introduction

This chapter reviews the literature relevant to this study. There are four aspects to this literature review. The first investigates literature relevant to technological practice and technology education beginning with a review of literature in the field of technology education. This is followed by a short historical overview of technology education in New Zealand and a section on Technological Skills and Knowledge. The technology section of this literature is concluded with an overview of technology education in the primary sector as this study was conducted in two primary classrooms.

The second section considers sociocultural learning theory, the theory underpinning this study, and it discusses how Funds of Knowledge (Gonzalez, et al., 2005), the knowledge and skills students bring to learning from their cultural and community experiences, influences their learning. These theories are particularly relevant to the field of technology education and this study because of the contextually bound nature of authentic technological practice for students and technologists alike.

The third aspect of the chapter investigates literature on the nature of conversation and its place in classroom based, problem solving learning. Terms such as dialogue (Mercer & Littleton, 2007; Shields & Edwards, 2005), dialogic teaching (Alexander, 2008; Bakhtin, 1981) and 'interthinking' (Mercer & Littleton, 2007), and the role played by conversation in developing thinking and understanding for all participants are explored in this section. Reuben's story outlined in the introduction of this study goes some way to explaining the focus on the nature of students' conversation technology. The study also identified a significant gap in the literature about the nature of conversation in technology education.

The fourth section of the chapter draws together technology education, learning theory and the theory of language and dialogue, identifying connections and issues. The chapter concludes with an outline of the significance and rationale of the study, the research aims, and questions.

2.2 Technology

This section gives an overview of the philosophy that underpins technology education. It also discusses the development of technology internationally and in New Zealand, giving an overview of both the 1995 and the 2007 curricula. The section concludes with discussion about the key components of knowledge unique to technology education.

2.2.1 Definition of Technology

Derived from the Greek work *techné*- the knowledge and discipline associated with the practical activity of human production *(poiésis)* (Feenburg, 2009), technology is defined as intervention by design (Ministry of Education, 2007). This includes the 'know how' and creative process that may utilise tools, resources and systems to solve technological problems allowing enhanced control over the natural and man-made environment with the aim of improving the quality of life (UNESCO, 1985). Technology is much more than just artefacts, "*Techné* includes the purpose and meaning of artefacts" (Feenburg, 2009, p. 161) and although it seems to have quite low status in modern culture, ironically it was present in ancient civilisation as the Greeks were the first consider non-arbitrary human action on the world (Feenburg, 2009).

Technology is socioculturally situated and value laden. Fleer and Jane (1999) argue that technology emerges from within a social context and does not occur in isolation. Technology is constructed within a particular culture taking into consideration the social and cultural needs of the society in which it was developed (Fleer & Jane, 1999; Siraj-Blatchford, 1997). Best fit technology is not necessarily the more sophisticated, complex or most expensive, but is what is most appropriate for that specific culture and may well use local resources which have been depleted in more 'developed' countries (Fleer & Jane, 1999). Technological solutions develop within the context of the community, in which needs arrive, using local skills, resources and existing technologies are likely to be the most successful.

2.2.2 Technological Literacy and Technology Education

Technology Education is a learning area that deals with the ways people develop their technological environment to better suit their needs (de Vries, 2009). The world today is technological, people engage with, and use technology from the minute they are born, some even before. Therefore, it makes sense that our children are educated about technology, how it is developed and how it influences and impacts their lives (de Vries, 2009). Whether technology education is dealt with as a separate discipline or whether it is integrated into other disciplines, such as science, technology education does have a separate body of knowledge (Jones, 1996). An important aim of technology education is to develop technological literacy (de Vries, 2009; Ministry of Education, 1995, 2007). The term, technological literacy, defined in a number of different ways, is essentially a level of literacy that it takes to function in today's technological world. Not only do people need to read and write (language literacy), engage with and use numbers (numeracy or number literacy), they also need to be able to engage with technological devices (technological literacy) (de Vries, 2009). Seemann (1995) coined the term 'techancy' to encompass this holistic meaning of technological literacy. However, technological literacy and technology education are not the same thing, as aspects of technological literacy may be covered in other discipline areas. Technology education deals with aspects of technological literacy that are unique to the discipline and where learning about technology is the main focus (de Vries, 2009).

2.2.3 The History of Technology Education

Internationally technology education has been evolving since the mid 1980s and has taken a number of different forms and approaches. When compared to other curriculum areas this is a relatively short and somewhat turbulent timeframe (de Vries, 2005, 2006). Approaches used vary from country to country and include:

craft based, design based, a vocational approach, high-tech, computer focused, an integrated approach through other curricula and technology as applied science. Some countries have a unified approach throughout while others differ between states or provinces. In some countries, such as The Netherlands, Malta and Scotland, progress once made, has been undone or is threatened, mainly due to the impatience of politicians (de Vries, 2006).

Despite international variances and challenges over the last 20 years, de Vries (2006) suggests some areas of significant progress. A philosophical base has evolved in the field of technology. Two main branches; continental and the broader analytical, are interested in analysing technology from the inside rather than making judgements about the 'impacts' or 'effects' of technology on people and society. This emerging field is interesting as it empowers educators and supporters of the field to clearly define and argue for their discipline (de Vries, 2006). The second significant area of progress is the broadening from a craft and skills based discipline to include social, cognitive, conceptual, and epistemic aspects. Hand-in-hand with this broadening has been the development of pedagogical understandings to the extent where students are engaged in authentic learning, developing their own ideas about potential technological solutions (de Vries, 2006; Turnbull, 2002). The final area of progress suggested by de Vries is the development of international technology related educational research. Technology now has several scholarly journals guaranteeing the publication of technology based research.

In New Zealand, technical education preceded the introduction of technology education in 1995 (Harwood & Compton, 2007). In the last 20 years technology education has found a place in the classroom, in the field of research and in initial teacher education (Jones, 2006). Technical education was a strongly skills based programme and a reflection of the social perspective of the time that boys should learn about metal work and wood work skills and girls should learn to cook and sew (Jones & Compton, 2009).

In the early 1990s, curriculum reform led to the recommendations that technology be established as a separate subject and that there be adequate teacher training and resourcing for technology education. In 1992, the Ministry of Education contracted the Centre for Science and Technology Education Research, University of Waikato to develop a policy framework for technology. The policy identified aims, technological areas, and implementation and assessment directions.

The general aims of technology education in *Technology in the New Zealand Curriculum* (Ministry of Education, 1995) were to develop:

- technological knowledge and understanding,
- an understanding and awareness of the interrelationship between technology and society,
- technological capability (Jones, 2006, p. 200).

Technology first appeared as a part of the New Zealand curriculum when it was included in *The New Zealand Curriculum Framework* (Ministry of Education, 1993a) as one of seven essential learning areas (Jones, 2006). That same year the draft technology curriculum was published (Ministry of Education, 1993b) and trialled in schools through 1994. After significant consultation with relevant sectors, *Technology in the New Zealand Curriculum* (Ministry of Education, 1995) was published for the first time in 1995. Learning was organised into eight levels of achievement from Years 1-13 and three strands: Technological Capability, Technological Knowledge, and Technology and Society. Within each sat a number of achievement objectives, eight in total. Technology was defined as the development of a range of products, systems, and environments aimed at making human existence easier, or to advance the human condition. All technological development was to take place within a social context (Ministry of Education, 1995). This approach was more inclusive of cultural values and beliefs than earlier New Zealand policy and similar policy documents in other nations. This was evident in the strand 'Technology and Society' (Ministry of Education, 1995). Full implementation occurred in February 1999 when technology became a part of the compulsory curriculum for Years 1-10 (5 to 14 year olds).

In *Technology in the New Zealand Curriculum* (Ministry of Education, 1995) technological literacy was defined as the understanding of technological capability, technological knowledge and Technology and Society. Figure 2.1 illustrates these three components of technological literacy. Each aspect of the aim formed the basis for one of the three strands. Technology was taught with an holistic approach which incorporated each of the aspects into each unit of work (Ministry of Education, 1995).

This curriculum (Ministry of Education, 1995) saw students working within seven technological areas: Biotechnology, Food Technology, Electronics and Control Technology, Information and Communication, Materials Technology, Production and Process Technology, and Structures and Mechanisms. Learning was identified to occur within a range of nine contexts: Personal, Home, School, Recreational, Community, Environmental, Energy, Business, and Industrial. Figure 2.2 illustrates the notion of the interconnectedness of the aspects of technology that were represented (Ministry of Education, 1995).

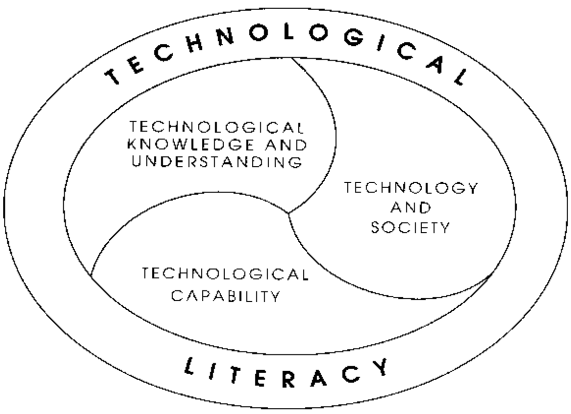


Figure 2.1: The Aims of the 1995 Technology in the New Zealand Curriculum (Ministry of Education, 1995, p. 8)

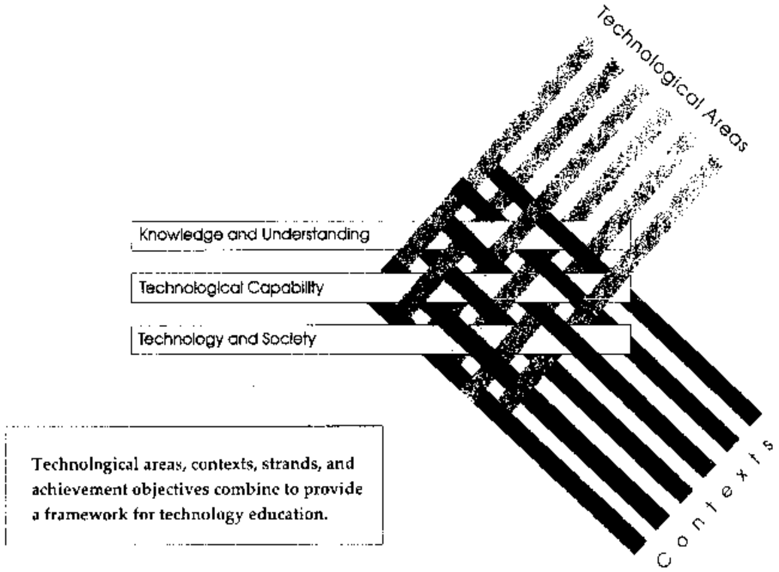


Figure 2.2: The Interconnectedness of the Three Strands (Ministry of Education, 1995, p. 13)

All students were required to cover units of work that covered a prescribed number of technological areas over a one or two year period. For example students in Years 1 to 3 were required to cover four technological areas over the two year period. Technology differed from other curricula in that, when students completed a unit of work in technology, they worked on achievement objectives in all three stands. All technology units were to produce a 'tangible outcome' (Ministry of Education, 1995, p. 16), and therefore students were involved in design processes, problem solving and product or system development each time they undertook technology.

In 2001 a curriculum stocktake was undertaken to review current curricula, teachers' experiences with it, and international trends. This resulted in the development of a revised and refined curriculum. The launch of the 2007 curriculum (Ministry of Education, 2007) saw significant changes in technology, including the introduction of two new strands. To fully understand technology in New Zealand it is important to understand both curricula (Ministry of Education, 1995, 2007), and the process used to make the changes that occurred between 1995 and 2007 documents. It is also important to note that when the 1995 technology curriculum was written, it had never been taught in schools.

This review process saw all curriculum statements reduced in size to two A 4 pages and put into a single document. Each curriculum community wrote a new essence statement and reconsidered the existing strands and achievement objectives. This differed from the preceding curriculum in which each curriculum area had its own document. In 2006 the New Zealand Ministry of Education released a new curriculum draft: The New Zealand Curriculum: Draft for Consultation (Ministry of Education, 2006) went out to the education and relevant related communities for consultation.

In *The New Zealand Curriculum - draft for consultation* - technology, the former three strands were reorganised into one strand - Technological Practice - and two new strands were introduced: The Nature of Technology and Technological Knowledge. The Nature of Technology has a focus on students' understanding technology as a field of endeavour and understanding the characteristics of technology. Technological Knowledge focuses on the place and purpose of modelling, the characteristics and functionality of materials and its relationship to fitness for purpose, and the inputs and outputs that make up systems. The Technological Practice strand supports students undertaking technological practice and examining the practice of others through brief development, planning for technological practice and developing and evaluating products and systems (Ministry of Education, 2007). The prescribed contexts for learning were removed and the technological areas changed to include bio-related, control, food-related, material-development, and structural and dynamic technologies (Ministry of Education, 2006). New achievement objectives were written in technology but were not published in the draft curriculum because of timeline issues; they were published in a separate pamphlet and released two months after the draft curriculum.

2.2.4 Technology in 'The New Zealand Curriculum' 2007

When *The New Zealand Curriculum* (NZC) (Ministry of Education, 2007) was released in October 2007, technology remained as one of the essential learning areas but was redefined as 'intervention by design, the use of practical and intellectual resources to develop products and systems [technological outcomes]'

(Ministry of Education, 2007, p. 32). The three new strands allowed for the considered and efficient development of culturally and environmentally situated technological outcomes.

The general aim of technology education in NZC remained to develop technological literacy, but how this was to be achieved was changed. Technological literacy is now developed through understanding:

- Technological Practice,
- Technological Knowledge,
- The Nature of Technology (Ministry of Education, 2007).

In the new curriculum (Ministry of Education, 2007) the concept of technological literacy was refined to enable students to develop a broader, deeper and more critical understanding of technology (Compton & Harwood, 2007). Table 2.1 gives an overview of the 2007 technology strands by listing a number of key components in each. Apart from new strands more changes were made to the draft curriculum. The technological areas were modified to biotechnology, control, food technology, information and communication technology, and structural technology (Ministry of Education, 2007). Also introduced was the concept of the transformation of materials, energy, or information. Transformation was defined as manipulation, storage, transportation or control of either materials, energy or information (Compton & France, 2006). The changes were instigated because of the implementation of technology into qualifications at senior secondary school. Through examinations, moderation and Ministry of Education research it was discovered students' understanding of technological literacy was somewhat haphazard and restrained because of the nature of technological practice undertaken by the students (Compton & Harwood, 2007).

Table 2.1: Technology Strand and Components

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

(Ministry of Education, 2007)

Implementation was staggered to allow teachers time for professional development in the two new strands of the technology curriculum. Full implementation of all three strands occurred in February 2010. Schools were encouraged to develop programmes of work that involved sequential development of all three strands within a context of learning. There was no longer a requirement for schools to provide learning experiences that covered a prescribed number of technological areas. Schools were expected to develop coherent learning programmes in technology across a broad range of contexts. These consider a variety of fields associated with communities of technological practice. To assist with implementation and teacher professional development, additional resource material was developed and made available to teachers through the website on *Techlink* (Ministry of Education, 2010). Initially these materials supported teachers in developing programmes and pedagogical strategies and was largely focussed on the Technological Practice strand. From 2010, additional resources were progressively added to the *Techlink* website to support teachers' knowledge and understanding of the Technological Knowledge and Nature of Technology strands.

2.2.5 Technological Knowledge and Skills

As already stated, the aim of technology education in New Zealand is the development of technological literacy (Ministry of Education, 1995, 2007; Moreland & Cowie, 2007a). This includes the knowledge and understanding required to skilfully and knowledgably undertake holistic technological practice within the bounds of the context of the study and NZC. It also includes the ability to critique technology and to understand its complexity including how it interacts with humans and the environment (Moreland & Cowie, 2007a).

Knowledge in technology is often difficult to define. Ryle's (1984) definition of knowledge includes not only 'knowing that' but also 'knowing how' which is particularly applicable to technological knowledge. Ryle believes there is a distinction between 'knowing-that' and 'knowing-how'. Early philosophers of technology identified that knowledge employed in the development of artefacts was borrowed from scientific knowledge, and hence the definition that technology is applied science. However, today most believe that technology is a body of knowledge in its own right. Users of technology have a body of different technological knowledge – knowing that. The two categories are particularly relevant to technological knowledge; and could be thought of as 'those who do' technology and 'those who use' technology.

Jones and Moreland (2001) state that technological skills and knowledge come from two main categories; the first is knowledge that is context specific and related directly to the areas in which the solution is being developed, and includes knowledge in a range of domains: procedural, conceptual, societal and technical. The second is generic technological knowledge; knowledge common to all technological development and also applicable across the four domains of knowledge mentioned above.

De Vries (2005) also considers the knowledge of processes involved in the functioning and or making of the object an aspect of technological knowledge. Links can be seen here to the procedural knowledge domain identified by Jones &

Moreland (2001), and Ryle's (1984) knowledge of 'those who do' or 'knowing how'. Technological solutions have intellectual, practical and ethical dimensions with each solution matching to the values of the culture within which it is developed (Fleer & Jane, 1999). To summarise Jones and Moreland, Ryle and de Vries suggest that technological knowledge is either about knowing how to make and use technology or understanding technology in relation to people, its impacts, influences and related issues.

In an attempt to explore this further de Vries (2005) draws attention to the functional and physical nature that artefacts inherit. Designers need to consider both features and how they interact with each other to improve fitness for purpose. He suggests one way to explore technological knowledge is to understand the 'dual nature' of a designed artefact. Technologists have knowledge about the physical nature of an object; this includes knowledge of its material properties such as arithmetical, spatial, kinematical, physical and biotic aspects. They have knowledge of its functional nature and what it means to function as a specific object. This knowledge includes the following aspects: sensitive, logical, historical, lingual, social, economic, aesthetic, juridical, ethical and pistic (strong belief in the power of technology) knowledge. Technologists' knowledge also includes the relationship between the physical and functional features and knowing how materials contribute to the artefact's fitness for purpose. However, many technologists are unable to articulate how they know and are able to use the practical knowledge and do skills specific to their field. "When designing an artefact the designer uses these various types of knowledge. It is thanks to this knowledge that artefacts become what they become. One could almost say that the knowledge has become 'absorbed' by the artefact" (de Vries, 2005, p. 38)

In the classroom, typically students are given a technological problem, communicated to them through a given brief from their teacher, for which they have to develop a technological solution. Students then engage in a selection of planned activities as a part of the unit to allow them to develop the necessary skills and knowledge to design and possibly develop an appropriate technological solution. Students, depending on their ages and level, then plan their practice through the identification of key tasks, required resources, and development of appropriate timelines. They subsequently undertake product development and evaluation by modelling through sketching, detailed drawing and developing three-dimensional models and or mock-up designs. These processes are referred to in the NZC technology support package as an aspect of functional modelling.

> *Technological modelling* refers to modelling practices used to enhance technological developments and includes functional modelling and prototyping. *Functional modelling* allows for the ongoing testing of design concepts for yet-to-be-realised technological outcomes (Ministry of Education, 2009a, p. 1).

> Three-dimensional mock-ups using easily manipulated material such as clay, cardboard, styrodur, and CAD software, are often used to enable design ideas to be evaluated in terms of appearance and function. (Ministry of Education, 2009a, p. 2).

> Functional modelling should therefore occur extensively in the early stages of technological practice, when establishing whether the design concept being developed has worth (in its widest social sense) and when 'what if?' questions need to be asked and explored. Early stages of functional modelling often employ 'guestimation', based on similar technological outcomes and developments and/or drawing from other 'known' situations or past problems/issues (Ministry of Education, 2009a, p. 2).

Finally students develop their final technological outcomes or prototypes. Technology education explicitly deals with the technological processes of investigating, designing, making and appraising technological solutions to identified problems or recognised opportunities within any given social and cultural context.

According to Jones (2009), progression in technology can be measured through a number of categories: the nature of technology, technological practice, generic knowledge and context specific knowledge. Both specific and generic knowledge include procedural, conceptual, technical and societal aspects. Understanding the nature of technology involves understanding the inter-relationships between technology and people, while knowledge of technological practice includes the ways in which students develop technological outcomes. Generic knowledge is common to more than one technological area, while ‘specific’ knowledge is related to a single technological area. Progression includes a broader and deeper understanding of what technology is, and the development of increased complexity and sophistication in skills knowledge and practice related to procedural, conceptual, technical and societal aspects of technology (Jones, 2009).

Technology education has a symbiotic relationship with a number of other curriculum areas (Fleer & Jane, 1999, p. 73). Programmes using authentic learning offer models for inquiry-based learning, facilitating the integration of numerous curriculum areas. Compton and France (2006) recognise that technology is increasingly interdisciplinary and requires technologists to work in an integrated manner. Technology topics are generally ‘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). Other areas of the curriculum become more accessible (Lewis, 1999) and students are given authentic opportunities to measure, speak, write reports, discuss and consider all manner of issues (for example, social, health).

2.2.6 Primary Technology

The introduction of Technology into the New Zealand curriculum in 1995 was the first time technology in any form of technology had been considered as a part of the primary (Years 1-6) curriculum in New Zealand (Compton, 2011). Internationally Technology in the primary sector is also a relatively recent phenomenon and research into it is an emerging field (Benson & Lund, 2011; Cross, 2011; Lund, 2009).

The most significant difference between the primary and the intermediate & secondary (Years 7-13) sectors in technology is that primary teachers learn to teach technology along with all other curriculum areas and do not normally have specialist subject knowledge. Many teachers are required to teach technology with very little training. In recent times technology teacher educators in initial teacher education programmes have struggled with diminishing time with their students (Forret, et al., 2011), particularly in the primary sector due to a current emphasis on literacy and numeracy, thus beginning teachers often struggle to grasp a sound subject matter knowledge (SMK). In their study of the relations between teacher knowledge and students' attitude in primary technology Rohaan, Taconis, & Jochems (2010) identify that teacher knowledge has two distinct categories: SMK and pedagogical content knowledge (PCK). They suggest that both categories play an important role in students' attitudes to and therefore achievement in technology. Teachers in the primary sector often have limited or narrow perceptions of technology which impacts on their ability and confidence to teach technology (Jones & Moreland, 2001; Rohaan, et al., 2010).

The literature review in this study identified a limited body of research on technology education in the primary sector and even less on the nature of conversation in technology. A number of studies have used students' conversations as a research tool for investigating aspects of technology (Ariff, Badke-Schaub, & Eris, 2012; Hyun & Davis, 2005) however these studies did not analyse the actual nature (sources and purposes) of conversation, just the conversation content. An extensive search of international journals of technology education, the Education Resources Information Centre (ERIC) database, the

Sense Publishers' series of Technology Education Handbooks failed to turn up anything on the actual nature of students' conversation in technology education either the secondary or primary sectors, thus identifying a significant gap in research in this field.

To ensure students make progress as they work through programmes of work in technology it is important to be cognisant of learning theories that assist understandings in the ways students learn and develop technological literacy. The next section explores some of these theories.

2.3 Learning Theories

This section discusses learning theory relevant to technology particularly when students engage in technological practices at school. The mixture of practical skills and knowledge and culturally situated theory makes technology unique in the school curriculum. Sociocultural learning theory acknowledges the role that culturally situated tools play in learning. Sociocultural theory, and its relationship to culturally situated tools, encapsulate this, and is, therefore, discussed in depth. To study technology education there is the need to understand how students use tools to construct knowledge and understanding and identified technological outcomes. Hennessy states "It is obvious that merely presenting children with new information and experiences in the classroom is insufficient to promote learning" (Hennessy, 1993, p. 11).

Sociocultural Learning Theory enables the exploration of dialogue and its place in developing understanding. "To understand how individuals learn and develop through participation in the sociocultural world, it is necessary to grant that meaning is more than a construction by individuals" (Rogoff, 1998, cited in Fleer, et al., 2006, p. 31). It also allows the consideration of the place of culturally situated tools within the learning process. Identification of and using individual's funds of knowledge – cultural knowledge and ways of doing from home and community also contribute significantly to learning in technology education.

2.3.1 Sociocultural Learning Theory

Sociocultural theory considers the role of action and tools in the construction of knowledge (Wertsch, 1998). Sociocultural theory deals with the concept that child cognitive development is dependent upon an individual child's responses to cultural and societal influences. The goal of the sociocultural approach to understand the relationships between, human action and mental functioning, on the one hand, and the cultural, institutional, and historical context in which this action occurs, on the other and associated impacts (Resnick, Levine, & Teasley, 1991; Wertsch, 1998; Wertsch, Del Rio, & Alverez, 1995). Wertsch (1998) argues that virtually all human action, whether on a individual or social 'interaction plane', is socioculturally situated, even when the individual sits in solitude, because of mediational means employed.

> Within a conceptual framework for the sociocultural context of cognitive development, the basic unit of analysis is not the individual but the activity involving participation of people in socially constituted practices or "the appropriation of sociocultural means and modes of activity" (Wertsch, Minick, & Arns, 1999, p. 152).

A fundamental claim of sociocultural theory is that its focus is on external or internal human action, which may be carried out by large or small groups or by individuals (Wertsch, 1998). Mediations often emerge in response to a host of forces typically unrelated to the form of mental functioning at issue, and are often incorporated into action in unanticipated ways. This implies that human action, including mental functioning, is shaped by forces that have little to do with an ideal design (Ihde, 2006). Many factors contribute to the success of a single technological development. Ihde (2006) suggests that the designers' intended use of a technological outcome frequently differs from its eventual actual use.

Many current ideas about learning are inspired by sociocultural learning theories (Schepens, Aelterman, & Van Keer, 2007). Murphy and Hall (2008) suggest Vygotsky's fundamental principle that psychological functions, such as perceptions and memory, appear first as elementary functions, such as rote learning times tables, then higher functions, such as understanding and using multiplication, occur through assimilation into sociocultural practices that occur when people live and work together. This account of functioning suggests that any change in a child's cultural development appears twice or on two planes, first in the social plane-intermental functioning and then psychological plane-intramental functioning (Murphy & Hall, 2008; Rogoff & Lave, 1999; Wertsch, 1981; Wertsch, et al., 1999). Rogoff (1990) outlines a sociocultural approach involving three planes of analysis corresponding to 'personal' (intrapersonal), 'interpersonal' and 'community' process and emphasises the need to consider all three planes in sociocultural research. Another way of explaining this in relation to a child's cultural development is that it appears on two planes; first the social plane and then on the psychological plane. First it appears between the child and another person as an interpsychological category, and then within the child as an intrapsychological category. Internationalisation will transform the process itself and change its structure and function (Daniels, 1996b; Vygotsky, 1978; Wertsch, 1981). Fleer (1995) gives an example to explain the interpsychological and intrapsychological planes.

> A toddler participating in hand washing after visiting the toilet or before eating. This ritual is practised by the child's family and hence is a part of accepted behaviour patterns known to the child. However, the child may not necessarily fully understand what this action means. Vygotsky termed this social behaviour as occurring at an *interpsychological* level of functioning- at a social level of functioning without understanding. It is when the child understands why she/he is washing her/his hands that the child is said to be operating at an *intrapsychological* level of

> functioning. Learning occurs when the child moves from one level of functioning to another (Fleer, 1995, p. 21).

The difference between a child's actual level of cognitive function and development and their potential, Richardson (1998) defined the as the "latent learning gap" between what the child can do on his or her own and what can be done with the help of a more skilful other" (Richardson, 1998). Vygotsky (1978) called it the Zone of Proximal Development (ZPD). The role of the more experienced is to guide children through the latent learning gap by guiding, modelling, talking to and challenging children into new learning.

Wertsch, et al. (1999) state, from a Vygotskian perspective, that activity applies not only to the individual but also the collective. They also state that there are two ways activity for children may be a social undertaking; the first is that a child's experiences involve social activity with one or more people (social interactional and intermental engagement). The other consideration is that activity is socioculturally situated; therefore, ways of doing are determined by the social context in which they are situated. Actions carried out on the social and individual planes and on the external and internal planes of the individual are linked (Leont'ev, 1981; Vygotsky, 1978; Wertsch, 1998).

Mental functioning involves cultural tools or mediated means. Human mental function, even when carried out by the individuals acting in isolation is inherently social in that it incorporates socially evolved organised cultural tools such as language. Notions of action and mediation are intertwined and are essential building blocks in the formulation of sociocultural research (Daniels, 1996b).

Action and Mediation

There are two fundamental and defining themes running through sociocultural research: *action* and *mediation.* One of the fundamental claims that Vygotsky made is that human activity on both the individual and social planes is mediated by tools and signs (Wertsch, 1981). The underlying assumptions are that humans have access to the world only indirectly or mediately rather than directly or immediately. External tools mediate action allowing the internalisation of that action (Zinchenko, 1985).

'Mediational means' and 'cultural tools' are terms that are used interchangeably and play an essential role in the basic formulation of sociocultural research, as they provide a link between concrete actions carried out by individuals and groups and the cultural, institutional, and historical setting in which they occur. The terms 'cultural tools' or 'mediational means' and 'mediated action' are used very broadly to include; all cooperatively and socially organised activities, inventions of shared thought - number systems, language and writing systems, schemes for cooperative action - shared plans, a range of social rules, principles for managing recourses and relationships and technological tools and devices (Richardson, 1998).

Wertsch et al. (1995) assume that action and the employed mediational means exist in complex cultural, institutional and historical real world settings. These settings then shape the tools when carrying out action. For example, emergence of writing has allowed the development and understanding of the structure and nature of language well beyond the original need of communication.

Collaborative Learning

Sociocultural theory focuses on the role adults and/or more capable peers play in learning with an emphasis on peer group interactions and collaborative learning (Daniels, 1996a; Richardson, 1998). Smith (1998, p. 21) suggests that within a sociocultural approach children gradually come to know and understand the world through participation in their own activities and in communication with others.

Child development in a sociocultural paradigm is related to cultural practices and circumstances of the communities in which they develop (Rogoff, 1990). Hedegaard (2004, cited in Fleer, et al., 2006) argues that child development occurs through everyday participation in societal institutions and reflects the relationship between the child and its society. Development does not exist within the child, but rather it occurs as the child interacts with the cultural community in which they live (Fleer, et al., 2006), therefore it can be said that, to study the development of a child it must be done within the context of their own community (Rogoff, 1990). This is significant to this research, as it means that observing and recording of students in relation to social participation within socially significant activities is of considerably greater significance than if individuals are studied regardless of sociocultural context (Fleer, et al., 2006).

Intersubjectivity and Alterity

Two opposing tendencies or forces are seen as characterising social interaction: 'Intersubjectivity' and 'Alterity'. Intersubjectivity is the dialogue between the novice and an expert, with the aim of moving the novice to a state in which performance can be carried out independently (Daniels, 1996a, p. 119). It also concerns the degree to which individuals in a communicative situation share a perspective, in what sense, and under what conditions the two individuals engage in dialogue. Resnick, Levine and Teasley (1991) term this information 'transmission'. Alterity is concerned with the distinction between self and others; in other words how people understand the utterances of others. It is concerned with the distinction between self and other within thought generating tendencies (Resnick, et al., 1991).

In any particular episode of social interaction the relative importance of intersubjectivity and alterity may vary, but both are always at work; the challenge is to 'live in the middle'. Virtually every text is viewed as involving both the giving of information and transmission of ideas (intersubjectivity) and dialogic thought generating tendencies (alterity) (Wertsch, 1998). Intersubjectivity is the degree to which the participants in a social interaction share a perspective, or the degree to which they can transcend their two private worlds (univocal function) (Daniels, 1996a). A Vygotskian perspective suggests that intermental functioning focuses on intersubjectivity with the expert guiding the novice from the interpsychological plane – doing without understanding – to the intrapsychological plane – doing with understanding and reasoning. Alterity occurs when individuals experience discrepancy or conflict of opinion or perspective between their own and other's views, sparking cognitive development. In dialogue with another, the listener perceives and understands the meaning and simultaneously has an active response to it, either agreeing or disagreeing, partially or completely; augments it, applies it and prepares for its execution. The individual adopts a responsive attitude for the entire duration of the process of listening (Bakhtin, 1986). Any understanding of live speech is inherently responsive, although the degree varies and is imbued with response, elicited in one form or another. A passive understanding of the meaning of speech is only an abstract aspect of responsive understanding, then actualised in a subsequent response when it is articulated.

Although Vygotsky's work did not explicitly discuss the adult-child interaction dialogue, using the concepts of intersubjectivity and alterity can help to make sense of classroom interaction and learning that is taking place. When a conversation member possesses a more encompassing view of a task, they are able to challenge other members by means of a "one step ahead" strategy, by balancing weaknesses and challenging developmental potential. Through a longitudinal study of mother-infant dyads in apprenticeship interactions, Lave and Wenger (1996) suggest that it is through challenge and conflict that development can be brought about. As a child requires support, it is up to the more capable person to use their sensitivity to produce the right degree of challenge. Interacting with others can facilitate cognitive development under many circumstances, however, it is unlikely that all skills acquired at all stages of development originate in social interactions. Therefore, there is a need to establish what type of social interaction promotes what kind of cognitive achievement, at what age and in what manner (Lave & Wenger, 1996). Children's cognitive development is embedded in the context of social relationships and sociocultural tools and practices. Children, as apprentices in thinking within sociocultural theory require the following important considerations:

- an active role in making use of social guidance,

- the importance of tacit and routine arrangements of activities,
- participation in skilled cultural activities that are not conceived as instructional,
- the cultural variegations in both the goals of development and the means by which they achieve a shared understanding with those who serve as their guides through explanation, discussion, provision of expert's models, joint participation, active observation, and arrangement of children's roles (Rogoff, 1990).

The social nature of development, and the interactions between the expert and the novice, naturally allows power and authority to be present. The most obvious location of authority is with the individual. When people speak they may be judged by others to have authority if they sound or appear knowledgeable. Authority and power can be bestowed through a variety of other means or agents, for example, institutions with positions of authority can act as agents; a change in government following general election is a case in point. Positions of power and authority are not static and often a combination of factors evokes a change in authority and power.

Sociocultural Conflict Theory

The basic tenant of sociocultural conflict theory is that discrepancy or conflict best sparks cognitive development. A subset of sociocultural theory, with a focus on the use of language as a tool, socio-cognitive conflict theory identifies conflict as an essential ingredient of any joint involvement to bring about cognitive change. Doise and colleagues (Doise & Mugny, 1984) have demonstrated, in an extensive programme of research, that children working in pairs solve problems at a more advanced level than those working by themselves (regardless of the ability of the partner). Their studies revealed that coming up against an alternative point of view (not necessarily the correct one) in the course of joint problem solving, forces the child to co-ordinate his or her own viewpoint with that of other children. The conflict can only be resolved if cognitive restructuring takes place, and therefore mental change occurs because of social interaction. Thus, the social interaction stimulates cognitive development by permitting dyadic (people working in pairs) co-ordination to facilitate inner co-ordination. This does not happen through passive presentation of points of view. When children are actively engaged in defending their particular view, and reasoning with those of other individuals, they experience confrontational socio-cognitive conflict. The following mental restructuring allows each partner to adopt an approach to this specific class of problem that is more advanced than that adopted previously when working as an individual (Lave & Wenger, 1996).

In conclusion, sociocultural theory deals with how people use cultural tools to make sense of the world and develop cognitively. The use of culturally situated tools including technological artefacts and language are key factors making this theory particularly relevant to this study. Language as a tool is a key component of interaction. The literature indicates that interaction with peers and adults, the use of language and solving differences and conflict through dialogue is a critical part of the learning. Therefore, it makes sense that the experiences children have in their homes and communities will influence their interactions in the classroom, and their abilities to make sense of engagement with tools and artefacts they are exposed to in the classroom, and the associated cognitive development. Acknowledging, understanding and using children's home and community experiences, also referred to as Funds of Knowledge (Gonzalez, et al., 2005) can advance students' learning. The next section explores Funds of Knowledge and what can be learned from considering them for practice and research purposes.

2.3.2 Funds of Knowledge

Knowledge from experiences and activities undertaken at home or within their wider community that are then brought into the classroom and contribute to the students' engagement in, and understanding of, the lessons being taught (Gonzalez, et al., 2005).

"It is the responsibility of each teacher to attempt to learn something special about each child they teach" (Lopez, 2010, p. 2). Generating an understanding of students and their families' funds of knowledge is one way teachers can do this.

Funds of Knowledge describe the developed bodies of skills and knowledge that are accumulated by a group, for example, a family or the individuals within, to ensure that they can function appropriately within their social and community contexts (Lopez, 2010). Individuals may be shaped by any number of Funds of Knowledge; for example, family, peer group or other network of relationships (Moje, et al., 2004). From a sociocultural perspective and based on the writings of Vygotsky (1978), Gonzalez, Moll and Amanti (2005) remind us that culture provides human beings with the tools and resources to mediate thinking. These resources and tools, some stable across time and some moving with time, are always implicated in the way people think and develop. The theory of Funds of Knowledge draws on the perspective that learning does not just take place just between the ears, but is a social process bound within a wider social context. People have wide knowledge, given to them through their life experiences. The knowledge that students come to school with can enhance their learning and facilitate useful interactions between knowledge found inside and outside the classroom (Gonzalez, et al., 2005). Lopez (2010), and Fleer & Quinones (2009) suggest that teachers can make more of the learning in their classrooms if they understand that students bring with them knowledge from their families, culture and background. They also say that teachers can legitimise this knowledge through purposeful classroom engagement; "one can create conditions for fruitful interactions between knowledge found inside and outside the classroom" (Gonzalez, et al., 2005, p. 20).

To ensure a high level of engagement from a full range of students in any class, each who have a range of funds of knowledge to draw from, means that teachers need to maximise use of integration. In their study, undertaken by a number of teachers, Gonzalez et al.(2005) found that teachers who actively participated in understanding and getting to know the families of their students renewed their interest in an inquiry model of teaching in which students are actively involved in developing their own knowledge, and which facilitates authentic integration of learning. Moje and colleagues (2004) call this integration of knowledge, construction of the "third space" as it merges knowledge from peoples' homes, peer networks and communities - the "first space" with discourses encountered at school and other more formalised institutions such as work or church - the "second space". Moje and colleagues (2004) also argue that different funds of knowledge and discourse may shape students' reading, writing and talking about texts in their science classroom (Moje, et al., 2004). One could argue that this is equally applicable, or even more so, to students undertaking technological practice because technology is fundamentally about the understanding the place and role of technological outcomes (tools) in society and development of new, or enhancement of existing tools. People within any given community draw on a range of sources of knowledge to make sense of their world. This blending of different sources of knowledge creates 'in-between or hybrid spaces of knowledge (Moje, et al., 2004, p. 42), and has been referred to as Hybridity theory (Moje, et al., 2004). When participating in technology education, for example, students require a range of academic, social and physical skills in order for them to collaboratively develop technological solutions to meet identified needs or opportunities (Ministry of Education, 1995). With a focus on the physical, hands-on nature of technology education, Hybridity theory is particularly suitable.

The above sections review the literature around technology education, sociocultural learning theory, conversation and its role in learning and the theory that students' "Funds of Knowledge" can contribute to their classroom based learning. This leaves us to ponder the nature of conversation in technology education, the types of talk used by students when engaged in learning technology. The following section explores the rationale for investigating the nature of students' conversation while undertaking technology practice.

2.3.3 Learning Theory in Technology Education

A number of factors influence the quality of the learning for students in technology education. The LITE Research (Moreland, Jones, & Chambers, 2001), clearly indicates that teacher understanding of technology, and teacher knowledge of the relevant technological practice engaged by the students, influences the quality of learning that occurs for the students. Formative teacher interactions with students may become distorted with a lack of subject knowledge and its construction. Therefore, teachers must teach and assess learning in technology based on a thorough knowledge of the relevant technological practice (W. Fox-Turnbull, 2006), technological knowledge and the Nature of Technology (Compton & France, 2006).

Shulman (1987, cited in Jones and Moreland, 2001) suggests an emphasis is needed to develop a strong teacher knowledge base in the areas of content knowledge, general pedagogy, curriculum, pedagogy content, learners' educational context, and educational ends. Moreland, Jones and Chambers (2001) identify that effective teaching and assessment in technology is positively influenced by the development of a knowledge base in four domains: procedural, conceptual, societal and technical. Research that is more recent has focused on the classroom delivery and assessment of technology. The LITE research (Jones & Moreland, 2001) was pivotal in developing understanding of the necessity for teachers to have specific knowledge within the identified technological practice and how this is used to plan, implement and assess quality programmes of work in technology education.

Another factor is the relevance or authenticity of the task in relationship to the students. An important message about the nature of activities that children undertake, taken from the theories of it, is that authentic learning engages students and encourages learning (Hennessy & Murphy, 1999; Hill, 1998; Rogoff, 1990). Hennessy and Murphy (1999) discuss the possibility that authentic practice actually happens at two levels; "real" to the students may be: real to their own lives and real to situations that they may encounter in the future workplace. Activity is said to be authentic if it is (i) coherent and personally meaningful and (ii) purposeful within a social framework - the ordinary practices of culture" (Hennessy & Murphy, 1999, p. 8). Zuga (1992) acknowledges that women have a more holistic method of knowing and doing which in turn lends itself to learning within authentic contexts. There is strong evidence here that authentic learning in technology needs primarily to be authentic to culture and practice, but there is also evidence that authentic learning at a personal level also aids students' learning (W. Fox-Turnbull, 2003). Students' funds of knowledge will, therefore, influence what each student identifies as culturally authentic.

In conclusion, Sociocultural and Funds of Knowledge theories are particularly relevant to technology education and this study because of the significance placed on interaction with culturally situated tools. This section described aspects of Sociocultural Theory particularly relevant to aspects of technological practice. Conflict or alterity are seen as an important part of the learning process, along with students being involved in the authentic and culturally situated practice of technologists. In the next section, the theory of language and its role in learning is investigated. Language is a culturally situated tool and plays an underrated role in learning. The literature exploring the actual role language, particularly conversation, plays is learning is discussed below.

2.4 Language: its Role in Cognitive Development

Bakhtin (1986) introduced the idea that all text is culturally situated and has the potential to have multiple meanings defined by social and cultural settings. There is an integral link between thought and language. There is also an increasing understanding of the place that language plays in cognitive development (Burr, 1995; Clarke, 2003; Clarke, Hattie, & Timperley, 2003; Fleer, 1995; Seung & Schallert, 2004). It has long been understood that focussed and considered dialogue between teachers and their students can considerably enhance learning, although much of the dialogue between teachers and students is about management (Davis, Mahar, & Noddings, 1990). However, there is also a considerable body of knowledge on understanding how conversations between students can enhance learning (Alexander, 2008; Mercer & Dawes, 2008; Mercer & Littleton, 2007; Stith & Roth, 2008; Wertsch, et al., 1999). This section explores terms such as dialogue (Mercer & Littleton, 2007; Shields & Edwards, 2005), dialogic teaching (Alexander, 2008; Bakhtin, 1981) and 'interthinking', and the role played by conversation in developing thinking and understanding for all participants.

Mercer (1995) describes language as a social mode of thinking that carries with it a cultural knowledge of community, while Vygotsky (1978) describes language as a psychological tool which people use to make sense of their world and experiences in it. Language can also be considered a cultural tool as it allows people to communicate and share experiences, therefore allowing the transformation of experiences into cultural knowledge and understanding (Mercer, 1995). Language allows one generation to share knowledge and experiences with a succeeding generation. It also allows people from the same generation to debate and discuss new ideas and findings, therefore it facilitates people thinking and learning together (Mercer, 1995).

The cultural function of language, communicating, and the psychological function, thinking, are so inextricably intertwined it is difficult to consider one without the other. During conversation, people think about what is said by others, often fusing these ideas with their own, facilitating the development of new ideas. Conversation with other students, when brainstorming for example, offers a chance to involve other people in the development of their own thoughts (Mercer, 1995).

Currently in New Zealand schools there is a strong push to develop and test literacy and numeracy skills. Alexander (2008) suggests that within literacy, reading and written language are targeted, while oral language does not appear to be valued to the same degree. In this section the theories of language, particularly spoken language, dialogue, narrative and discourse, are discussed with an aim to understand current findings on the role that conversation plays in advancing thinking and learning.

2.4.1 Language and Speech: Cultural Tool and Mediated Action

> "Language enters life through concrete utterances, and life enters language through concrete utterances as well" (Bakhtin 1981, cited in Gergen, 2000, p. 167).

A sociocultural perspective determines that the meaning of language is inextricably linked to the sociocultural context within which it exists (Rogoff, 1990). Gergen (2000) states that language gains meaning through its use. Any word or phrase could mean one thing in one social context and yet have a completely different meaning within a different social context. Burr (1995) also suggests there is a multiplicity of meanings inherent in any piece of text or speech. As communication takes place, people are involved in the process of constructing and reconstructing themselves. Language is not a system of set meanings with which everyone agrees. Single utterances can mean different things to different people implying that there is potential for conflict and disagreement (Burr, 1995). The significance of any given utterance is understood against the background of language and its actual meaning is determined against a background of other utterances and actions (Bakhtin, 1981). In the classroom, relationships between teachers and students, and between students, will affect the understanding of conversations. For instance, "you can do that" has multiple meanings depending on the participants, their relationships, the context of the statement and tone and infliction of voice. A teacher encouraging a student 'you ***can*** do that' or a peer telling a classmate that they are expected to do an undesirable task '***you*** can do that' are two examples. Burr (1995) also cites a simple example; the asking of the question "Does he take sugar?" to a parent about their child would be considered quite normal and acceptable. On the other hand, when asked to the wife of a blind man in his presence the same question is insulting and demeaning. The same words have a different meaning when the situation and the people change. Language provides people with a method of structuring their experience of the world and the place they play in it.

Interaction between people is a central aspect of cognitive, social and cultural development within a sociocultural paradigm, and therefore language is more than a form of expression (Burr, 1995). Language is a form of action because as people interact they construct their worlds. Wertsch et al. (1999) state that "cognitive development is explained through appropriation of socioculturally evolved means of mediation and modes of activity" (Wertsch, et al., 1999, p. 152).

This does not rule out biological growth and physical experiences as a contributor to cognitive development but a major force of cognitive development occurs through the interaction with socioculturally defined tools. Language provides both the process and the product for cognitively focussed interactions, therefore we can say that learning is a social process and takes on a theoretical perspective of socially constructed learning (Fleer, 1995).

Bakhtin (1986) coined the phrase ‘utterances’ as the real unit of speech communication. Utterances are not the product of an agent in isolation or simply the product of a “speech subject”, but are constrained by other factors. Bakhtin (1986) states that behind each text strand lies a language system and that all text is repeatable and reproducible. Everything that can be given outside the text (the given) conforms to the language system but at the same time each text (utterance) is different and unique as it is revealed in a particular situation and in a chain of texts. Analysis of utterances involves the repeatable (the actual spoken word) and unrepeatable aspects (inferred meanings and individual given social context) causing tension between the two. Speech genre is not a form of language, but a typical form of utterance. As such, speech includes a certain typical kind of expression and the word acquires a certain kind of expression. Genres correspond to typical situations of speech communication, typical themes, and consequently also particular contracts between meanings of words and actual concrete reality under certain typical circumstances (Bakhtin, 1986).

Meaningful utterances can be thought of as ‘speech acts’ (Gergen, 2000). Gergen asks how ‘doing things with words’ helps us to give understanding to the world? He suggests that some accounts of the world give us understanding or ‘true information’ while other accounts are misleading or false. There are rules to play, rather like when playing a game where cultural ritual comes into play. The rules to the game are not formalised. Gergen cites an example:

> Although the rules are not formalised, we may speak of the game of truth. This is to say that when we engage in actions such as “**describing**”, “explaining” or “theorising” we are also performing a kind of cultural ritual. After I announce, “Let me tell you what happened this morning”, I cannot say just anything, shout, or jump up and down.

> There are implicit rules - just as in games - for what counts as a proper description. In contrast , if I tell you "Let me show you how I felt about what happened to me this morning", I enter another kind of game; in this case shouting and jumping might be perfectly acceptable. So while the presumption of transcendental truth - beyond culture, history and circumstance seems ill conceived, we may say "there is truth", but always within the rules of specific or circumscribed game.(Gergen, 2000, p. 36)

Speech genres organise speech in similar ways syntactical forms do. Speech is not learned in generic forms, and when hearing another's speech, its genre is guessed from the very first words; the approximate length of the speech and certain compositional structure is predicted and the end predicted. From the beginning there is a sense of the whole speech, which is differentiated during the actual speech process (Bakhtin, 1986). Speech genres are constantly employed to produce utterances and understanding the utterances of others, whether conscious of it or not. They are powerful and this is reflected in the fact that listeners may feel discomfort when utterances do not seem to be organised in accordance with a recognised generic form first identified (Wertsch, 1998).

Language and thought are inseparable. Burr (1995) suggests language provides us with the basis of all thought. It enables people to divide their experiences and give meaning to them, for this reason it can be said that identity is a product of language. "Language produces and constructs our experience of ourselves and each other, and is not the simple reflecting mirror belonging to our traditional (western) humanist philosophy" (Burr, 1995, p. 44).

Narrative

Narrative or story telling is a major means for making ourselves understood. Baldock (2006) also emphasises the importance of storytelling, while Gergen (2000) suggests there are three reasons for expressing ideas in the form of storytelling and that people are more prepared to believe and understand ideas.

Stories are easily comprehensible because of frequent exposure to storytelling from a young age. Secondly stories invite fuller audience engagement as listeners are invited to create images, relive drama, suffer and celebrate with the speaker. Finally personal stories are able to generate feelings of acceptance rather than resistance, as the teller has ownership of the story and the associated feelings. “Narrative operates in the everyday world” (Baldock, 2006, p. 118). The use of interesting narrative by teachers can provide very effective ways of generating knowledge for later recall by students (Mercer, 1995).

Baldock (2006) suggests that inviting children to tell stories gives them the opportunity to explore the issues with which the chosen stories deal. He too suggests that these stories offer an excellent opportunity for observation, however, he points out that all interpretations must be tentative especially as children are less able to construct and shape their own ideas than adults. In order to construct their ideas children must have narrative competence, which develops from aged two to 17 years and is described as the extent to which children respond to the invitation to tell a story and make use of conventions such as formal opening and closures and consistent use of past tense. If teachers are to encourage students to tell their learning stories then interaction becomes a necessary tool for enhancing learning when stories are told in an oral form. The next section identifies and discusses several theories of interaction relevant to this study.

2.4.2 Theories of Interaction

Interaction theory focuses on the oral interaction between two people in which both are contributing, unlike narrative, which may or may not be interactive. Research presented below gives clear indication of the advantages interaction offers to learning and cognitive development.

To explain the complexity of adult-child interaction and the ways interactions can be framed by adults, Jordon (2004, cited Fleer, et al., 2006, p. 36) uses the term co-construction. A powerful conceptual tool, co-construction helps us think about how adults and children interact together to support learning, represented in

Figure 2.3. The area of shared meaning is extended when the child and adult are equal partners in their interactions.

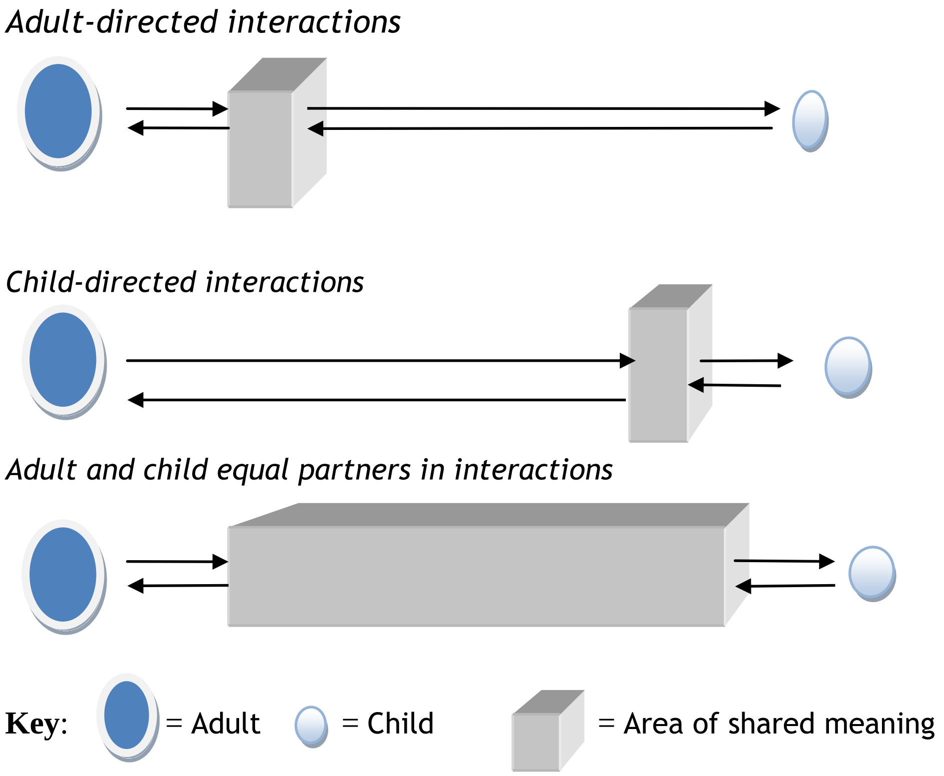


Figure 2.3: Jordon's Model of Co-construction

This is particularly relevant to this study because challenging conversation between adults and students and for that matter between peers is an essential component of the methods deployed. When an 'equal partners' status is obtained between conversation participants then the likelihood of cognitive growth increases. Clearly constructive dialogue, discussed below, is critical in this process.

Dialogue

Dialogue is much more than talk, because it involves the relating to others. Not all talk is dialogue and not all dialogue is talk. It is complex and dynamic and often involves very different cultures, perspectives, ideas, and people. Dialogue generally involves the use of words and it requires engagement with people (Mercer & Littleton, 2007; Shields & Edwards, 2005). Mercer and Littleton use a specific definition with a focus on 'the discussion that takes place during the course of education activities' (Mercer & Littleton, 2007, p. 1). Shields and

Edwards suggest that dialogue can bring moments of intense connection with another person with feelings of remarkable openness, deeply affirming moments, which can be highly exhilarating and powerful.

It is argued that teachers need to engage in quality dialogue with students and parents to help them make sense both cognitively and experientially of the world in which they live and work (Mercer & Littleton, 2007; Shields & Edwards, 2005). To engage in dialogue involves trust and some degree of relationship between the people involved. It cannot happen if one person treats the other person as an object, but instead it requires people to be treated with 'absolute regard'(Sharrat, 1991, cited in Shields & Edwards, 2005).

Mercer & Littleton (2007) and Shields & Edwards (2005) agree as to the importance of dialogue in learning. The following quote from Mercer & Littleton suggests that the place of dialogue in learning is considerably more important than has been demonstrated in schools in the past. "A sociocultural perspective raises the possibility that educational success and failure may be explained by the quality of educational dialogue, rather than simply by considering the capability of individual students or the skill of their teachers" (p. 4). When people work together in problem solving situations they do much more than just talk together, they "inter-think" (Mercer & Littleton, 2007, p. 57) by combining shared understanding, combining their intellects in creative ways often reaching outcomes that are well above the capability of each individual. Problem solving situations involve a dynamic engagement of ideas with dialogue as the principle means used to establish a shared understanding, testing solutions and reaching agreement or compromise. Dialogue and thinking together is an important part of life and one that has long been ignored or actively discouraged in schools (Mercer & Littleton, 2007). There are very clear implications here for technology given the collaborative nature of problem solving required to develop technological outcomes.

The Joint Interactive Episode (JIE) approach concentrates on the analysis of social interaction situations and how children's behaviour is changed by it (Daniels, 1996a, 1996b; Lave & Wenger, 1996). Schaffer (cited in Daniels, 1996b, p. 269) suggest that how adults and children behave in JIE needs to be established in order to better understanding of the types of interactions which give rise to cognitive development. Fleer (1995) suggests that teachers often make assumptions regarding background culture, values and language of the students to whom they are speaking. Gonzalez and colleagues (2005) suggest that teachers do not always understand and appreciate the value of and use of home and cultural knowledge students have to offer. This can cause difficulties and misunderstanding and decrease the quality of the conversations teachers have with their students (Gonzalez, et al., 2005).

Mercer and Littleton (2007) state that education is a dialogic process between students or with their teachers, within settings that reflect the values and social practices of schools as cultural institutions. A sociocultural perspective suggests that education success and failure may be explained by the quality of educational dialogue, rather than simply by considering the capability of individual students or the skill of their teachers. This perspective enables the investigation of the relationship between language and 'intermental' and the 'intramental' thinking. Social interaction is increasingly being seen as significant in shaping children's cognitive development through the social and psychological processes of learning, development, and intellectual endeavour.

For two people to communicate, both participants need to contribute to the conversation. People engaged in conversation normally establish a collective purpose for the conversation. To be able to do this, both must have common understanding of the exchange that is taking place or is about to take place (Clark & Brennan, 1991; Mercer & Littleton, 2007). This common understanding is called *grounding:* its purpose is to ensure "what has been said has been understood" (Clark & Brennan, 1991, p. 128). Grounding as defined by Clark and Brennan is a collective process by which participants try to reach a mutual belief of understanding about what a contributor means. They also suggest that grounding is a basic component of and essential to communication and all other collective actions, and is shaped by two main factors, *purpose,* and *medium*. The process of understanding speech communication falls into two process, the first is the decoding the language codes and the second is concerned with the movement of the codes to the deeper sense of communication (Luria, 1982). Returning to the "you can do that" example used earlier in Section 2.4.1, for students to understand and react to the phrase they must share common understanding of the context of the conversation and the role of participants before a shared meaning can be determined.

Stith and Roth (2008) present us with the concept of co-generative-dialogues as a space in which teachers and students engage in critical interrogation of a shared experiences from their individual perspectives. The goals of co-generative dialogue are to find common areas of agreement and understanding. Students are then enabled to use learning experiences from one situation, and transport them and make them meaningful in another situation. Stith and Roth suggest that this is an example of what Guba and Lincoln (1989) present as the concept of transportability. Transportability offers efficiency - not having to learn the same concept in different contexts - and independence to learners, enhancing abilities to make their own and help others' connections and progression. This is particularly relevant to technology if we want students to utilise skills and knowledge learnt elsewhere in the curriculum and from their cultural communities.

Discourse

The term 'discourse' is used increasingly when discussing language and how it is accomplished. The definition of the term itself varies according to the writers' theoretical traditions, but essentially draws on the idea of variability of meaning in language (Burr, 1995). Fairclough (2003) states that "discourses are different ways of representing the world" (p. 215). From a structuralism and poststructuralist point of view, the focus is on identity, selfhood, personal and social change and power relations. An alternative focus is on the performative qualities of discourse, or what people are doing with their talk and their speech;

how accounts are constructed and how they bring about effects for the speaker. Burr (1995) suggests that

> a discourse refers to a set of meanings, metaphors, representations, images, stories, statements and so on that in some way together produce a particular version of events. It refers to a particular picture that is painted of an event or person or class of persons), a particular way of representing it or them in a certain light (p. 48).

Given the understanding that a variety of versions of an event is potentially available through language, this means that surrounding any person, event or object there are a number of different discourses, "each with a different story to tell about the object in question, a different way of representing it to the world." (Burr, 1995, p. 48). Bakhtin (1981) suggests that in everyday dialogue the speaker regularly considers the listener and his or her response giving the speaker insight into perceived discourse. When the response is aligned with that of the speaker's understanding of discourse the conversation is enriched; when perceptions of discourse differs the speaker can sense resistance.

Language provides both the process and the product for cognitively focussed interactions. Therefore, we can say that learning is a social process and takes on a theoretical perspective of socially constructed learning (Fleer, 1995). This is particularly relevant to technology education, especially when students are working on developing a common technological outcome. Language, especially conversation allows students to find common ground in order to advance understanding of their learning context, design and outcome ideas.

2.4.3 Conversations to Advance Thinking in an Educational Context

Structured conversations based on various forms of evidence can result in a real change of learning (Earl & Timperley, 2008), however, having the conversations and the evidence is not enough. Learning and the development of new knowledge involves a process of deep collaboration and inquiry.

Hakkarainen, Paavola & Lehtinen (2004) describe knowledge as created through dialogue or conversations that make presuppositions, ideas and beliefs explicit and available for exploration. It is in these conversations that new ideas, tools and practices are created and the initial knowledge is either substantially enriched or transformed during the process. Innovative solutions arise when people in groups draw on evidence and explicit outside knowledge then combine it with tacit knowledge in response to authentic problems (Nonaka & Takeuchi, 1995)

> It is our contention that when educators engage in conversations about what evidence means, it sets the stage for new knowledge to emerge as participants encounter new ideas or discover that the ideas that they had held as "truth" do not hold up under scrutiny and the use the recognition as an opportunity to think what they know and what they do (Earl & Timperley, 2008, p. 2).

In such conversations participants are required to reveal what they believe and why. They must explain their views and why their perspective is preferable to those of others, they must also be open to critique and challenge. Often what is known, for example 'their theory', is implicit, but participants have to explain these to others who hold alternative views and are therefore required to make explicit their beliefs and values that underpin their theories (Earl & Timperley, 2008).

Evidence informed conversations involve an iterative process of asking questions, examining the evidence and thinking about what the evidence means within a particular context. Earl and Timperley (2008) coined the phrase "inquiring habits of mind" to describe conversations which skilfully integrate the above three aspects. This process can be described as the on-going process of using evidence to make decisions; collecting evidence and interpreting the data in ways to advance thinking. As well as an inquiring habit of mind, Figure 2.3 illustrates how Earl and Timperley (p. 3) argue that relevant evidence and a relationship which commands respect and challenge are also needed to allow informed learning to take place. Like a three-legged stool all three areas are required to ensure quality evidence based conversations take place.

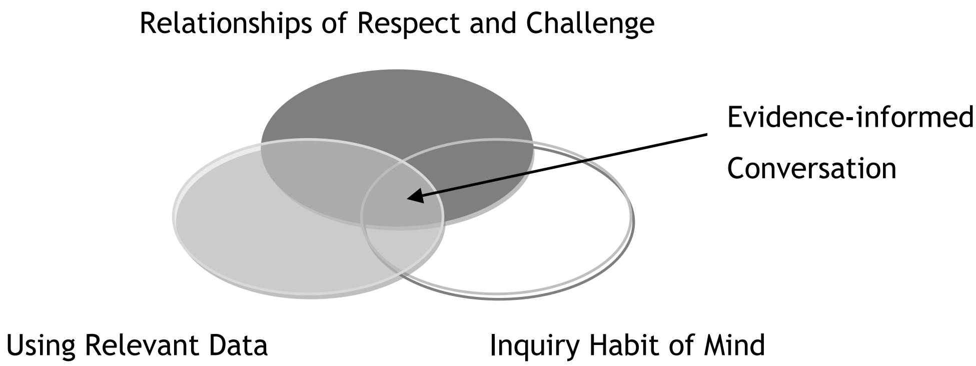


Figure 2.4: The Processes for Evidence-informed Conversations (Earl & Timperley, 2008, p. 3)

To further explain this model each aspect is discussed in the following paragraphs. An 'inquiry habit of mind' enables competence in managing the environment and making decisions, but incorporating dispositional, emotional, motivational, and personality variables. It emphasises a dynamic way of thinking, involving feedback loops, moving towards clearer direction drawing on and seeking out information as participants develop understanding (Earl & Timperley, 2008).

'Using relevant data' refers to the data teachers use to make decisions for educational purposes. This data comes either from the teachers' experienced anecdotal and personal observations or from test results. However, both sets of data can be interpreted in a variety of ways. Value and utility of data comes from careful and considered collection and collation of data, and from the careful consideration into the way the data is transformed into knowledge (Earl & Timperley, 2008). If educators are going to involve themselves in the use and interpretation of data and challenge or dispute the interpretations of others, they must become knowledgeable about judging the value and the quality of the evidence, and thinking and talking about meaning. Clarity of purpose, specific criteria to judge evidence and knowledge about statistical measurement for interpretation are vital for this process. Conversations are also vital to this interpretation process, however, the types of conversations need to incorporate thinking, formulating possibilities, developing convincing arguments, locating logical flaws and establishing feasible and defensible notions. This may well involve new skills and processes that teachers need to be aware of and learn to ensure effective change (Earl & Timperley, 2008).

The third aspect needed for evidence-based conversations is 'Relationships of Respect and Challenge'. Improvement in education contexts is social rather than individual. If knowledge is to become more generic or institutionalised then individuals must do more than demonstrate patches of brilliance in their own classroom, they must allow the knowledge to become socially constructed by the key participants. This occurs through dialogue and debate, in order to expose potential flaws and develop a sense of ownership. This dialogue and debate typically occurs through conversation with colleagues (Earl & Timperley, 2008). However, conversation can occur through a variety of modes.

2.4.4 Modes of Communicating

For two people to communicate both participants need to contribute to the conversation. People engaged in conversation normally establish a collective purpose for the conversation. To do this a number of techniques are employed which typically change according to the purpose and content of conversations. There are many different modes of communication some of which are constantly changing: telegraph, telephone, video, email, fax, 'post-it' notes, personal face-to-face communication, teleconferencing and texting to name a few. More recently the internet has proved to be a popular communication tool, with wiki spaces such as "Twitter" (twitter.com). Techniques employed to establish clear purpose for communication must differ according to the media used. One technique discussed by Clark and Brennan (1991), is the technique of "least collective effort" which suggests that people do not like to put in any more effort than required. This means that exchanges are brief and often lead to short cuts when communicating. The use of the term 'okay' is a technique often employed in 'face-to-face' and telephone conversations to ensure the speaker does not say more than necessary. 'Okay' indicates that the listener has enough information for understanding. However, this technique is not often used in keyboard teleconferencing as it is difficult to time its addition without interrupting the typist's flow of conversation. Although essentially evolved since Clark and Brennan identified the concept of "least collective effort", text language is another example of this. Teenagers have embraced the cell phone and particularly texting as a way of communicating with their friends. Text languages developed within cohorts tend to minimise the use of letters and can use numerals instead, for example: LOL short for 'lots of laughs', k for okay and L8R to replace 'later' (Allen, 2010).

Not all communication is equal. Modes of communication come with specific and shared characteristics that impact on the quality of the conversation. Clark and Brennan (1991) consider eight characteristics that specific media impose on communication between two people:

- Co-presence: sharing the same physical environment, can readily see and hear each other.
- Visibility: to see each other as in face-to-face conversation.
- Audibility: communicating by speaking as in face-to-face communication or speaking on the telephone and allows participants to note timing and intonation.
- Co-temporality: received at roughly the same time as it is produced without delay.
- Simultaneity: both people can send and receive at once.
- Sequentiality: when the communicators' 'turns' cannot get out of sequence. In emails and answering machines, replying can become muddled with other irrelevant messages or activities.

- Reviewability: ability to review the messages of the other, for example, letters and emails.
- Revisability- the message can be revised privately before sending it such as in emails and letters.

It is important for teachers to be cognisant of the impacts mode can have on the nature of the communication taking place. Using seven suggested medium or modes of personal communication suitable to dialogic communication, Clark and Brennan (1991) identify the characteristics associated with each, as seen in Table 2.2. Note that transcription of the conversations may appear to add ‘reviewability’ and ‘revisability’ to face-to-face conversation, however, these constraints only affect the researcher as the conversationalists will not have free access to their recorded conversations as they might in email or telephone answer machines.

Table 2.2: Seven Media and their associated constraints

Medium	Constraints
Face-to-face	Co-presence, visibility, sequentiality. simultaneity, audibility, co-temporality
Telephone	Co-presence ,audibility, co-temporality, simultaneity, sequentiality
Video teleconferencing	Audibility, co-temporality, simultaneity, sequentiality
Terminal teleconferencing	Co-temporality, audibility, sequentiality, simultaneity, visibility
Answering machines	Co-temporality, sequentiality, reviewability,
Electronic Mail	Audibility, reviewability,
Letters	Reviewability, revisability

(Clark & Brennan, 1991, p. 142)

Socially shared cognition is critical in the direct interaction between two people. The media selected for communication clearly impacts on its quality. Shared understanding of what went before and what actions lie ahead also determines the viability of the interaction between participants (Schegloff, 1991). This intersubjectivity is not always a smooth process. Talk can be organised and strategies developed that contribute to the shared understanding between participants. One such strategy is *organisation of repair*. This arrangement allows participants to deal with misunderstandings. Strategies can be instituted at various stages of the talk and Schelgoff (1991) suggests that patterns to clarify a shared cognition can be established.

This section has considered a range of theories that impact on understanding of the importance of oral communication within and for human development. The next section focuses on the role of oral communication amongst children and between adults and children.

2.4.5 Interaction Between Child and Adults and Between Children

Many people have tried to describe quality interaction between adult and child, however, there is no one ideal way of interacting with children. Interactions are bound by context and are specific to the immediate situation (Fleer, 1995; Seung & Schallert, 2004). Mercer and Littleton (2007) suggest that many children are not taught useful ways of using spoken language as a tool for learning and working collaboratively. High quality interaction is best exemplified when teachers engage in the philosophy that all students are unique individuals. Fleer (1995) found that in many cases during interactions with adults or older children, children are not given time to think about what they are doing in relation to the wider situation or previous learning and experiences

Educationalists are becoming increasingly aware of the significance of conversations in learning. Through conversations, teachers and parents can encourage children to reshape their thoughts (Mercer, 1995). Students' experiences in the classroom are intellectual, social and interpersonal (Seung &

Schallert, 2004). Alexander (2008) introduces the term dialogic teaching and states that talk is an essential tool for learning and "children need to talk and to experience a rich diet of spoken language, in order to think and learn" (Alexander, 2008, p. 9).

Green, Weade and Graham (1988) suggest that there are two texts in any one lesson; the academic text which refers to the lesson content and the social text which refers information about behaviour and expectations for participation, for example, who can talk, where and when can they talk. The two texts are intertwined, co-occur and are interrelated (Seung & Schallert, 2004). Mercer (1995) identifies three categories for classifying interaction and conversations between children and adults: establishment of shared understanding, asserting some intellectual authority and joint pursuit of learning. Mercer suggests that teachers use talk to do three things:

- elicit relevant knowledge from students,
- respond to things that students say,
- describe classroom experiences that they share with the students.

Spoken language is one of the tools children use to make sense of the world. It is also a teacher's main pedagogical tool and therefore spoken language deserves special attention (Mercer & Littleton, 2007). Mercer and Littleton (2007) found ample evidence that teachers can make a powerful contribution to the way students think and talk. Teachers convey powerful messages about thinking by the way they structure classroom activity and talk to the students. To increase students' ability to use language as a tool for both collective and solitary thinking they need to be involved in "thoughtful and reasoned dialogue" (Mercer & Littleton, 2007, p. 56). This type of teaching Bakhtin (1981) also termed 'dialogic teaching'. When teachers model and scaffold useful language strategies to extend students' thinking and dialogue with adults and peers; and when students are given ample opportunity to practice using language to reflect, enquire and explain their thinking to others, students are then able to seek and compare points of view and use language to compare, debate and reconcile questions. This takes their learning beyond a level that requires only answers to teachers' factual questions.

Teachers need to engage students taking into consideration their special interests and temperaments (Fleer, 1995) and the knowledge brought from their home and cultural backgrounds (Gonzalez, et al., 2005). They must ask questions of students to find out things they know and the teacher doesn't, why students are doing things a certain way or about their experiences outside of school. Teachers also ask questions that they already know the answers to, because they need to know if, and who of the students, know these answers as well. Typically if the first student does not know the answer teachers will ask another student until the question is answered correctly. Often, if none of the students can answer the question, the teacher will use further probing questions and give clues to draw the answer they require from the students. Mercer (1995) calls this "cued elicitation". Cued elicitation is also widespread, long established and popular with teachers using child-centred learning. It enables teachers to avoid monologue and attempts to engage students actively in the lesson. Questioning is often used for cued elicitation. It is known that teachers ask a great many questions, over half of which are managerial (Mercer, 1995). This therefore triggers debate over the part questioning plays in the construction of knowledge.

> A sociocultural perspective raises the possibility that education success and failure may be explained by the quality of education dialogue, rather than simply by considering the capability of individual students or the skill of their teachers. It encourages the investigation of the relationship between language and thinking and also the relationship between what Vygotsky called 'intermental' and the 'intramental' - the social and psychological - in the processes of learning, development and intellectual endeavour. Partly through the influence of these

> ideas, social interaction has increasingly come to be seen as significant in shaping children's cognitive development (Mercer & Littleton, 2007, p. 4).

Feedback Following Formative Assessment

One form of interaction that is vital in the classroom is feedback following formative assessment. Teacher guidance at critical points in learning is vital to enhance learning. In order for teachers to do this, they must have critical content and process knowledge, understand the specific needs of their students and identify when to offer guidance and how much to give (W. Fox-Turnbull, 2003; Kuhlthau, Maniotes, & Caspari, 2007). This process involves ongoing formative assessment. Formative assessment consists of four basic components: sharing learning goals, effective questioning and conversation, self and peer evaluation and effective feedback. These are underpinned by the confidence that every student can improve and an awareness of the value of self esteem (Clarke, 2005b).

There is strong evidence that formative assessment can raise achievement (Clarke, 2008). Active learning is at the heart of formative assessment and should allow teachers and students to collaborate in all stages of learning from planning, deciding the context of study, establishing intended learning and associated success criteria, and critically engaging in analysing learning through classroom talk (Clarke, 2008).

Clarke (2008) suggests that to ensure maximum impact on motivation and achievement schools need to make their curriculum creative and flexible. Student engagement in preplanning and planning will ensure learning is pitched at the correct level, increasing motivation and achievement. Teachers need to present students with minimum coverage, as a starting point for discussions. Accessible learning objectives (intentions) should be displayed so that students can refer to them when needed. Learning also needs to be interactive and flexible enough to change direction if students' interests dictate it and as long as curriculum coverage is not compromised.

2.4.6 Talking to Enhance Learning Through Collaboration

It is part of human nature to consider to whom we are talking, their views and aims for the conversation, and what is being achieved when we converse with each other. Identification of types of talk allows us to determine how participants orientate themselves within conversation. In order to understand these types of talk we must first understand argument. Mercer (Mercer, 1995; Mercer & Littleton, 2007) identifies a range of definitions of argument, from heated aggressive debate to rhetorical presentation of ideas. These two examples could be seen as extremes on an argument continuum, with exploratory conversation situated midway between the two. The most useful definition for the purposes of this study is the definition of argument relating to “reasoned debate”, extended conversation on a specific theme with the aim of establishing a truth within a contentious problem or issue. Any one conversation or debate may contain elements from a number of discussion models. Mercer suggests that argument is characterised by three specific types of talk: disputational, cumulative and exploratory.

Disputational talk is prevalent in, but by no means restricted to, an aggressive type of argument and is characterised by a participant’s unwillingness to understand another person’s point-of-view, with a constant reassertion of his or her own. Collaborative activity becomes almost impossible as participants vie to have their views adopted. Defensive and uncooperative behaviour typify this type of talk. Participants compete for control of the discussion and aim to hold power.

The second type of talk identified by Mercer (2006) is cumulative talk in which the participants take their own ideas and build on these ideas using the ideas of others. The environment is mutually supportive and uncritical while participants construct a body of knowledge together. Participants are able to gather collective support for their ideas and perhaps jointly determine their argumentative stance. In cumulative talk there is no striving for control, but also it does not lead to a shared common understanding

The third type of talk introduced by Mercer (2006) is exploratory talk in which the participants engage constructively and critically. Ideas are challenged and counter challenged, with reasons for thinking made explicit. Alternative ideas are given with the aim of joint progress. In this type of talk "control is a matter for constant negotiation" (Mercer, 2006, p. 99). Opinions offered, if accepted, will sway the subsequent direction of the collective thinking. In his comparative study with children involved in 'Talk Lessons' Mercer notices a prevalence of words such as 'because', 'if', 'I think' and 'why' used by those children who had undergone the 'talk lessons' as opposed to a control group who had not. These key words can therefore be shown to be indicators of exploratory and reasoned talk (Mercer, 2006).

Mercer and Dawes (2008) suggest that education talk is either symmetrical or asymmetrical. Asymmetrical talk is described as the talk between teachers and students where one person takes the lead, usually the teacher. Symmetrical talk is talk between students where participants are considered to have equal status and control. Symmetrical talk is more likely to happen when students are working in pairs or small groups. Mercer and Dawes suggest that most educational talk in the classroom is asymmetrical; teachers often have to act as arbiters of knowledge, and therefore act with authority by leading their conversations through demonstrating, explaining to or correcting students. However, it is desirable from an educational perspective to have both symmetrical and asymmetrical kinds of dialogue happen in the classroom. Similarly Scott (2008) suggests classroom conversation can be Interactive or Non-interactive. Interactive talk includes verbal participation of all participants; non-interactive talk only involves only one person, the teacher.

The literature suggests that from Symmetrical and Interactive talk two subsections emerge, the first of which is Cumulative Talk described above (Mercer & Dawes, 2008). The second subsection describes talk where participants value, and build on each other's contributions and understanding and are supportive and critical in a constructive, supportive way. Participants' shared understandings are developed and new joint understanding develops. Alexander (2008) suggests that teachers need to "provide and promote the right kind of talk" (p. 10) to ensure that students learn more effectively and efficiently. He introduces *dialogic teaching,* a pedagogical approach in which talk is given prominence. Dialogic teaching demands both student engagement and teacher intervention through talk. Dialogic teaching can occur in any organisational context, whether whole class teaching or small group collaborative discussion. It forces the consideration of the power of talk in all teaching and learning situations. "The term dialogic teaching therefore draws attention from the organisation setting and concentrates on the 'quality, dynamics and content of talk'"(Alexander, 2008, p. 23).

Mercer and Littleton (2007) discuss a pedagogical approach, *Thinking Together,* based on "interthinking". The approach teaches students to use language to think and learn together. Thinking collectively is activity in which knowledge and understanding are reached through conflict, debate, and co-operation.

In this study, the researcher has coined the term Intercognitive talk to describe talk of this nature and involves the clustering of a number of different types of talk, outlined in Table 3.6 These include: Exploratory talk, described above (Mercer, 2006); Dialogic talk (Alexander, 2008); Interthinking (Mercer, 2006) and talk in the Intermental Development Zone (IDZ) (Mercer, 2006). It may also include Feedback as a part of formative assessment (Black & Wiliam, 1998; Clarke, 2003) and Hybridity Theory (Gonzalez, 2005; Moje, et al., 2004). Intercognitive conversation is further explored in Chapter 3.

Discourse Analysis

Discourse Analysis involves qualitative analysis of discourse. Although there are a variety of approaches, the term 'analysis' implies that something is done with the data (Antaki, Billig, Edwards, & Potter, 2003). For example, in the field of Social Psychology analysis is focused on the conduct of the conversational interactive setting; in Ideology the focus is on talk and written text within in a social context. Whichever approach, analysis of data must contain more than just a summary but must go some way into attempting to analyse in-depth to allow understanding of discourse (Antaki, et al., 2003).

Discourse informs ways of thinking, and therefore consideration of situated means and how social languages are constructed during an interview influences the way participants use language to represent themselves (Young, 2004). Cultural models are the everyday storylines or theories that help individuals determine what is normal and what is typical within a particular discourse (Young, 2004). It is the beliefs, values and attitudes held that inform the way people act, read, what they say and how they interact. These are not static and may change with experience and adapt to new situations. Rogers (2004, p. 10) suggests that language is constructing and constructed by local, cultural, political and economic contexts. For example, when interaction between a student and a teacher is analysed, researchers might think about the way in which the student and the teacher are interacting (genre, model), the relationship between them (tenor) and the way they call on larger discourses of achievement (field). The analysis of the way the discourses are linked together is the context. Every context has a history of discourse links and practices that are chained together in particular ways.

Rogers (2004) discusses several analytical procedures for discourse. Fairclough (1995) includes a three-tiered model, including description, interpretation, and explanation of discursive relations and social practices at the local, institutional and societal domains of analysis. Gee's (1999, cited Young, 2004) analytical procedures include a set of connection building activities that includes describing, interpreting and explaining the relationship between language bits (discourse with small 'd') and the cultural models, situated identities and situated meanings (Discourse with a big 'D').

Young (2004) mentions a number of analytical tools for discourse: the notions of discourses, social language, situated means and cultural examples. The Joint Involvement Episodes (JIE) approach concentrates on the analysis of social interaction situations and how children's behaviour is changed by it (Daniels, 1996a; Lave & Wenger, 1996). Schaffer (cited in Daniels, 1996b, p. 269) identifies that how adults and children behave in JIE needs to be established to ensure that a better understanding of the types of interactions which give rise to cognitive development. Schaffer's work used the context of mother and children, but the same applies to teacher and student (Lave & Wenger, 1996). Fleer (1995) suggests that teachers often make assumptions regarding background culture, values and language of the students to whom they are speaking. This can cause difficulties and misunderstanding and decrease the quality of the conversations teachers have with their students.

In summary, Section 2.4 discussed the role of language and interaction in the cognitive development of students within a sociocultural paradigm. More specifically it explored the nature and role of oral language in cognitive development. The section also explored specific types of classroom dialogue and introduced the term 'Intercognitive Conversations' to cluster a number of similar approaches in which all participants benefit. In order to allow this type of talk to emerge in the classroom, learning must be carefully managed. Literature in this area is explored in the following section.

2.5 Classroom Management

Classroom management is essential in the successful classroom. Conversation is an important aspect of successful classroom management. Much conversation that occurs in the classroom is about management of things other than learning. As technology includes significant practical work, the management of resources and behaviour are critical for safe practice. However, some aspects of classroom management may not advance learning and engage students in higher-level thinking and critical debate.

Learning involves students making sense of every day experiences and is optimised through social interaction according to constructivist principles (Bourne, 1994). Bourne states that learners are much more able to make sense of new material if it is clearly structured and organised. Therefore, careful management of learning ensures students are able to maximise the learning time within the classroom. It may include classroom organisation and layout, flow and transitions between and within lessons, pedagogical strategies employed to engage student learning, and management of student behaviour to ensure minimal disturbance. Yates (2001) suggests that one of the many challenges teachers face on a daily basis is the management of their classes and classrooms. Although many factors influencing students' learning are out of a teacher's control, for example home environment and diet, many very influential factors are directly within their control, including management of time, space and students.

Management of time is an area that involves a number of complex decisions involving balancing the best interests of all students, the class and the school. Teachers need to compromise their preferences to ensure a balance of needs. Long term planning across the school and within each classroom, balanced with a degree of flexibility and collaboration is one effective strategy to manage time effectively and efficiently. Teachers also manage time through planning individual lessons within units of work. Some curriculum areas are taught end on, for example, a technology unit may be taught in the first five weeks of the term and science in the second five weeks. English and Maths are taught on a daily basis while other curriculum areas are taught one to three times per week, for example physical education, art and music. A third aspect of managing time is the lesson pace and management time within lessons. Teachers aim to maximise the time students are actively engaged in learning and minimise time students spend in transitions between learning episodes (Yates, 2001).

Managing space is influenced by the personal teaching philosophy of the teacher, the teaching space available, whether the teaching space is a specialist area, and the resources available. Students spend a great deal of time in their classrooms, and therefore they should be purposeful, exciting, rewarding, stimulating and challenging (Yates, 2001). They should maintain a balance between aesthetics and functionality. A number of factors will enhance students' engagement and motivation in learning. These include: the display of students' work, ensuring students are comfortable and not distracted by specialist spaces within the room, including areas for display, quiet learning and ICT.

Management of students and the development of a positive learning environment have a huge influence on learning. Behaviour management is a huge challenge for teachers and is dependent on the development of a framework within which students know their boundaries and have a degree of shared ownership with their teacher (Collis & Dalton, 1994; Yates, 2001). Collis and Dalton suggest that one of the key strategies for effective learning is students' self-responsibility for learning. Porter (2000, cited by Yates, 2001) also suggests self discipline along with emotional regulation, co-operation and integrity as key goals for managing behaviour.

Management of learning in a primary classroom is a vast area of research. In the section above, the researcher has touched on four areas most significant to the study: Management of activities, resources, time and behaviour. In the following section the previous three sections of this literature review are drawn together.

2.6 Technology, Sociocultural Theory and the Theory of Language Drawn Together

Sociocultural learning theory is particularly relevant to technology education because of the collaborative and practical nature of the curriculum, and the fact that technology is about interaction with and development of artefacts and tools. In authentic technological practice, students frequently work collaboratively and co-operatively with peers and stakeholders. Individuals with a variety of perspectives and skills feed into the development of suitable technological outcomes. Students also need to understand the physical and functional natures of technological outcomes, and how these impact and influence further developments. Sociocultural theory is grounded in mediation with cultural tools in which students construct knowledge through social interaction and problem solving using cultural tools and artefacts, including language. This theory advances understanding of constructivism as it involves understanding how interaction with culturally situated tools and artefacts advances learning. Technology education lends itself to a sociocultural model of learning because of the vital part development and interaction of culturally situated artefacts and tools, including language, play in developing students' understanding of technological knowledge, skills, and practice.

The language and social interaction literature presented in this review determines that language as a cultural tool is essential to learning. The literature also suggests that debate and conflict further enhance learning. In technology, children are frequently required to work collaboratively and co-operatively with peers and seek the options of expert and stakeholders from the wider community to enable them to participate successfully. For a group of students to be able to work collaboratively and co-operatively on the development of single technological outcomes, clear communication and ultimately consensus is essential. Technology education requires children to design and develop solutions for identified problems or to meet specific needs. To do this they are involved in technological practice which ultimately leads to the development of the product or system, known in *The New Zealand Curriculum* as a technological outcome (Ministry of Education, 2007, p. 32). The very nature of developing technological solutions also includes problem solving. Students need to be able to discuss, debate, disagree and reason with an open mind to solve the technological problems they encounter. Thus they are embedded in a sociocultural paradigm using cultural tools, such as language and interaction, and technological tools to advance their thinking and doing.

The knowledge and understanding students bring to their technological practice will directly influence their contribution. It is essential that teachers and students are aware of and recognise the value of individuals' funds of knowledge. When teachers assess technology education they are required to assess a range of aspects of technological practice including that of the process undertaken and the quality and suitability of the outcome developed. From this researcher's experience as a teacher educator in the primary sector, assessment of technology is often 'product' based rather than developing a clear understanding of the processes engaged in during technological practice. The researcher also believes that students design their technological solutions for specific reasons and with specific purpose in mind. These reasons or 'stories' help give insight into the students' understanding of the identified problem and their ability to link all aspects of technological practice to form a suitable solution. Primary school aged children are all too often in a situation where their ideas are more advanced than their physical ability to create their designed ideas. One way teachers can understand the complexity of the students' thinking and understanding of the technological practice and solutions is by engaging them in focused higher-level discussion about their ideas, and reasoning for their decision making and designed outcomes.

The nature of conversation in technology education that advances students' learning and teachers' understandings of that learning has not been raised in the literature; this study endeavours to investigate the nature of those conversations in technology education that advance students' learning. It will also investigate whether successful conversation differs at varying stages of the technological development process and across two different levels of the curriculum.

In conclusion, this section of the literature review draws together the literature on technology education, sociocultural theory and the theories of language and interaction to identify common links and threads. Therefore, the researcher concludes that little is known about the nature of conversation that contributes to successful learning in technology.

2.7 Research Rational and Questions

This section provides a rationale for this research, and outlines its aims. The section concludes with the research questions.

2.7.1 A Statement of the Research Topic

A thorough literature search of international journals relevant to technology education, education databases and the Sense Publishers' series of Technology

Education Handbooks indicates that there is very little New Zealand and international research on the nature of students' conversations in technology education. Classroom conversations are core to establishing successful learning for children. This research explores the nature of conversation in technology education in primary classrooms and the implications for teaching and learning. It uses an ethnographic approach using participant observations, interviews, autophotography, and work samples, to develop a rich description of classroom conversation. Over-arching types of conversation include student-student conversations and teacher-student (instigated by either party) conversations. Within each of these types fall two subtypes: interactive and non-interactive.

Classroom conversation needs to be considered from two perspectives: strategy and knowledge. Strategy refers to the strategy used to ignite and facilitate the conversation; knowledge refers to the actual technological content knowledge of the conversation (Fleer 2006). This study advances research in the area of students' learning in technology by studying students from two primary year levels working in the same or very similar technological practice. This allows insight into how previous experiences, background and culture impact on and contribute to students' understanding in technological literacy and practice and the types of conversation that facilitate this process.

2.7.2 Aims

The aims of the study are to*:*

- gain an enhanced understanding of the learning that influences students when developing technological solutions;
- understand the nature of conversation most beneficial to students and how and when are these conversations best undertaken to effectively enhance students' learning;

- illustrate the value and influence of focussed conversations between teacher and student to give teachers clear insight into students' learning and achievement in technology.

2.7.3 Main Research Question

What is the nature of conversation in Technology Education?

Sub Questions

1) What types of conversations enable students to participate in collaborative technological practice?

2) How do students' prior and concurrent experiences influence their technological practice?

3) What happens in the classroom to increase the likelihood of students deploying knowledge and skills from other areas into technology?

4) What insights into technology education can be gained through an analysis of students' conversations with their teachers and peers while participating in technology education?

2.8 Conclusion

In summary, this chapter initially investigates literature in three distinct areas: Technology Education, Learning Theory including Funds of Knowledge and theories of language and Interaction. Firstly, it discusses literature in the field of technology education in both the global and national context. It introduces and discusses Sociocultural Theory and illustrates how it is fully embedded in technology education in the primary classroom. It explores Funds of Knowledge with a view to understanding how a student's social and community experiences contribute to learning in Technology. The chapter also reviews the relevant literature on language and specifically the role oral language plays in learning. To enhance our understanding of learning in technology education, it is necessary also to listen to and understand the conversations of students and the conversations between students and their teachers. This will give insight into the impacts of previous experiences and new learning on learning in technology. The chapter concludes by drawing all three areas together, identifying an issue central to this study and identifying the research aims and questions.

Chapter 3. Research Methodology

3.1 Introduction

This study is a qualitative study that employs an interpretive paradigm to investigate the nature of conversation in technology education. An interpretive paradigm enables the researcher to understand how students and teachers construct meaning through conversation. Within the interpretive paradigm sits an ethnographic approach. This approach, used in this study, enables thick description of teachers and students' conversations. Reliability, validity, ethical considerations, and sampling methods used for the study are introduced, along with the data gathering methods employed in the study. These include Stimulated Recall through autophotography, used to stimulate recall of technological practice, participant observations, individual and focus group interviews, recorded classroom conversations, and students' work samples, each discussed, with advantages and disadvantages highlighted.

This chapter discusses the theoretical methodology and framework for this study. It then outlines the methods and process used for data analysis and identification of themes. The chapter concludes with identification of the framework used to organise and discuss the study's findings in subsequent discussion chapters.

3.2 An Outline of the Significance of the Topic

There is very little research in New Zealand or internationally on the nature of students' conversation in technology education. This study advances research in the area of learning in technology education by studying two different age groups working on the same technological practice. This will give insight into the nature of students' conversation with experts, teachers and peers that contributes to their understanding in technological literacy and practice.

3.3 Methodology

This section outlines the methodology underpinning this study. The study fits within an interpretive paradigm using qualitative method. It is primarily about socially embedded action, and therefore takes place within a sociocultural framework and follows qualitative methodology. Qualitative methods allow the researcher to gain rich, socially constructed data. An interpretive paradigm is employed to answer the research questions. This research draws from an ethnographic design approach and aims to use participant observation, interview and student work samples to develop rich description around classroom conversation and how they enhance learning and understanding in technology education. Qualitative method is suitable as the research occurred in a natural classroom setting, with a clear focus on actions and interactions of the students and their teachers. The study takes place in two primary school classrooms, with the aim to understand how conversation can enhance students' learning in technology education.

In this research, the culture of the classrooms and the particular groups of students being studied were a clear focus point. The researcher role was clearly understood by all participants and she was clearly present in the classroom during data gathering. The students' ability and willingness to tell their stories to and share their ideas of technological practice with their peers, their teachers, and the researcher depended on, among other things on the culture of their classroom. The holistic and contextualised nature of ethnographic research fits well with the philosophy of technology education. The researcher interviewed students initially and then became fully immersed within the culture of their classrooms. During the second half of Term 2 (May/June) 2008 the researcher assisted the teachers in the delivery of the first unit (Round 1). The second unit (Round 2) was taught in each classroom late in Term 3 (August/September) and was when most of the data gathering occurred, as the students knew, and had worked with the researcher previously.

3.3.1 Interpretive Social Science Paradigm

A major theoretical paradigm widely used in social sciences fields – *interpretivism* - is the study of meaningful social action and is mostly concerned with achieving understanding through feelings and world views (Neuman, 2000; Taylor & Bogdan, 1998). The central aim of the interpretive paradigm is to understand the subjective world of human experience while maintaining the integrity of the subject. It also aims to understand how people construct meaning in a natural setting (Neuman, 2000; Taylor & Bogdan, 1998). Interpretative social sciences include ethnography, which assumes that people make inferences, and is the study of culture and understanding another way of life from the native point of view (Neuman, 2000, p. 347).Interpretivism enables the researcher to examine how students and teachers interact with technologies and other culturally situated tools, such as language, to construct knowledge and understanding in technology education. In an interpretive paradigm, theory is emergent and should be 'grounded' in the data generated by the research

Interpretive researchers often use participant-observation, and field research, and typically spend many hours in the field of study with direct personal contact with participants. The aim of this research is to understand and describe the meaning of social action embedded in the context of fluid social interactions. Analysis of conversation transcripts and video tapes of behaviour are detailed and include investigation into non-verbal communication to fully understand interactions (Neuman, 2000). Neuman succinctly describes the extent of social action thus: "Not just the external or observable behaviour of people. Social action is the action to which people attach subjective meaning; it is activity with purpose or intent" (Neuman, 2000, p. 71).

The interpretative approach uses systematic analysis of socially meaningful action through the direct and detailed observation of people in their natural setting in order to interpret and understand how they create and maintain their social worlds (Neuman, 2000). In order to be able to do this, researchers need to be able to understand how human action, setting, and environment interact and influence each other. This approach allows rich description to merge from gathered data to achieve the necessary thick description and is particularly relevant in curriculum areas where students are given the freedom to explore and develop a range of outcomes.

A sociocultural framework provides researchers with structure and freedom to study students' learning when engaged in the practical nature of technology education (Rogoff & Lave, 1999). This study will focus on the examination of human action and thinking within the context of technology education in the primary classroom. Understanding of specific human action within the social setting is best served when it take a sociocultural perspective and uses a qualitative approach to research.

3.3.2 Qualitative Research

The purpose of the qualitative approach is to understand and interpret social interactions with an emphasis on holistic description (Fraenkel & Wallen, 2006). Qualitative research proposes ways of doing this in a structured and meaningful manner. It may include quantitative approaches, but it is concerned with social reality. Situated within Interpretivism, it allows the study of meaningful social action. Groups studied tend to be small and non-random. Researchers may or may not get involved with those being studied and tend to study the whole rather than specific variables (Bogdan & Biklen, 2007). In qualitative research, the main interest is in words, observed behaviour and visual data and has a more personal, less formal writing style than quantitative research (Lichtman, 2006; Maykut & Morehouse, 1994). Bogdan and Biklen (2007) suggest that qualitative researchers are concerned with processes rather than outcomes.

Lichtman (2006) describes qualitative research as an umbrella term that includes a range of ideas and aspects including: traditions, methods and assumptions as shown in Figure 3.1. Methods include interviews, transcripts, field notes, photographs, audio recordings, videotapes, diaries, personal comments, memos, official records, textbook passages, and anything else that conveys actual words or actions of people.

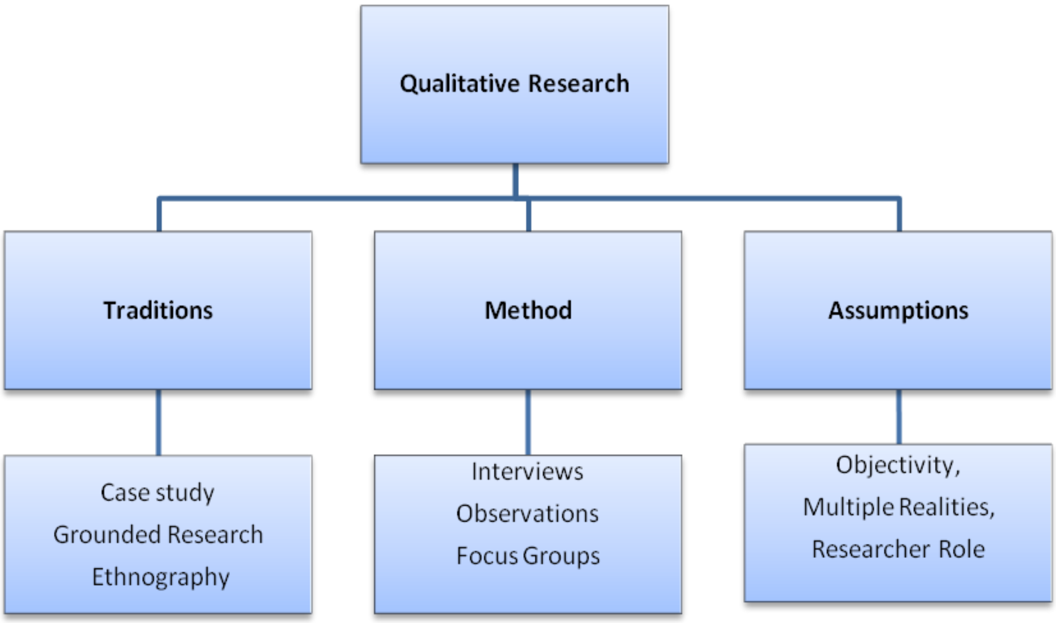


Figure 3.1: Overview of Qualitative Research - adapted from Lichtman (2006)

Three traditions were originally considered to frame the research approach of this study. These were Case Study, Grounded Research and Ethnography. Ethnography was selected as the most suitable; a rationale for this selection is given below.

3.3.3 Ethnographic Research

Wolcott (1988) states ethnography or the ethnographic approach has been welcomed as a research strategy within education since the mid 1980s and suggests it literally means 'way of life'. Best and Kahn (1998) suggest central questions for ethnography are 'what is the culture of this group of people?' and ' how do people make sense of their everyday activities so as to behave in socially acceptable ways?' respectively. Ethnography allows the analysis and presentation of reality, of powerless people in society and can challenge traditional authority structures (Taylor & Bogdan, 1998).

The purpose of ethnography is to describe the culture or aspects of culture and social interactions of a particular group, setting or sub-group (Bogdan & Biklen, 2007; Lichtman, 2006; Wolcott, 1988). Ethnographic research attempts to move out into the world and find out what people actually do. What people observe and believe is often not the reality. A major advantage of ethnographic research is that it attempts to move into natural settings to "see" things that otherwise might not have been seen or even anticipated (Fraenkel & Wallen, 2006; Wolcott, 1988). According to Fraenkel and Wallen (2006) there are seven important concepts, outlined in Table 3.1, that guide ethnographic research in the field.

Ethnographic researchers will employ emic and etic perspectives, starting from an emic perspective when involved in data collection, and then moving to an etic perspective when trying to make sense of what they have collected from a more objective scientific analysis. "Ethnographic researchers try to combine an insightful sensitive cultural interpretation with a rigorous collection and analysis of what they have seen and heard" (Fraenkel & Wallen, 2006, p. 514). Fraenkel and Wallen (2006) suggest that researchers who undertake ethnographic research in education want to obtain a holistic picture of an educational setting.

One of the challenges of ethnographic research is not so much in gathering the data and doing the fieldwork, but the subsequent organisation and analysis of the data in a comprehensive and meaningful manner. An ethnographer tries hard to know more about the cultural system they are studying than any of the individual participants, but notably is never likely to totally understand the insider's point of view (Wolcott, 1988).

The strength of this methodology is that multiple instruments (for example, participant observation, interviews and work samples) and data gathering opportunities are used. Researchers are typically in the field for a long period of time; one year or full cycle of activity. All information is triangulated and analysed in many ways rather than relying on a sole instrument approach (Wolcott, 1988).

Table 3.1: Fraenkel & Wallen's Outline of Ethnographic Concepts

Concept	Description
Culture	Comprises beliefs, ideas, behaviour, customs and ways of life. Helps search for patterns and behaviours that characterise a group.
Holistic perspective	Description about the culture of the group to gain some idea of the group's history, social structure, politics, religious beliefs, symbols, customs, rituals and environments.
Contextualisation	Data, that is what is seen and heard and must be placed into a larger perspective.
Emic & Etic Perspectives	Emic: At the heart of ethnographic research, this is an 'insiders' perspective' and is essential to understanding and describing what the researcher sees and hears. Recognises the concept of multiple realities and will document multiple perspectives. Etic: An external objective perspective on reality.
Thick Description	Reporting what is seen and heard in great detail, frequently using extensive quotations from participants to 'paint a picture' of the culture to make it come alive for the reader.
Member Checking	Participants check the review of what the researchers have written for accuracy and completeness. Used to validate accuracy of researcher's findings.
Non-judgemental Orientation	Researchers do their best to refrain from making judgement about practices that are unfamiliar to them by guarding against obvious biases.

(Fraenkel & Wallen, 2006)

Ethnography Selection Rationale

An ethnographic tradition enabled the researcher access to the classroom, students and their teachers in a way that may have been restricted in other methods. The researcher was a participant observer, facilitating the capturing of rich data and insight into the culture of each of the classrooms, and the students and teachers' thinking. Data enabled the development of rich description of students' activity and their associated conversations. Using this tradition meant that the researcher spent many hours in each classroom; becoming familiar with the culture and rituals of both. Therefore, she was able to identify patterns and behaviours that characterised each class and the smaller groups within. Familiarity with each class enabled the researcher to refrain from making judgements, thus guarding against bias. Finally, this approach enabled the placing of data into the larger education perspective.

3.4 Method

This section discusses methods and ethical considerations used in this research. Two methods used, Stimulated Recall and Autophotography are introduced and discussed. Other significant sources of data for this study, such as semi-structured and focus group interviews, and observations are also discussed. Aspects of reliability and validity, including sampling methods relevant to the study, are discussed; so too are students' work samples, which provided triangulation in the study. Discussion about ethical considerations for the study, including entry into the field and ethics approval, and aspects of anonymity and confidentiality, conclude the section.

3.4.1 Stimulated Recall

Stimulated Recall can be viewed as a subset of introspective research methods which access participants' reflections on mental processes, and has its origins in philosophy and psychology (Mackey & Gass, 2005). Lyle supports this view saying: "Stimulated Recall is a family of introspective research procedures through which cognitive processes can be investigated by inviting subjects to recall when prompted by a video sequence, their concurrent thinking during that event" (Mackey, cited in Lyle, 2002, p. 861).

Many studies have used Stimulated Recall to study classroom practice (Beers, Boshuizen, Kirschner, Gijselaers, & Westendorp, 2006; Plaut, 2006; Sime, 2006; Slough, 2001). Stimulated Recall interviews are used to gain qualitative insight into the actual working memory processes (Beers, et al., 2006). Both audio and video recordings have frequently been used for research purposes (Plaut, 2006; Seung & Schallert, 2004; Slough, 2001) Photographs selected and taken by the researcher (Epstein, Stevens, McKeever, & Baruchel, 2006) and photographs taken by participants (autophotography) (De Marie, 2008; Moreland & Cowie, 2007b) have also been used. Moreland and Cowie (2007b) employed Stimulated Recall by using autophotography and then used the photographs as prompts in semi-structured interviews. Slough (2001) used observation and field notes to inform and enhance the Stimulated Recall with interviews using videotape, thus providing a comprehensive range of data. Beers and colleagues (Beers, et al., 2006) published a study on how information and communication technologies (ICT) tools augment learning in a variety of tasks using Stimulated Recall (Seung & Schallert, 2004).

Stimulated Recall protocols should include opening interviews with background questions, and open-ended prompts to give the researcher information on participants' understanding (Plaut, 2006; Slough, 2001). Mackey and Gass (2005) suggest that when using Stimulated Recall extreme care must be taken, given issues of memory, retrieval, timing and instructions. The following recommendations are made to avoid the pitfalls associated with these issues:

- giving clear guidelines to each participant (Schepens, et al., 2007);
- carrying out the Stimulated Recall interviews as soon as possible after the actual incident (Mackey & Gass, 2005; Schepens, et al., 2007; Seung & Schallert, 2004);

- audio taping each Stimulated Recall interview (there are incidences of participants using observation field notes) (Seung & Schallert, 2004) and transcribed participant conversations (Moreland & Cowie, 2007b; Schepens, et al., 2007);
- participants should be minimally trained to enable them to carry out the procedure but they should not be cued to extra and unnecessary knowledge (Lyle, 2002; Mackey & Gass, 2005);
- stimulus should be as strong as possible (Lyle, 2002; Mackey & Gass, 2005);
- if participants are involved in the selection and control of the stimulus episodes there is less likelihood of researcher interference (Lyle, 2002; Mackey & Gass, 2005).

3.4.2 Photography

Visual methodologies have previously played a minor role in social research because of a reliance on "word-based" disciplines but recently have become a more commonly used technique because of user-friendly and relatively cheap technologies including disposable and digital cameras. (Epstein, et al., 2006; Taylor & Bogdan, 1998). Photographs can provide an excellent source of data for qualitative research. A photograph is a static image that can be used to recall thinking or doing at the specific time the photograph was taken. Epstein and colleagues (2006), took specific photographs and used them in interviews with the children. Photographs can also be developed and recorded digitally, and therefore are easy to insert into text during the analysis and writing phase of the project. An advantage that photography has over video, another commonly used method in qualitative research, is that because a photograph captures a very specific point in time; it tends to be more focused than other visual methodologies.

Autophotography

Autophotography (Moreland & Cowie, 2007b) in this study refers to participants' self-taken photographs. Autophotography is well situated within the Sociocultural context in this study as the camera, as a cultural tool, enabled students to select and take photographs that were subsequently used to stimulate dialogue and facilitate cognitive development (Wertsch, 1998). Epstein and colleagues (2006) discuss photographs taken by participants and suggest *reflexive* photography or *autodriving* photography as terms for this strategy. The pictures people take gives insight into what they think is important; therefore, a camera can be a very useful tool as it can capture details that would otherwise have been forgotten (Taylor & Bogdan, 1998). Autophotographs enable the participant voice to be heard and enables researchers to investigate participant thinking around specific participant-selected aspects of prior experiences (De Marie, 2008). The defining difference of autophotography, when compared to other forms of Stimulated Recall research methods is that in autophotography the photographer has ownership over content. When interviewing participants a single photograph depicts a specific action or decision made and can be discussed as such (Moreland & Cowie, 2007b).

De Marie (2008) gave cameras to primary school, and pre-school children, in their study to elicit children's perspective of summer camp fieldtrips. In this study De Marie (2008) asked students to take photographs to show other people what a zoo was like. She suggests that autophotographs reveal important information on what the students noticed and remembered about their experience. Ziller and colleagues (1981) undertook numerous projects using photographs, one of which studied students who were given cameras and asked to record who they were. Ziller et al. suggest that adults can use children's autobiographical photographs to understand the children's views of themselves and their relationships with persons, objects, and their environment. More recently Moreland and Cowie (2007b) gave disposable cameras to primary aged children and asked them to record aspects of technology and science at home to elicit their understanding of either science and technology. It can be seen from the examples above that this approach sits very comfortably within a sociocultural paradigm because of the culturally situated nature of photographs taken by the participants.

3.4.3 Interview

Face-to-face interviewing is one of the most commonly used methods of gathering data in qualitative research. Interviews can be informal with few structured questions, semi-formal with a number of predetermined questions, and others can be more formal with all predetermined questions following strict protocols (Lichtman, 2006; Taylor & Bogdan, 1998).

Informal In-depth Interviewing

Individual in-depth interviews are described by Lichtman (2006) as a conversation between the interviewer and the participant, and are a type of face-to-face interview (Neuman, 2000). In the hands of the qualitative researcher, the interview can move in a variety of potential directions (Bogdan & Biklen, 2007). The purpose of such an interview is to hear what the participant has to say in their own words, voice and perspective (Best & Kahn, 1998; Lichtman, 2006) and involves repeated face-to-face encounters with the participants. Fraenkel and Wallen (2006) suggest that this method of in-depth interviewing is called informal interviewing and is the most common variety of interview in qualitative research. Bogdan and Biklen (2007) suggest that qualitative interviews allow the researcher some latitude to pursue a range of topics. If the researcher controls the interview too rigidly, the participant is unable to tell his or her story in his or her own words. Best and Kahn (1998) state that an interview is particularly appropriate when dealing with young children and is likely the best method of getting a response. In an informal in-depth interview there are few prescribed questions, but the interview needs to build up in several stages. The researcher needs to undertake careful advanced planning by identifying a list of five to ten topics to be covered in the interview. This research adopted this interview method.

Before beginning the interview, preliminary information must be given to the participants. The participants must have agreed to the interview, the researcher needs to introduce him or herself and outline the project. After the preliminaries, the researcher needs to develop a rapport with the interviewee and ensure he or she feels comfortable (Fraenkel & Wallen, 2006; Lichtman, 2006). During the body of the interview the researcher used the semi-structured or unstructured guidelines to ensure the interview progressed smoothly. Fraenkel & Wallen (2006) and Lichtman (2006) suggests that the interviewer does not take complete notes, but does note down aspects that need to be followed up on. In this study all interviews were audio recorded and later transcribed. To close the interview ,the researcher may ask the participant if they have anything to share, before they are thanked. When the participant has left it is wise for the interviewer to take time to organise notes and data, and label and date tapes. Researcher notes can then be added to the journal (Lichtman, 2006). During this study the researcher interviewed a number of students one after the other because of timetable constraints with the school; notes were taken at the end of each interview session.

Focus Group Interviews

Group Interviews are another form of interview frequently employed in qualitative research. This approach allows the interviewer to bring the participants together to talk about their perspectives and experiences using open ended questions as a starting point to generate discussion (Taylor & Bogdan, 1998). Focus groups are a slightly more formal approach and are designed to explore how, why and what people do (Taylor & Bogdan, 1998). One of the advantages of the focus group is that they are likely to yield insight not otherwise accessible in other forms of interview, as the participants are often prompted by other's contributions. Another advantage is that group interviews with children allow them to challenge each other in a way that would not be possible in a one-to-one interview with an adult (Cohen, Manion, & Morrison, 2001).

3.4.4 Observations

In qualitative research, observations usually occur in the natural setting so that researchers can observe participants undertaking behaviours that are a natural part of their lives within any given cultural setting (Cohen, et al., 2001; Fraenkel & Wallen, 2006; Lichtman, 2006). This allows the researcher to understand the complexity of human behaviour and interrelationships among groups, and allows data to be gathered on the physical, human, interactional and programme settings. Kinds of observations range from structured, fully planned studies with full researcher knowledge of what is being sought, to unstructured observations - with no clear picture of what is expected, and therefore the significance of the observation is determined after the actual observation to enable the researcher to enter and understand the situation being observed (Cohen, et al., 2001).

Taylor and Bogdan (1998) discuss a range of perspectives of observation with qualitative data. When in the field researchers must spend a great deal of time paying attention and watching and listening carefully (Neuman, 2000). Observations allow the researcher to see the interactions not only between people, but also between people and artefacts. Such detail is extremely important as a researcher is unable to predict what information will be important when all the data is analysed together (Neuman, 2000).

Cohen et al. (2001) suggest that semi-structured and unstructured observations will be hypothesis generating rather than hypothesis testing, and therefore more likely to be suitable for a qualitative study. Observing and assessing children through a sociocultural approach requires the researchers to think about more than the individual. They also need to consider how the children are influencing each other and the context of the observation, what is happening around the children that is influencing their capacity to work and act. During assessment, teachers need to consider more than the individual student, but also the relationships between the student and his or her peers and other students, how they are influencing each other and how the collective support is advancing their own and other's learning (Fleer, et al., 2006). Fleer's (2006) model of sociocultural assessment reflects an approach by Vygotsky who argued that assessment should not only identify the fully developed cognitive processes of the child but also those that are in a state of being developed. This development depends on the co-operative interaction between child and adult who represent the culture and helps the child to acquire the necessary symbolic learning tools. This approach is significant to this study as it provides a framework for the gathering of rich observation of individuals within a group settling. In technology education, students typically work collaboratively and co-operatively with their peers, teachers and other adults (Ministry of Education, 1995)

Audio Recorded Observation

To ensure the capture of rich observations, participant students' were audio recorded as they worked on their technological practice. These recordings were transcribed as soon as possible after they were recorded. Transcripts also aim to decrease data depth and complexity (Cohen, et al., 2001). By the very nature of the transcribing process, it is inevitable that the data undergoes some sort of interpretation. In the case of interviews, non verbal gestures and other physical signs of communication are lost and contexts of the conversations are not always clear.

Participant-Observer

Wolcott (1988) states that the term participant-observer can cause confusion with two meanings. Sometimes referred to as *being* a participant-observer, it is an important way for ethnographers to gain information. However, collectively it can refer to all the techniques used in fieldwork. This study uses the first and narrower definition. Taylor and Bogdan (1998) suggest that participant observation is different from informal interview because of the setting. Participant observation occurs within the natural setting while informal interviewing take place in a place specifically arranged for the purpose.

As a participant observer the researcher is present among the members of the group being studied, with the explicit idea of entering their lives to understand culture and action (Maykut & Morehouse, 1994; Taylor & Bogdan, 1998; Wolcott, 1988). This has been described as a most useful strategy used in ethnographic studies, particularly when studies take place in schools (Maykut & Morehouse, 1994; Wolcott, 1988). In participant observational studies the researcher stays with the participants for a substantial amount of time to reduce reactivity effects - the effect the researcher has on the participants. This means the researcher will take a role in proceedings while observing. Cohen et al. (2001) suggest in schools this might include sharing the teaching and or supervision, participation in the life of the school, recording impressions and conversations. Staying in the situation for a long period of time researcher will be able to present a more holistic point of view and facilitates ‘thick description’ which leads to an accurate explanation and interpretation of the events rather than relying on researcher inferences (Cohen, et al., 2001).

3.4.5 Document Analysis - Work samples and Teacher Planning

Ethnographers use a range of primary source documents for their research (Wolcott, 1988). Document Analysis is usually used in conjunction with other techniques, such as observations and interviews or other techniques (Bogdan & Biklen, 2007; Fraenkel & Wallen, 2006). Documents may come from primary or secondary sources, and may include such things as meeting minutes, formal policy statements and various types of archival data (Fraenkel & Wallen, 2006). Although not specifically mentioned by Fraenkel and Wallen, this researcher also included teachers' planning and assessment records and students' work samples in this category. Fraenkel and Wallen define these documents as "records kept and written by actual participants in, or witnesses of, an event. These sources are produced for transmitting information to be used in the future" (Fraenkel & Wallen, 2006, p. 85 & 86). Bogdan and Biklen (2007) also suggest that documents for research analysis purposes can be written by participants themselves or contain written information about them. They state that narratives written as school assignments and teacher records are also potentially good sources of documentary data and that students' work samples are, indeed, a valid form of documentation in qualitative research. The documents analysed in this study were samples of the children's work and the unit plans for both Rounds 1 and 2.

3.4.6 Validity and Reliability

All social researchers want their measurements to be reliable and valid. Both concepts are important in establishing the truthfulness and credibility of the data. Perfect reliability and validity are virtually impossible to obtain but are ideals researchers strive for (Neuman, 2000).

Reliability

When considering reliability in research, researchers need to ask the question: 'Will two researchers independently studying the same setting or subject come up with the same findings?' (Bogdan & Biklen, 2007, p. 39). Reliability is the ability to replicate a study (Bogdan & Biklen, 2007; Neuman, 2000) and is less relevant for qualitative research than for quantitative research (Bogdan & Biklen, 2007; Cohen, et al., 2001). In qualitative research exact replication need not be necessary. Cohen, Manion and Morrison (Cohen, et al., 2001) and Bogdan and Biklen suggest that research reliability in qualitative research can be regarded as the fit between the data and what actually occurs. Best and Kahn (1998) suggest that that reliability of interviews may be increased by restating questions within the interview or repeating interviews at a later date. However, both these options are time consuming.

Validity

Validity refers to truthfulness and is a match between the construct and the actual measure of a study; in other words, how well the ideas about reality fit with actual reality (Neuman, 2000). In qualitative research researchers tend to be more focused on authenticity than validity. This means giving an honest, balanced and fair account of the social life from the point of view of a participant who is fully immersed in it. Typically qualitative researchers develop several substitutes when approaching validity and endeavour to be truthful and to create a tight fit between their understandings, ideas and statements about the social world and what is actually occurring in it (Neuman, 2000).

External validity refers to the ability to generalise findings from the study of a wider population. Used mainly in experimental research it is highly irrelevant to this research as the nature and purpose of the study are to describe reality for a small group of participants. There is no intention to generalise findings further (Neuman, 2000). Internal validity means that there are no errors in the design of the research project as the methods of gathering data.

Triangulation

Triangulation is the term widely used in qualitative research to describe the methods used for obtaining data from a range of sources. The term is a maritime nautical term used to ensure accuracy in navigation. It was borrowed by social sciences and attends to the need to obtain data from a variety of sources (Bogdan

& Biklen, 2007) in an attempt to ensure that the richness and complexity of human behaviour is fully described (Cohen, et al., 2001). Cohen and colleagues suggest that triangulation is a powerful method of demonstrating concurrent validity in qualitative research.

In this study triangulation was used to counter the limitations of the research methods used. Triangulation occurred through the range of data gathered. Participants' conversations were recorded as they undertook technological practice in the development of their props. This along with researcher observations enabled the researcher to record aspects of classroom practice that were not recorded by the participants when they took their autophotographs, and therefore contributed to a holistic picture of the classroom. The unit plans drove the classroom activities undertaken by the students and, were written by the teachers, in collaboration with the researcher. The work samples were of these classroom activities. The collaborative approach to planning decreased the subjectivity of the documents developed and collected by the researcher, because it ensured a clear focus on the intended learning.

Researcher input into the planning also helped to counter the possibility of researcher bias. The researcher was very familiar with the classroom environment as she is a primary trained teacher and has taught in a similar school to the one used in this study. This meant the observations and judgements were made through a researcher culture similar to that of the classroom. Researcher input into planning also meant that she had some influence on the activities the children undertook as a part of the unit, and therefore she was confident that the students' learning experiences were relevant to and focussed on the development of the desired technological outcomes. The unit plans (Appendix 15) gave structure to the lessons implemented by both teachers in their respective classrooms. This ensured that all the children continued to see their teacher as the main authority figure in the classroom, allowing the researcher the freedom to engage students in meaningful conversations thus contributing to a participant-observation relationship balance.

3.4.7 Sampling

Qualitative researchers tend to use non-probability sampling techniques to allow them access to a small collection of cases that can clarify and deepen understanding of social life (Cohen, et al., 2001; Neuman, 2000). Maykut and Morehouse (1994) suggest that, in qualitative research, especially in settings such as schools, participants should be carefully selected for inclusion. They use the term 'purposeful sampling' and state that it increases the likelihood that variability common to any social grouping will be present. Convenience sampling is a highly unrepresentative sample and means that sampling is selected for convenience for the researcher. (Cohen, et al., 2001; Maykut & Morehouse, 1994). The sampling used in this study will be a combination of purposeful quota and convenient sampling

For this study the researcher identified a number of criteria for the school: These included: a mid-decile primary school, urban location whose student population represented the cultural mix of the city. The school needed to be located within easy reach of the university as the researcher was also working fulltime as a teacher educator and travel was limited.

3.4.8 Ethical Considerations

There are a number of ethical considerations relevant to this study. The main purpose should be to protect research participants and the researcher. Field researchers often study those without power in society. The views of the less powerful must be heard. The voice heard should be one that is not often heard (Neuman, 2000; Wolcott, 1988). To avoid a degree of artificiality the interviewer must establish a rapport and begin the interview with low stake, non-threatening questions in the first instance. Researchers should take all measures not to impact negatively on classroom practices and relationships, while fostering and encouraging conversation.

Confidentiality and Anonymity are two important ethical considerations. Within any conversation, reporting or publication, the research school must also not be recognisable by way of description or location. Anonymity must be guaranteed for all participants, including the classroom teachers (Neuman, 2000). Informed consent must be sought by all participants and their caregivers when children are involved (Neuman, 2000). Participants must also be given the option to withdraw from the study at any time with no negative consequences.

Ethics Approval

Ethics Approval was sought and gained from the University of Waikato before undertaking the study. The researcher took a range of precautions to ensure appropriate ethical considerations were made (Appendices 1-9).

To avoid a degree of artificiality the interviewer established a rapport with the students during Round 1, and began all interviews with low stake, non threatening questions. The researcher also spent the first round working with the students in the classroom to establish a rapport, based on respect rather than power. The students referred to the researcher by first name and clearly differentiated her from the classroom teacher in most lessons. Most data for the study was gathered in Round 2 once relationships were established.

In the classroom, there were times when conversation and observation opportunities were missed because of a clash of roles. One of the ethical dilemmas that arose was the clash between the researcher developing a climate of ease and familiarity and at the same time trying to learn detail about the participant's lives. On two occasions in the Yr 6 class the classroom teacher asked the researcher to take the lessons because she was unable to be present. During these classes, a reliever was in the classroom but the researcher became the teacher and the familiar face in the eyes of the children. This meant that the researcher was not in a position to take observational field notes but was able to record conversations with the whole class initially and with the participants later in the lessons.

There was no hidden agenda for this research. The purpose of the study was clearly outlined in the consent letters sent to the school, teachers and parents. The teachers and the students were told about the focus of the study from the outset (Appendices 5-7).

To assist in keeping the participants in this study safe during the consent process, all parties were told that they were able to withdraw at any time. The researcher made immediate sensitive decisions during the interview on a number of occasions for a variety of reasons. For example, in the interviews three of the Yr 2 children: Issy, Adam and Debby, were initially reluctant to talk to the researcher because they were shy. Simple modification of some of the early questions allowed the researcher to draw more information from these children. In Yr 6 one participant, Teddy appeared reluctant to record his learning on camera; this led to the changing of the instructions to the children asking them to photograph their activity rather than their learning. Another Yr 6 participant, Dougal, appeared to feel that his contribution was undervalued by his group. On a number of occasions, the researcher took time to help Dougal and encourage his contribution to his team. His ideas were valuable and the researcher felt that he needed this extra support to maximise his contribution to and learning of his team.

By the second round, when the majority of the data was gathered, the students appeared to feel more comfortable discussing all aspects of their practice. The researcher also introduced focus group interviews at the conclusion of the study. This enabled participants to agree or disagree with what was said by others rather than articulating the ideas themselves.

The school is not recognisable in this report by way of description, location or name. Anonymity was guaranteed for all participant students and classroom teachers. In all reports the teachers' names were changed and first names only were used for the twelve participant children. Parental permission was sought to undertake interviews and to photograph the children. As the children were photographed in their natural classroom environment, parental permission from all students in both classes was obtained. Confidentiality was guaranteed to all participants, their families and schools (Appendices 1-5). All data was stored in a secure office and will be destroyed at the completion of the study.

Member checking did not occur as the time delay between recording and transcription was such that students would have had difficulty remembering. For this reason it was seen as not possible, however, as she was a constant presence in the room and had input into the activities undertaken by the students, the researcher is confident that accurate interpretation of the data occurred. When talking to the students the researcher clearly articulated the process and verbally asked for permission to include (or not) anything she thought may not be for sharing.

Ethical consent for the students was obtained initially through a letter to their parents (Appendix 7), then through written consent from the students themselves (Appendix 6). Ethical consent was also obtained from the two participating classroom teachers (Appendix 3), the school principal and Board of Trustees (Appendix 1).

Entering the Field

For a qualitative researcher, entering a research field requires a plan of action which involves a negotiated access to the site. Careful negotiation of access is a vital component in research in the classroom (James & van Laren, 2009). Access needs to be gained through the 'gatekeepers', people who have the authority to control access to the site (Neuman, 2000; Taylor & Bogdan, 1998). Once the gatekeepers are identified, they are approached in a courteous professional manner with a formal request for access. In order to do this in a school setting, access to the school must be obtained and then access to the teachers and students must be negotiated, all through the principal (James & van Laren, 2009). This section outlined the methods used in the study, and discusses aspects of reliability, validity and the ethical considerations relevant to the study.

3.5 Data Analysis

Lichtman (2006) suggests that data analysis is the most "complex and mysterious of all the phases of a qualitative project" (p. 160). Qualitative data analysis is a process of induction, interpretation, reasoning, thinking and theorising (Bogdan & Biklen, 2007; Campbell, McNamara, & Gilroy, 2004; Lichtman, 2006; Taylor & Bogdan, 1998). Cohen, Manion & Morrison (2001) describe this as 'discovering system relations'. After the data has been collected, the researcher then begins coding the data and refining understanding of the subject matter. Data analysis can be thought of as a series of layers of increasing complexity:

1) the actual data (raw data),

2) the accounts of those events given by observer/participants/researcher (codes) (categories),

3) the subsequent interpretation of the accounts of the events by the researcher and others (concepts).

Lichtman's (2006) suggested four steps: raw data, codes, categories and concepts, offer more insight into Step 2 above, by suggesting that initial coding is firstly revisited and refined before being reorganised into categories. In short, codes are clustered into several lists of categories of which the codes become subsets. Most qualitative researchers analyse and code their own data. Data analysis is a dynamic and creative process (Taylor & Bogdan, 1998). In qualitative research data collection and data analysis go hand in hand. Throughout participant-observation and in-depth interviews, researchers constantly theorise and attempt to make sense of their data (Taylor & Bogdan, 1998). Researchers gradually make sense of their data through use, insight and intuition combined with an intimate knowledge of the data (Bogdan & Biklen, 2007; Taylor & Bogdan, 1998). Taylor and Bogdan (1998) suggest a number of steps to aid the process of theme development and concept identification:

- Read and reread all field notes, transcripts, documents and other material carefully.
- Keep track of hunches, interpretations and ideas, have a notebook handy and ensure that everything is recorded, make annotations in the margins when reading through data.
- Look for emerging themes, patterns. Conversation topics, vocabulary, reoccurring activities, meanings, feelings, and sayings. Researchers should not be afraid to identify emerging themes.
- Construct typologies or classification schemes, these can then help in the identification of themes, concepts and theory.
- Develop concepts and theoretical propositions to move from description to interpretation and theory. Concepts are abstract ideas generalised from observation, interview or other data.
- Read literature, become familiar with other studies and theoretical frameworks relevant to the topic. These will help the researcher understand concepts and propositions that will help interpret data. The researcher should not force their data into another's framework but if their data fits then it can be useful to borrow.
- Develop charts, diagrams and figures to highlight and explore patterns in the data

  Researchers need to write analytic memos about what they think they are learning throughout the data gathering process and subsequent analysis steps. To do this may require the researcher to stand back from the data. Memos may attempt to summarise major findings or just aspects of the study.

3.5.1 Coding

Coding is a method used for developing and refining interpretation of the data. It involves bringing together and analysing all the data around major themes, ideas, concepts and interpretations. Vague ideas, hunches and general insights are refined, expanded, discarded or fully developed during this process (Taylor & Bogdan, 1998). The creation of categories allows the researcher to think about a fewer number of things (Campbell, et al., 2004). Again Taylor and Bogdan (1998) suggest a number of strategies to aid this process. The first is to develop a storyline to guide the theorising and story analysis, Campbell et al. (2004) also suggest this. The story line is the analytic thread that unites and integrates the major themes of the study and will answer the question 'what is this a study of?' Coding should be based on what researchers want to write. The story line will help them decide what themes and concepts they want to communicate and how the data should be organised. The second strategy is for the researcher to develop ongoing lists of all the major themes, typologies and concepts, as well as their own ideas. Specificity is important and some ideas will be well developed. However, some ideas will be tentative and vague initially. These lists become the major code categories. The third strategy is to code the data. Done in a variety of ways, it usually involves the assignment of symbols, highlight colours or numbers to each coding category. Direct statements and indirect observations are coded. Coding systems and categories are refined as the process evolves. It is very important that codes fit the data and some data will fit into more than one code category. The fifth and final step in the coding operation is the comparison and analysis of the data. Glaser and Strauss (1967, cited in Campbell, et al., 2004; Maykut & Morehouse, 1994; Taylor & Bogdan, 1998) developed what is known as the constant comparative method. By comparing different pieces of data researchers can refine and tighten their ideas, thus facilitating the way to high conceptualisation.

Types of Coding

Bogdan and Biklen (2007) suggest a number of different types of coding. Open or initial Coding is the first level of coding and is helpful for giving an action a name. The first codes should be a very close fit to the data and will often use actual words or phrases. These are likely to change as the data analysis progresses (Campbell, et al., 2004; Lichtman, 2006). Once the codes and categories have been established the researcher then assigns letters or numbers to each one, to form the actual code. If listed alphabetically or numerically the researcher is more likely to memorise the codes. The researcher then goes through the data assigning the appropriate code to each sentence or paragraph. This involves careful scrutiny of all sentences and the making of decisions as to where the sentence, or phrases within sentences, sit within the coding system (Bogdan & Biklen, 2007). After the coding process is completed researchers then need to study their process and their findings to ensure against bias, and then they need to undertake theory development using their analytical framework (Taylor & Bogdan, 1998).

In this section research tools and strategies relevant to this study used for the analysis of data was discussed. Data analysis is an iterative process that involves full emersion in the data for the researcher.

3.6 This Study

This section outlines the method of the actual study. It discusses how the researcher gained access to the school. It also outlines the research tools used and strategies employed for gathering data. The section then discusses data analysis; how the data in this study was organised and analysed. It identifies the themes and codes used to analyse data and concludes with the framework used in the analysis process. The results are presented in Chapters 4 and 5. Synthesis of data gathered and literature is discussed in Chapter 6.

3.6.1 Approach to Schools

The study took place in a New Zealand primary school and focused on 12 students; six in each of Years 2 and 6, all of whom were willing participants. Initially the researcher approached three mid-decile state-funded schools with families from a range of socio-economic backgrounds and representative ethic mix. One state mid-decile primary school, with single level or non-composite classes was sought at Year 2 and Year 6. A single level or non-composite class means that the class had only the one year level as opposed to a composite class which may have children from two to any number of year levels.

Practical reasons, such as ease of access, close proximity and central location, influenced the initial identification of three schools who met all the criteria mentioned above, and also influenced the final selection of the school. The three schools identified were approached in a professional manner.

The gatekeepers in this study were the Boards of Trustees (BoT) and school principals in the first instance and then the classroom teachers. A letter was sent to Principals of three schools who met the required criteria (Appendix 1). The letter outlined the project and requested research access to staff and students. Two of the schools replied affirmatively and one school did not reply to my approach. Both of the schools who replied affirmatively would have been suitable, the final selection of Park School (pseudonym) was because of the central location of the school. At this stage a letter was sent to the principal of the selected school thanking them for support and agreeing to undertake the project (Appendix 2).

The Park School principal made an initial oral approach to two potential teachers. After the teachers' verbal consent to the principal, the researcher formally approached them to request access to interview and observe their students, and request permission to interview them and obtain class information (Appendices 3, 4 and 5). On confirmation from the classroom teachers, letters were sent to all students (Appendix 6) and their parents (Appendix 7) outlining the project and seeking the required permission and consent. This letter also sought permission to select their child for more in-depth observation and interview in the second round of the project. This was done at this stage to streamline the permission progress and to avoid rejection of participants selected in Round 2. At the conclusion of Round 1, the researcher consulted with the teachers to identify six students in each class as focus participants for the next round. The researcher attempted to ensure the student selected were a balanced and representative mix in terms of academic ability, gender, ethnic origin and cultural and socioeconomic background. Letters were then sent to these students gaining their permission to be studied (Appendix 8) and to the non-selected students requesting permission for the researcher to observe them as a part of the class (Appendix 9).

3.6.2 Research Tools

Stimulated Recall using autophotographs was one of the research tools employed in this research. The participants were taught how to take photographs on digital cameras in Round 1 and given disposable cameras in Round 2 to record their own technological practice. Photographs were used because they allow students to capture a specific moment or activity, rather than video, which is more encompassing, less specific and much more time consuming to analyse. The term autophotography has been used throughout this study to describe the process of self-generated photographs by participants. The photographs generated by the students were then used to stimulate discussion about technological practice. Disposable cameras were used because it enabled the researcher to give every student in the class their own camera. They were relatively inexpensive, sturdy and easy to use and students were not able to delete photographs taken.

Other methods of data gathering employed were initial semi-structured interviews of each participant on their understanding of technological practice. The researcher then facilitated ongoing conversations with the students as they worked. She undertook: participant observations, gathered student work samples and took researcher generated photographs of the students undertaking their technological practice. One final focus group interview with each year group of participants was also undertaken as well as on-going interviews with the classroom teacher.

3.6.3 Data

Three methods of gathering data were employed. The first was transcribed in-depth and semi-structured interviews between the students and the researcher, and interviews with the classroom teachers at intervals throughout the project; the second was audio recordings of the students as they worked in their groups of three, again transcribed and augmented with detailed observations by the researcher. Students' work and teachers' planning samples were the third, allowing triangulation of data.

Interviews with the Child Participants

Semi-structured and informal in-depth interviews with the student participants and teachers were used in this study. The first round of semi-structured interviews took place after the researcher's first few visits to the classroom. The students were familiar with her and understood that she was going to be a regular presence in the classroom. In the letter to parents and students the researcher's role was clearly established. The researcher also articulated her role to the students the first time she observed in the classroom so during the first interview the participants were aware of her role.

Throughout the duration of the study the researcher also conducted a number of informal interviews with the students, particularly when they were developing ideas and designs for their technological solutions. Interviews were recorded and later transcribed or the researcher noted their content in her research journal at the conclusion of the conversation. A final individual semi-structured interview occurred after the last technology unit was completed, with the 12 individual participants using the autophotographs to stimulate recall and discussion about technological practice. In the Initial stages of the study, the researcher decided on a further round of semiformal interviews towards to end of the study and these took the form of two focus group interviews with the six participants from each level.

Interviews with Classroom Teachers

The researcher realised there was a need to interview the teachers involved in the project to gain an understanding of the teachers' views on the technology conversations and learning. These interviews were initially omitted from the ethics approval. Ethics Approval was sought for these interviews (Appendices 10 and 11). The researcher subsequently requested formal permission from the two teachers (Appendix 12). These became an appendix sent to the ethics committee one month before Round 1 began.

These interviews were conducted using a semi-structured interview format at three times during the study; one prior to Round 1 (Appendix 13.1), one prior to Round 2 and one after Round 2 (Appendix 13.8). The first interview was planned to take place with the teachers together, but one of the teacher was absent owing to illness, therefore interviews were completed one week apart. The second interview took place individually in each teacher's classroom one lunchtime, and the final interview took place with both teachers at the same time at the conclusion of both units in one classroom at lunchtime.

Recordings of Participants Working Collaboratively and Observations

The best way to describe the observation used in this study is 'observer-participant'. The researcher was well known to the participants and they appeared comfortable with the researcher in their presence. As the participants worked in groups they were recorded. During this time the researcher circulated discussing the students' work with them. These conversations were captured along with conversations between teachers and their students.

After classroom teachers were identified, the researcher worked with them to plan the two technology units of work. In Round 1 the researcher assisted the teachers in the delivery of the first unit. During this time, anecdotal observations were made as relationships with the students developed. It was during the second unit in Round 2 that audio recordings and detailed participant-observations using photographs and field notes were taken.

Document Analysis - Work Samples

The third method of data collection used in this study was the analysis of the participants' work samples. While participating in the technology units of work the students produced a number of work examples giving evidence of their learning. These included activity sheets they were required to fill in as they worked through specific activities to build their conceptual knowledge of props and drawn planning of their props.

3.6.4 Reliability and Validity (Authenticity)

In this research, reliability depended on the accuracy and richness of observations taken. This was aided by detailed researcher notes and audio recordings of the interaction within the groups of students. Participants were given many opportunities to articulate their technological practice in interview situations with the researcher, and discussions with their peers and teachers. The gathering of copies of relevant written work associated with the unit for each participant also contributed to data richness. These methods allowed the development of in-depth descriptions and therefore ensured reliability of the study.

A number of measures ensured authenticity rather than validity in this study. During data gathering, the researcher ensured that her presence in the classroom was as natural as possible and when interviewing, the researcher ensured the participants were comfortable. Researcher behaviour minimised bias towards such aspects as gender, race, age and personality. The researcher was also aware that researcher behaviour, such as non-verbal behaviours, dress and style could influence participant responses. As a registered teacher with 12 years' experience teaching in the primary classroom the researcher was very familiar with the behaviour expectations of primary teachers. When in the classrooms she quickly became an accepted member of the class and all students responded to her with respect throughout the project.

The researcher recognised that participants were able drop out of the study at any time and clearly articulated this in writing to both parents and students. Moving school was a likely reason for the removal of children. The study was designed to cater for this unexpected outcome by gathering the most critical data during Round 2 only. This short time span one week for Year 2 and five weeks for Year 6 decreased the likelihood of participants leaving the study during this period. To aid authenticity of data, triangulation was used by gathering information from interviews, observations and analysis of work samples (Cohen, et al., 2001).

During data analysis the researcher ensured that coding was done methodically and accurately and that selective use of the data to illustrate a preconceived idea was avoided. Subjective statements about participants were taken into consideration and the researcher explicitly declared any information that was gained through experiences other than the planned data gathering opportunities, such as the interviews and observations (Cohen, et al., 2001). These strategies ensured that the data gathered told an authentic story of technology occurring in the two participant classrooms during the period of the study.

Triangulation

In this study, full and accurate description of participant behaviours was obtained through detailed informal observation, semi-formal and informal transcribed interviews and document analysis of participant's work samples.

3.6.5 Scope of the Study

Within the selected school, two single year classes - one Year 2 and one Year 6 class - were identified. Over the period of a year, two technology units were taught in each class. See Appendix 14 for an overview of technology sessions. At the conclusion of Round 1 six students were identified and selected by the researcher, in conjunction with their classroom teacher, to be full participants in Round 2 of the study, as illustrated in Table 3.2. Pseudonyms were used for the purposes of anonymity and confidentiality. The units taught were designed and planned by the classroom teachers in conjunction with the researcher and were loosely based on the technology in the '*New Zealand Curriculum*' (Ministry of Education, 2007). Two units were taught at each level. The original units were planned for Year 2; then modified for Year 6 to ensure that, as the level and age of the children increased so did the complexity of the technological processes, knowledge and skills taught. By teaching two units the researcher was able to establish rapport, confidence and respect with the students in Round 2, facilitating the likelihood of rich conversations in Round 2.

Table 3.2: Scope of the Study

School	Class	Teacher	Units/ Rounds	Child Codes					
				1	2	3	4	5	6
Park School	Year 2 (Yr2)	Fleur	1	Observation and rapport establishment. Participants for Round 2 identified					
			2	Adam	Rex	Ellis	Debby	Issy	Anne
	Year 6 (Yr6)	Clara	1	Observation and rapport establishment. Participants for Round 2 identified					
			2	Teddy	Alan	Dougal	Minnie	Mandy	Jay

3.7 Resourcing

The resource requirements for this study were not onerous. In her capacity as a lecturer at The University of Canterbury, the researcher applied for and received funding for the consumable costs of implementing technology units in schools, travel to and from the school and transcribing costs. Study costs are outlined in Appendix 15.

The aim was that the research should be cost neutral to the school. Appendix 15b outlines the planned cost of the study. Study leave for the data gathering process was also applied for. However, owing to researcher workload commitments (in Round 1 the researcher was also teaching two classes at her institution and in Round Two she was visiting her teacher education students in schools on they were on Professional Practice) during the data gathering phase, timetables of available and agreed teaching times were developed by the researcher and given to the classroom teachers to ensure all teaching and learning episodes were maximised (Appendix 15b).

3.8 Actual Timeline

The proposal for this study was submitted and accepted in February 2007 with full enrolment occurring in March 2007. The main data gathering occurred during 2008. In 2009 the researcher obtained six months study leave and used this time to write the draft methodology and method chapter, and data analysis. The

September 2010 and February 2011 earthquakes in Christchurch, plus the death of her father in January 2011 severely impacted on the researcher's ability to meet the initial deadline given in the proposal with delays of approximately 12 months. The actual timeline is outlined in Table 3.3.

Table 3.3: Actual Timeframe for the Project

Time Frames	Thesis Stage
February - August 2007	Proposal Preparation
August 2007 - April 2008	Literature review Methodology research and preparation Gained access and ethical consent
May - December 2008	Data Gathered
January 2009 - December 2009	Analysis of data and identification of themes
January - June 2010	Further literature review for emerging themes
July 2010 - June 2012	Writing results and relevant discussion
July – Nov 2012	Writing conclusion and making recommendations for further study
Dec 2012	Proof reading and editing
February 2013	Submitted thesis for examination

3.9 Data Analysis

The data in this study was mainly obtained through interview and observation (Bogdan & Biklen, 2007). Coding remained entirely open and responsive to the data, and codes used emerged with the data. This method of coding is open coding. Campbell et al.(2004) note that initially the code categories should be a very close fit to the data and may use actual words for phrases from the data.

Glasser and Strauss (Best & Kahn, 1998; Campbell, et al., 2004) call these code ‘in vivo’ codes.

Campbell et al (Campbell, et al., 2004) suggest that the layers of complexity when interpreting data are often three fold. The first layer is the actual event, virtually all the raw data is actually a story of the event. The researcher then adds another layer through the interpretation of the data, which becomes a story of the story of the event. Eventually the actual event disappears under layers of interpretation.

In this study, in preparation for analysis, the raw data was as detailed as possible. All interviews were audio taped and then transcribed, and the participants recorded photographic evidence of their technological practice. Detailed anecdotal observation notes were taken as students worked. Conversations of the participants talking to their peers and their teachers were audio recorded. Campbell et al (2004) also suggest that once the analysis process starts, the complexity of it is increased as the process evolves. Systematic and meticulous organisation of the data was required. During this phase the researcher was open to multiple meanings, looked at situations from a variety of perspectives, and thought creatively when devising the conceptual analytical framework with connections to relevant theoretical insights.

The steps used for data analysis in this study follow the process suggested by Lichtman (2004) and included the following:

Step 1. Initial coding, recognition of some central ideas from the raw data.

Step 2. Revisiting initial coding- refining and modifying where necessary.

Step 3. Developing an initial set of categories or central ideas.

Step 4. Modifying of initial list after some additional rereading.

Step 5. Revisiting categories and subcategories.

Step 6. Moving from categories into concepts (themes and in this case elements).

3.9.1 Data Analysis in this Study

In this study the key method of data analysis, to determine the nature of conversation in technology practice by students and their teachers, was analysis by coding of the transcribed audio-recorded student conversations as they worked in groups of three, and transcribed participant and teacher interviews. Other relevant data included researcher observation notes, participant autophotographs and annotated work samples.

Recorded conversations were transcribed as soon as possible after the event to ensure a minimum loss or distortion of data. However, because of the number and length of the recordings, at times there were significant delays before the transcribed conversations were returned and checked. Because of delays in transcription, the age of the participants and the short, intense timeframe of data gathering, member checking was not undertaken; however, once transcribed, all files were checked for accuracy by the researcher and corrected if inaccuracies were recognised.

Emersion in the data and initial coding led to the development of a framework that facilitated the analysis of the nature of conversations in a technology education setting. In the first instance, initial coding was broad with diverse categories to formulate early ideas. Once the open coding phase was complete data was re-examined to ensure that the researcher had not been overly biased. The next stage was to further develop the categories allowing sub-categories to emerge. Campbell et al (2004) noted that a sub-category might be named but have no actual data. This highlights the absence of data as significant.

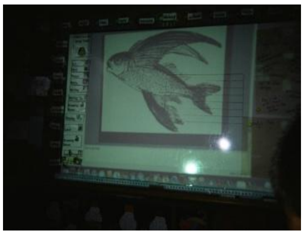
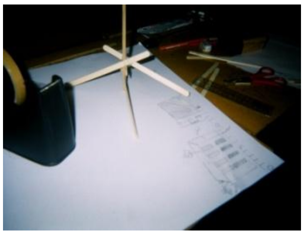
Key ideas were visited and revisited until pertinent concepts were identified. Appendix 17 shows the initial categories and their codes. Initial codes were very broad and wide ranging and evolved as transcripts were analysed. This early coding served the purpose of immersing the researcher in the data. Following the development of these codes, the researcher identified two distinct types of conversation; those involving students only (student-student) and those initiated by either teacher or students but involved the teacher (teacher-student) conversations. The nature of the analysis and the structure and components of the framework are introduced below.

Autophotograph Analysis

The next step involved analysis of the students' autophotographs. To do this the researcher analysed all autophotographs taken by the students by firstly identifying the content of each photograph and then identifying when within the technological practice they were taken. From this analysis it was clear that there were four significant stages of practice for the students and thus the identification of four unit stages used to structure the reporting of this study. The first was when the students were learning about props: Stage 1 Character and Function; the second was the sketching and drawing of their design ideas: Stage 2 Planning. The third was the construction of the mock-up designs: Stage 3 Mock-up and Stage 4 Construction showed the students undertaking the construction of their final props.

This was triangulated with analysis of teacher planning and the students' work samples leading to the identification of the significant stages in the unit as seen in Table 3.4. The planned unit enabled students to undertake technological practice, and it contained intended learning for each lesson. The researcher categorised the autophotographs from the six participants, against to the intended learning (Appendix 18). This analysis showed four significant stages in the unit. Table 3.4 illustrates how the autophotographs were linked to the unit plan and the curriculum achievement objectives; four are shown by way of illustration, but this process was used for all relevant autophotographs. Most of the photographs were in one of the following four stages of technological practice: building an understanding of the character and function of props (42 photographs), initiating and sketching conceptual ideas and plans (28 photographs), three dimensional modelling of their intended outcome (48 photographs) and the final construction of the outcome or completed prop (104 photographs).

Table 3.4: Examples of How Analysis of Autophotographs led to the Identification of Stages

Participant Code	Autophotograph	Learning Intentions	Learning Experience	Strand & Achievement Objective	Elements
Ellis		Research technology outcomes from different eras and cultures identifying specific links.	Research how props portray different eras and cultures and what makes a prop specific for an era or culture.	Nature of Technology CTO	Character and Function
Rex		Plan technology outcomes in detail considering specifica-tions and stake-holders	Plan their prop in detail.	Technology Practice MO/ODE/BD	Planning
Alan		Create a mock up for identified technology outcomes	Create a mock-up of selected prop.	Technology Knowledge Technological Practice MoO/ODE/ BD	Mock-up
Minnie		Create final design Design and technology outcomes evaluation	Create final props and test to use on stage.	Technology Knowledge ODE	Construc-tion

Key: BD-Brief Development; ODE-Outcome Development and Evaluation; Mo-Modelling; CTO - Characteristics of Technological Outcomes.

One child photographed an activity aimed at evaluating students' understanding of technological practice and in Year 6, six photographs were taken of their intended timeframe (Planning for Practice). The latter two were not considered key stages because of the low numbers involved.

Classification of Conversations

The next phase of the data analysis involved in-depth classification. Broad conversation categories were identifying based on the intent and purpose of the conversation, how and why the conversation occurred. Early categories (Appendix 16) included: Management of the Classroom Programme and Behaviour, Management of Learning, Thinking Challenged, Using Prior Learning and Technological Practice. Refinement occurred through literature investigation and further analysis leading to the identification of the five key elements of conversation: Funds of Knowledge, Making Connections, Transmission of Knowledge, Management of Learning and Technological Knowledge. This was later revised and collapsed into four elements as Transmission was identified as a sub set of Management of Learning.

The researcher then identified types of talk from the literature and clustered these according to their characteristics. Data showed differences between student-student talk and teacher-student talk. Conversations that facilitated higher-level thinking were identified as desirable in the literature. Analysis indicated that there were a variety of conversations, some interactive with all parties involved and others non-interactive, with either only one party involved or dominated by one person (Appendix 19).

Identification of the stages and elements led to the development of the Conversation Framework (Table 3.5). This facilitated in-depth analysis of conversation. To undertake in-depth analysis the transcribed conversations were arranged by lesson. Significant conversations giving insight into students' understandings were identified from the transcripts, linked to the lesson, and intended learning in which they occurred.

Evidence of learning and relevant autophotographs were also identified for each lesson. Within each stage, conversations were identified as an authentic classroom conversation within technology practice, either between students and teachers or among students, and evidence that technological learning had taken place. These conversations included such things as researcher conversations with participants during their practice or following their practice in the Stimulated Recall Interviews and teacher interviews. There was overlap at times when students evidenced the implementation of learning in technology earlier in the unit and applied it to current learning. Authentic classroom conversations were reanalysed to identify conversations within each of the key elements. Highlighting was used to do this: pink - Funds of Knowledge, blue - Making Connections, yellow - Management of Learning with Transmission in red and green - Technological Knowledge.

As this study is situated within an interpretative paradigm, the empirical data led to the development of a provisional hypothesis. Conversations within each stage and key elements were extracted and studied in-depth, giving rise to further clustering and classification into sub-elements and against the types of talk identified in the framework. Theory began to emerge. The Analytical Framework is reported in Section 3.10.

3.10 Analytical Framework

This section introduces a three dimensional theoretical framework and is outlined in Tables 3.5. The framework allowed the analysis of conversation in technology education. It outlines the components of the framework and justifies their inclusion. The framework introduced in this study identified components critical for determining the nature of conversation for these students in technology, and it allowed the critical analysis of the nature of conversation undertaken by the Year 2 and Year 6 students. The framework used four main key elements to describe the nature of the conversation: Funds of Knowledge, Making Connections and Links, Management of Learning and Technological Skills and Knowledge. Key elements were critical influences on the nature of conversations that occurred in the classroom between students and teachers or among students. These elements evolved through close analysis of the transcribed recordings of classroom conversation.

Table 3.5: Overview of the Analytical Framework

Stages of Technological Practice Types of Talk	Character and Function	Planning	Mock-up	Construction	Key
1 Student-student					**Elements**
a)Interactive					Funds of Knowledge
Cumulative					
Intercognitive					
b)Non- Interactive					
Authoritative					Making Connections
Disputational					
2 Teacher-student					
a) Interactive					
Authoritative					Management of Learning
Modelling					
Intercognitive					
b) Non-Interactive					
Revisitational					Technologies and skills
Authoritative					
Encouragement					

Four Stages of practice were identified within the students' technological practice and were closely related to authentic technological practice in that they reflected the practice of technologists in the field. These stages were linked directly to aspects of Technological Practice, Technological Knowledge and The Nature of Technology as stated in *The New Zealand Curriculum* (2006, p. 168).

The third dimension to the framework was the type of classroom talk engaged in. There were two main categories of talk in the framework: student-student and teacher-student (also including the researcher when in the role of teacher, as she was involved in the teaching and learning process. Please note that the 'teacher-student' category applies whether conversations were instigated by the student or the teacher). Within each of these types of talk there is further breakdown and classification according purpose and content of the conversation.

Through the identification of types of talk in the literature and early analysis of the data the researcher was able to develop an overview in which to present the findings of the study. This overview is introduced in the following section.

3.11 Analysis Overview

As outlined in Table 3.6 the results are presented in a framework that consists of the four stages of the study, as identified through analysis of the autophotographs taken by the participants and their work samples, and the key elements identified through the analysis of the transcribed conversations. The results are organised to identify types of conversation across stages and within elements which contribute to students' learning in technology education. The first three elements are considered the inputs into learning in technology, while the fourth element "technological Knowledge and Skills' offers evidence of learning in technology education. Also considered within the framework were the identification of differences between conversations at Year 2 and Year 6.

3.12 Conclusion

This chapter introduced the methodology employed in this study. This is a qualitative study working within an Interpretivist paradigm. It employed an ethnographic approach to investigate the nature of conversations that occur within technology education. The chapter explores the methods used in the study to gather and analyse the data. It also discusses issues of reliability, validity and ethical considerations, and how these have been considered and implemented to ensure the integrity of the study and the safety of the participants.

Table 3.6: The Analysis Overview

Stages **Elements**	**Character and Function**	**Planning**	**Mock-up**	**Construction**
Funds of Knowledge Linkages/ Connections Managed Learning Opportunities	Analysis of the type of talk across stages and inputs, shifts in type and number of conversations across stages and year levels			
Interaction and conversation central to learning Nature of conversation: shifts in types through stages Teacher-student and student-student conversations				
Outputs Technological Knowledge and Skills	The nature of the talk evidencing the learning in technology across stages and levels			

The chapter concludes with an introduction of an analytical framework developed through initial emersion in the data, for the detailed analysis of the nature of conversation in technology education.

Chapter 4. Results - Character & Function and Planning

4.1 Introduction

This chapter uses the framework developed by the researcher and introduced in Chapter 3 to analyse conversations in technology education to investigate the nature of conversation during the technology unit on the topic of ‘Stage props’ undertaken in both Years 2 and 6 in a New Zealand urban primary school. For ease of analysis, the data in this study is divided into four stages identified as significant to the students through the analysis of their autophotographs. Stages 1 and 2 are reported in this chapter, Chapter 4, and Stages 3 and 4 are reported in Chapter 5. The data illustrates the nature of students’ conversation while undertaking technological practice. The main data set consisted of recorded audio conversations and researcher observations conducted while the students were participating in the technology unit. This data was supplemented with photographs taken by the researcher, participant autophotographs, teacher unit plans and participant work samples. Teacher interviews were conducted before, during and after the units were implemented. Data gathering concluded with focus group interviews at Year 2 and Year 6. All recordings and interviews were audio recorded, transcribed and checked for validity.

The unit of work undertaken at both levels involved the students designing and developing the props required for their class’s section of the annual school production. In the first stage, ‘Character and Function’, students built their understating of the character and function of props. This learning included a presentation from the local theatre’s props manager, Julian, about what props were and the different kinds of props used in his theatre. In the Character and Function stage, the students also viewed videos of two stage shows to help them determine the definition and role of props and to establish the difference between a prop and a costume. The second stage was Planning. In this stage the students developed initial ideas for their designs, evaluated and selected one design per group, and developed a plan of their proposed outcome in detail. This stage also included some aspects of planning for practice, such as task definition, timeline management and the identification of resources and materials required for prop production.

Initial data analysis led to the identification of four elements of learning running through all four stages. These elements are: Element 1, Funds of Knowledge; Element 2, Making Connections; Element 3, Management of Learning and Element 4, Technology Knowledge and Skills. In this chapter, and Chapter 5, the conversation framework introduced in Chapter 3 is used to identify the nature of conversation within each of the identified stages in both Years 2 and Year 6 across all four elements. In Chapter 6 the research questions are answered using detailed discussion through elements and stages.

4.2 Data Analysis Process

Data Analysis for this study was detailed in Chapter 3, however, this section briefly reviews those processes. The main data set, evidencing the nature of conversation as students participated in technological practice, comprised the analysed and coded transcribed audio-recorded student conversations, their autophotographs and interviews with both teachers. Initial coding was broad with diverse categories, with key ideas revisited until pertinent concepts were identified. Initial data analysis led to the development of the conversation framework introduced in Chapter 3. Chapters 4 and 5 focus on the nature of conversation between the participants, students and their teachers, and between the students themselves as they worked through their technological practice as a class and in groups of three. Students' work samples, researcher photographs, autophotographs and the research journal are also used when applicable. In each element sub-elements are identified. In some cases sub-elements are broken down further into subsections, thus allowing in-depth analysis across the unit. Where applicable, comparisons are also made across each year level, between Years 2 and 6 and across unit stages.

The sections below are organised around the first two unit stages and begin with an overview of lessons and their learning purpose. In each stage, links are made to *The New Zealand Curriculum* (Ministry of Education, 2007) and *The Indicators of Progression* (Ministry of Education, 2009b). Elements and sub-elements are identified, clustered further if appropriate, and discussed. Sub-elements and in some cases further sub-sections within, are illustrated with relevant extracts from the data where appropriate. Table 4.1 illustrates the nature of this organisation.

Table 4.1: The Nature of the Organisation of elements, Sub-elements and Sub-sections

<table>
<tr><td rowspan="4">Stages 1-4</td><td rowspan="4">Element</td><td rowspan="2">Sub-element</td><td>Sub-section</td></tr>
<tr><td>Sub-section</td></tr>
<tr><td rowspan="2">Sub-element</td><td>Sub-section</td></tr>
<tr><td>Sub-section</td></tr>
</table>

An outline of the elements and sub-elements for Stages 1 and 2 are presented in Tables 4.2 and 4.3. Sub-sections are detailed later in the chapter within each sub-element and are outlined in additional tables where applicable.

4.2.1 Analysis of Conversation in Technology Practice

This section details the analysis of the conversation at both Year 2 and Year 6. It is organised around the first two unit stages: Character and Function and Planning. Within each of these, conversations that show evidence of technological practice were identified, analysed and discussed within a framework of the four key elements: Funds of Knowledge, Making Connections, Management of Learning and Technology Knowledge and Skills.

Table 4.2: Overview of Elements and Sub-elements in Stage 1 Character and Function

Stage	Elements	Sub-elements (SE)	Yr 6	Yr 2
1: Character and Function	Funds of Knowledge	Passive Observation	8	6
		Participatory Enculturation	4	5
	Making Connections	Physical Prompts - real artefacts or images	30	14
		Knowledge -Other Disciplines	25	9
		Making Temporal Connections	9	0
	Management of Learning	Transmission	29 (1)	6
		Higher Order Thinking	27 (4)	10
		Drawing-out Pre-Determined Answers	22 (7)	8
		Peer Discussion	16	4
		Managing Students' Behaviour	3	8
		External Expert	3 (1)	2
		Specific Learning Strategy	2	4
	Technology Knowledge and Skills	Attributes	15	10
		Materials- Role and Function.	2	1
		Required Physical Skills.	0	1
		Planning for Practice	0 (1)	0

For this unit of work, in each class the students were divided into groups of three. In both classes, this was the first instance in the school year that the students had worked in groups that they had not selected themselves. It was a new experience for many of them working with people who were not 'their friends'. The reason for this was that in Year 2 the classroom teacher had identified the need for the students to work with others whom they may not consider a friend as a specific need for the class. In both classes it allowed the six identified study participants to be clustered together into two groups of three.

Table 4.3: Overview of Elements and Sub-elements in Stage 2 Planning.

Stage	Elements	Sub-elements (SE)	Yr 6	Yr 2
2: Planning	Funds of Knowledge	Passive Observation	8	0
		Participatory Enculturation	8	1
	Making Connections	Knowledge -Other	6	7
		Making Temporal	3	0
		New Technology Knowledge	2	0
	Management of Learning	Assisted Learning	26	15
		Higher Order Thinking	23	4
		Peer Discussion	16	17
		Transmission	12	1
		Eliciting Specific	12	3
		Managing Students' Behaviour	12	11
	Technology Knowledge and Skills	Attributes - Physical	28	9
		Process of Planning (practice & outcomes)	28	5
		Materials - identification of and function	13	0
		Attributes - Functional Features	13	0
		Planned Outcome - physical skills	10	5

The overall purpose of the early lessons in the unit was for the students to develop an understanding of the character and function of props in stage productions for the end of year school productions - one for the Junior School (Years 1-3), and one for the Senior School (Years 4-6). These lessons had two main areas of focus. The first was building students' understanding of the place and properties of props and the second was investigation into the actual props being developed and their situated context. In Year 2 the context was a Taiwanese folk fishing tale, with each group designing and developing a flying fish to be placed beside a Taiwanese boat on stage. The Year 6 students designed a range of props to support a short item written by two class members encapsulating the Olympic Games from 1896 to 1936.

This unit was the second technology unit undertaken by the students in that year. In the first unit students were introduced to technology education by undertaking the development of futuristic cars in Year 2 and space stations in Year 6.

4.3 Stage 1: Character and Function

The main purpose of the introductory lessons in this unit was to help the students to understand the character and function of props. Two of the early lessons in the unit were undertaken with both Year 2 and Year 6 children combined. Key conversations were classified and analysed in four elements at both Years 2 and 6. In each element, key ideas were illustrated with extracts from the research data from both Years 2 and 6. The concluding section in each element discusses the differences in the data between Years 2 and 6.

4.3.1 Overview of Lessons

The students were introduced to the unit with an outline of the brief: in groups of three they were to design and make props for their class items in the school productions, which were being held at the end of the school term. The over-arching theme for both productions was The Olympic Games. The first of the combined lessons involved the students watching two videos of plays - the first was a stage scene from the movie "Hook" and the second was a video of a stage show from a well known local theatre that had visited the school earlier that year.

The classroom teachers, Fleur (Year 2) and Clara (Year 6) then asked the students about the setting of the play, concluding with the students identifying that the props helped the audience engage with and understand the scene. This was a modification to the original planning, as both Fleur and Clare felt that the original idea of using a scene from a stage show in the film ‘Hook’, did not display props as well as they had hoped. At the last minute they decided to show an additional video of a stage production held at the school earlier in the year, The Magic Island. In mixed Year 2 and 6 groups, the students then listed the props they are able to identify, discussed the purpose of each and finally wrote a definition of ‘prop’. The students were introduced to the idea that props were needed to enhance the quality of the show, to enhance the performance of the actors and to engage further the audience. Students identified the props, and how and why they were used.

The following day all students listened to a guest speaker, Julian, who was the Props Manager from the local theatre. This was aimed at furthering the students’ understanding of the character and function of props. Julian explained what props were and how actors used and relied on props. He also discussed types of props commonly used, illustrating his talk with a range of prop types; some actual historical items, for example a coal bucket. Others were authentic looking but non-functional, for example, a plastic knife with a retracting blade and plastic banana. Props in a third category were comical and exaggerated in nature, for example a very large ‘blow up’ type of hammer with a face.

The final ‘function and character’ lesson undertaken by the Year 2 students was an activity aimed at consolidating concepts learned by undertaking an ‘Agree/ Disagree’ (Appendix 20 Strategy 6) activity. In this activity the teacher made statements about props, and the students were required to state whether they agreed or disagreed with the statement and give their reasons. In Year 6 the students investigated both Olympic and general artefacts for their class’s designated era 1896-1936. They also analysed photographs of props to determine how historical location and purpose were reflected in the design.

Following these introductory lessons both classes were involved in research of their specific props in their real context to identify key physical and functional features. The Year 6 class also critiqued a range of props against identified criteria. The Year 2 students also spent time building their understanding of the nature and characteristics of flying fish. This was because the Taiwanese tale they were acting out was a fishing tale. Flying fish were the species the fishermen hunted and therefore were required as props. After watching a video and some slides of flying fish (Figure 4.1 shows a few of these slides), Fleur used interactive authoritative talk to elicit what the children had learned.

Figure 4.1: A Sample of Slides from the Flying Fish PowerPoint

In summary, before undertaking the development of their own props, students needed to have clear conceptual, societal and procedural knowledge (Jones & Moreland, 2001; McCormick, 1997) of props with an understanding of their physical and functional natures (de Vries, 2005). The purposes of these lessons were to help students define props, understand the role and impact of props in a play, to identify the characteristics of props and to consider the skill set required to develop props. To do this the students watched props in action in a stage show and listened to a community expert talk about the props used in his company.

The key conversations were classified and analysed in each of the four elements: Funds of Knowledge, Connections and Links, Managing Learning and Technological Knowledge and Skills, at both Years 2 and 6. The following sections discuss each of the elements in turn, with identification of sub-elements.

4.3.2 Funds of Knowledge

Funds of Knowledge are information, knowledge and skills students bring to learning from their culture, home and community (Gonzalez, et al., 2005). Two categories or sub-elements of conversation were identified in the Funds of Knowledge element. The first was ‘Passive Observation’. This is knowledge that the students have obtained through observation that is one-way in nature. For example, knowledge gained from watching a movie or television. In Passive Observation situations, the participants are not given an opportunity to interact with the subject matter. The second Funds of Knowledge sub-element was ‘Participatory Enculturation’ in which participants were given the opportunity to interact, discuss and engage with the material. This includes instances when students are able to observe and engage with their parents or other people within their communities.

In Year 6, 12 key conversations were identified as Funds of Knowledge. Of these, eight were classified as Passive Observation and four as Participatory Enculturation. The two categories or sub-elements of conversation identified for Year 6 were also applicable in Year 2. Of the 11 key conversations identified in Year 2, six were Passive Observation and five were Participatory Enculturation. These findings are summarised in Table 4.4.

Passive Observation

The first element was identified when students referred to learnt knowledge they obtained through passive observations. They were non-participatory observers; for example through watching movies, television or through something they may

Table 4.4: Summary of Funds of Knowledge Conversations

Sub-elements and sub-sections	**Year 6**	**Year 2**
Passive Observation *Location* *Form and Function*	8	6
Participatory Enculturation	4	5
Total	12	11

have seen in books or at home. The data suggests that students used knowledge gained in a passive observatory role and applied it to the learning that took place in their classroom. This illustrated that students were able to transfer knowledge gained through passive means to inform their technological practice. Through Passive Observation the students were able to locate technology in historical and cultural contexts. There were two aspects of passive observation identified in the data: Location, and Form and Function.

Location

The first was that the students were able to understand that props assisted in the historical, geographical or cultural location of a play or setting. This is illustrated below. The Year 6 students were given a range of photographs of objects that were or could have been props in a play. As Minnie talked to the researcher (R) she recognised a cart. She knew they were from the past as she had heard about them in the song Little House on the Prairie, set in pioneer times in the mid-west of the United States of America.

Minnie: Oh, it's from the olden days, a cart or something.

R: So when do you, when did they use them?

Minnie: Probably like a hundred years ago or sooner, like. There's that song, Little House on the Prairie.

Other extracts suggested that students were also able to culturally situate artefacts through Passive Observation, for example in discussion with their teacher, four Year 6 boys were able to give a range of examples of when podia were used when asked by their teacher Clara. A podium was one of the props the students identified as needing to be developed for their class item. Given examples included game shows, rugby and rally car racing, which were regularly seen on television. The students understood that podia were an authentic object commonly used in sporting events. This assisted students' understanding of how a prop can assist the audience to situate the play culturally, in this case within the Olympic Games.

Form and Function

Students also learned about the function and form of an artefact within a setting. This was illustrated in the next extract. In Year 6, the students' main task was to develop props for the 1896 to 1936 Olympic Games. In discussion with the researcher (R) the students below were able to recognise microphones from this era as they had seen them on television and the movies.

R: So how did you know that microphones looked like this?

Alan: Because umm, I saw a thing on TV.

Dougal: Yeah, like on movies and stuff.

This extract demonstrated that the knowledge the two boys had about microphones came from watching television and movies, both activities commonly associated with their culture. This suggested that in technology education the students used prior observation to assist their construct of an object and the role it played.

Students also gained an understanding of the purpose and role of props through Passive Observation. All students listened to Julian from the local theatre. He explained the purpose and function of props, and illustrated his talk with a range of props his company have used in the past. He also discussed how each was used *in situ*. In the first extract, Issy from Year 2 was reminded of a show she saw in the last school holidays. As an audience member she observed one particular prop used in a variety of ways.

Issy:	I saw a show about a magic trunk in the holidays and it changed [voice trails off].
Julian:	Ohh, 'Auntie McDuff's Magical Trunk' [name of the performance]. That was the show that we did in the last school holidays. Yeah, so what they did was they had this big box and they opened up bits of the box and when they opened up the front bit of the box, they put umm, a, a, they used a blackboard and they put a little drawing of some wheels at the bottom of the box and then that prop became a train or a car and then they'd close another bit and they'd open another bit and they'd put umm, a flag on it and it would become a boat. So sometimes...
Issy:	....and a dog.
Julian:	and it became a dog at the end. Yeah. So sometimes you can use a prop a lot, lots and lots of different ways.

This extract illustrated that Issy was using the knowledge she gained from attending the theatre to assist her understanding of the definition of a technological outcome. Her input into the conversation indicated that she may have understood that the truck, as a prop, had multiple purposes.

This section demonstrated that students deployed knowledge gained through Passive Observation of objects and practices from home and community to assist them. Passive observation was that in which the observer was not involved two way interaction with the artefact, people or practices observed. Students also benefitted from knowledge gained through participatory engagement with artefacts. This is discussed in the section below.

Participatory Enculturation

The second sub-element of Funds of Knowledge involved being enculturated into an activity through engagement resulting in transferable knowledge. This engagement included active participation, where a child was involved in the activity, and peripheral participation where the child was on the periphery of the activity but able to engage in the activity through questions and conversation. In Year 6 there were four examples evidenced in the data and five at Year 2, as can be seen in Table 4.4. Gaining knowledge through Participatory Enculturation provided students with opportunities to know information their peers didn't and be involved in practices unique to their family and culture. Learning through these experiences appeared to provide them status or 'mana' (high status for Māori) within their peer group.

The data suggested that students brought learning from home, afterschool activities, and their community to assist them in understanding the character and function of props. When researching props much of the information the Year 6 students came across was from the United Stated of America. In the extract below Alan explained to the researcher how he knew the symbol ″ stood for inches. He cited the reason for knowing about this symbol (not taught in New Zealand schools), through his active participation in War Gaming on the computer. He also indicated that the knowledge may have come from his father.

Alan: Oh, dimensions.

Minnie: Yeah.

Alan: 13, one slash two.

R: 13 and a half something. What does that mean?

Alan: Inches.

R: How do you know that, Alan?

Alan: The two things?

R: Yeah.

Alan: It's like probably, I just know that from my father (unint.)…

R: But how did you know there's, you said inches. I can't see inches anywhere on that.

Alan: It's those two things. That's what inches is.

R: How do you know that?

Alan: Umm, because I do war gaming and that's what they use for inches

R: Okay, right. Good. So the little, two little things means inches. How big is an inch?

Alan: Like, that big [indicates an inch with his fingers - researcher notes]

R: Right. So you need to perhaps write the dimensions down.

Dougal: 13 and a half inches.

Alan: So it's probably about that big.

The above extract illustrated how drawing on information gained through participation assisted in understanding and interpreting information relating to research in another area. It is a requirement in technology to interpret designs of others; this extract demonstrated Alan's ability to interpret a symbol of measurement not used in his school environment but one that he used in his home environment.

The Year 2 students also deployed knowledge gained through Participatory Enculturation from their community and culture to assist their understanding of technological outcomes associated with the unit. Evidence of Participatory Enculturation occurred very early in the props unit. As a part of the project the students were given a disposable camera so that they could record their process of developing a prop. The students' first task was to ask a friend to take their photograph so that the first photograph in each camera was that of its owner. Moke was concerned that her camera was broken as this was her first experience with a non-digital camera, however David was able to reassure her as he had experienced how the photos are released.

Moke: Wendy my camera is broken.

R: What makes you say that Moke?

Moke: I cannot see the photograph inside the camera.

David: Oh, it's ok, you just take them to The Warehouse and they hit them with a hammer and the photos jump out.

R: How do you know that David?

David: My Dad had one and we went to The Warehouse and that's what they did (WF-T Field notes 26 Aug'09).

This conversation illustrated that knowledge gained through Participatory Enculturation gave David the confidence and status to reassure his classmate that her camera was not broken. It demonstrates that use and knowledge of technological devices gained from home and community assist students' confidence in their use.

The extract above demonstrated that students bring knowledge from experiences from home and the community to help make sense of and connections to learning in the classroom. Students at both levels deployed the knowledge they had gained from their home and community through Passive Observation and Participatory Enculturation to assist their own and others' understanding in the classroom, to contribute to their understanding of technology *in situ*.

In summary, in order to assist in the process of making sense of the physical and functional features of technological artefacts, students drew on knowledge from their homes, community and cultural background and practices. This knowledge was gained through indirect means – Passive Observation and direct means – Participatory Enculturation.

4.3.3 Making Connections and Links

Schooling is a cumulative business with students' revisiting key concepts in more and more complex forms as they progress. The New Zealand school curriculum is divided into eight disciplines of knowledge or learning areas. In order to situate learning and to assist students in their understanding, teachers need to make explicit links and connections to prior school based learning and experiences they know their students have already undertaken. This section differs from the Funds of Knowledge section, as the connections made are to school based learning as opposed to learning from home and community which are not specifically taught through the school curriculum. The data illustrates that teachers and students use prior school based learning to assist their current learning when planning their technological outcomes.

Teachers and some Year 6 students made explicit links to prior learning in other school based academic disciplines, and teachers frequently used direct or indirect connections to assist student learning. There were three sub-elements in the Making Connections and Links element at the Character and Function stage of the unit. These were teacher directed links to physical prompts of either real artefacts or images of artefacts (Physical Prompts); knowledge from other disciplines (Knowledge - Other Disciplines) and links to school based learning in technology (Making Temporal Connections).

In Year 6 there were 64 instances of connections made to school based activity within the three sub-elements: 30 examples of Physical Prompts, 25 examples of Knowledge - Other Disciplines and nine instances of students Making Temporal Connections. In Year 2 there were 23 instances in only two sub-elements: Physical Prompts with 14 examples, and Knowledge - Other Disciplines with nine examples. Table 4.5 summarises this data and indicates that the use of physical prompts and knowledge from other disciplines occurred more frequently at Year 6 than at Year 2. This is not necessarily a true indication of results as in the first two lessons the students were combined but included in the Year 6 data.

Physical Prompts

During the unit, both teachers used resources or images of resources to prompt and scaffold student learning. Physical prompts included video clips, pictures, slides of images, actual prop artefacts and specifically selected internet sites. The

Table 4.5: Summary of Making Connections and Links Conversations

Sub-elements and sub-sections	**Year 6**	**Year 2**
Physical Prompts- real artefacts or images *Definition of Prop* *Role of Props* *Desirable Attributes*	30	14
Knowledge -Other Disciplines *Student Deployed* *Teacher Initiated*	25	9
Making Temporal Connections	9	0
Total	64	23

prompts assisted students' learning and allowed them to visualise new information. The evidence suggests that the teachers employed specific prompts to assist student understanding in three aspects: defining prop, the roles of props and desirable attributes of props. Each of these is discussed and illustrated with one example in the sections below.

Definition of Prop

In the early stages of the unit both the Year 6 and Year 2 classes were combined for two lessons. Both these lessons relied heavily on prompts. In the first, students were shown a video of a stage show that had occurred in the school hall earlier in the year. Later in the same lesson, students were shown an extract from a well-known movie in which a stage show occurs using a range of props. These examples included artefacts *in situ*, that is, props being used in a stage show. In the next lesson, students were shown a range of actual props used by a local theatre company. Julian, the Props Manager, brought a range of props and explained rather than demonstrated how the props were used. The props Julian brought with him were a range of artefacts all used as props by his theatre. These activities assisted students in the initial stages to understand what a props was. The extract below is a small portion of Julian's talk as he explained three of the props he brought. It demonstrates Julian's focus; that some props are real artefacts, some are adapted for a different purpose, some are humanised (made to behave in a human like manner), for example a puppet talking hammer, and others are fake.

Julian: So what I've done is I've brought a few different ones [props] to show you the different ways that we can do props.........So first of all some props are nice and realistic. We've got here, a nice metal bucket. It's actually made of metal. It's reasonably heavy but it's got a, a handle that moves. So if there is a play where people need a metal bucket, we've got one for them, but it depends on when the play is set and where it's set. Thousands and thousands of years ago, you couldn't have a metal bucket because they hadn't figured out how to put metal into different shapes yet. So you might have to have a wooden bucket.

Some props, you could actually use for different things. Like, we had here, a coconut which we cut in half and then the prop can also be used backstage as a sound effect for horse's [feet], (Figure 4.2).

Figure 4.2: Coconut Shells

Another one, this is, this is one of my favourite ones. We did a kids' play which had a magic hammer, so they made this sort of giant hammer and they made a little bit where you can reach in at the back and the hammer becomes a puppet.

Julian also went on to talk about why a fake banana and knife with a retractable blade might be used. This extract illustrates the use of actual artefact prompts to assist students' understanding of the characteristics and function of props.

Three activities: two movie clips and the visit, illustrate examples of artefacts being used as prompts to assist student learning about the definition of props. Through the use of specific prompts the students were able to identify what props were. They also learned about the role they play on stage.

Role of Props

The teachers also used images of props to assist students' understanding of the role they play in locating a scene historically, culturally and geographically. This was illustrated in a Year 6 activity in which students Minnie, Dougal and Alan, with their teacher Clara analysed a range of prop images to identify whether each prop was a good or bad example, and how and why this was so. In the first extract the students are studying a picture of a cart, set on a stage. With prop images students were able to locate the scene historically.

Clara:	So the cart this time. How is it easily recognisable for someone sitting in the audience? Does it look like a cart?
Dougal:	It looks old.
Minnie:	It looks a bit like a western.
Clara:	It does look a bit like a western one. You're quite right. The pioneers sort of going across the plains.
Alan:	It could be like umm, for holding prisoners.

Minnie's recall came from Funds of Knowledge peripheral engagement as 'a western' is a genre of television and movie that is based in the early pioneering days of the mid-western states of the United States. The prompt assisted Minnie's deployment of Funds of Knowledge which enabled her to develop an understanding of the context of object and how such an artefact may be used as a prop to locate a scene historically.

Having established an understanding of the definition and role of props, teachers turned their attention to the identification of desirable attributes of props. Again they used the artefacts in the three activities to prompt students learning in this area.

Desirable Attributes

The teachers also assisted students' learning about desirable characteristics of props. In the initial combined lesson both classes watched a video of a stage scene in the film 'Hook". The teachers replayed the extract from a movie stage-play in sections, to help the students' identification of the key attributes of props, and this is illustrated in the extract below. Clara questioned the students about the props they saw. Debby answered initially, then Moke also contributed.

Clara:	What props did you see? What was the end thing?
Debby:	Oh it was a little thimble.
Clara:	Yes it was a little thimble. Do you think the people in the audience would have been able to see that little thimble under his finger?
Moke:	If it was gold.
Debby:	It was all shiny.
Clara:	Might have. So you think that people in the audience needed to have some prior knowledge though, of the story of Peter Pan to know what that might have been on his finger?
Moke:	Yeah, because if you were in the audience, I don't think you'd be able to see that.

In this extract Clara used the movie extract prompt to help the students understand that props need to be large enough to be seen by, and recognisable to the audience. In later lessons the students and teachers constructed a list of attributes for props, and size was listed by both Year 6 and 2.

This sub-element illustrates how prompts used by the teachers can assist students' learning when establishing an understanding of the character and function of props. Following the combined lessons, students worked in their own classes building on knowledge they learned in the introductory lessons. There are no clearly identifiable differences between Years 2 and 6 in this sub-element possibly because of the initial combined lessons. Another feature of learning in the Making Connections element was the use of knowledge drawn from other school academic disciplines. This is discussed in the next section.

Knowledge - Other Disciplines

Teachers and students also drew on prior knowledge from, or made connections to other disciplines to assist their learning. In Year 6 there were 25 examples and at Year 2 there were nine examples as seen in Table 4.5. At times students deployed relevant discipline knowledge without articulating that they were doing so, and at other times teachers made these links explicit. In Year 6, the students and teachers regularly drew on knowledge from other disciplines. The Year 2 students and teachers also drew on knowledge from other disciplines: science, drama, social studies, English, maths and visual art.

Student Deployed

The first extract demonstrated use of student deployed knowledge from mathematics. Mandy and Jay drew on mathematical knowledge as they attempted to read absent Teddy's research notes about the dimensions of radio speakers and the distance between the speakers. This was necessary as Teddy was absent from school at this time.

Mandy:	Twenty centimetres? No it's 50 centimetres. I can't read Teddy's writing. So 50 centimetres across.
Jay:	So that must be.
Mandy:	That's 50 centimetres in between. That's 20 centimetres [points to one measurement] and that 40 centimetres [points to the other].

In the above extract, Teddy had previously used his mathematics skills to record measurements on the drawing to assist the group's interpretation of an existing prop. Mandy used her mathematics knowledge to recognise that the numbers and abbreviations (cm) were related to the drawing dimensions. These students independently drew on knowledge learnt from other disciplines to assist their developing understanding of the character and function of props.

Teacher Initiated

Two extracts demonstrate the Year 2 students' knowledge of drama. Deployment of this knowledge was initiated by teachers. Demonstrated in the first extract was the role of props in a play. The students watched a video of a performance from a local theatre. They demonstrated knowledge of drama by recognising the role props play in a production. Fleur asked the students, Anne, Rex, and Gabriella about the role of props.

Fleur:	Why have props in a play?
Gabriella:	Because they wanted the play to be exciting.
Anne:	Because in The Magic Island, because if they didn't have the props it would be called the School Hall Island [where the Magic island play was performed to the children]…
Rex:	Because it'd be nothing.

These students demonstrated knowledge of drama by identifying the role props play in a production. In the second extract Anne demonstrated her understanding of drama knowledge when asked to explain how props in their play will reflect Taiwanese culture. In her conversation with the researcher (R) she understood that props influenced the audiences' ability to locate the play in a foreign land.

R:	Anne and Ellis are going to be talking about how the props tell you that the story is set in Taiwan and not in New Zealand?
Anne:	Well, the props will look like Taiwan stuff, not New Zealand stuff.
R:	Well, you tell me what Taiwan stuff is.

Anne: Well, there'd be, just, there would be a flying fish and not in New Zealand, you don't normally get flying fish because we don't have that much warm water in New Zealand.

This extract demonstrated that students can draw on knowledge from other disciplines. Sometimes the links are made by the students without specific instruction or assistance and at times they are overtly facilitated by the classroom teacher. Employment of knowledge from other curriculum areas occurred almost three times more often in Year 6 than Year 2. The students in Year 6 were more likely to initiate this deployment but in Year 2 it was mostly initiated by teachers. The students also made connections to prior learning in technology as discussed below.

Making Temporal Connection

'Making temporal connections' describes connections made to prior learning in technology education. It draws on generic technological knowledge as well as context specific knowledge. In this initial stage of the unit, Year 6 students made explicit prior learning references to assist their understanding of the place and purpose of a specific technological outcome on nine occasions, as seen in Table 4.5. There were none at Year 2. Some references were to the previous unit and some to lessons previously undertaken in the current unit. The data suggests that students identify links to prior learning in technology to help themselves and each other to make sense of their current learning. In both extracts provided, an adult was a part of the conversation but the prompt to prior learning was instigated by the students. In the quote below Shelia, Year 6, made an explicit link to the process she had undertaken to design the space station while searching for examples of props on the internet: "That's what we did in our spaceships except we didn't varnish it". She noticed that some were made of papier-mâché and painted, and was therefore able to recognise a common process used.

In summary, throughout the first phase of this unit, teachers in both Year 2 and Year 6 facilitated students' learning through the use of physical prompts including artefacts, images and videos. Students from both levels also deployed relevant knowledge from other disciplines to assist their learning in technology. In Year 6, students also made these connections for themselves, and with each other, to learning from the previous technology unit and the early lessons in the current unit.

4.3.4 Management of Learning

A number of learning strategies were purposefully implemented during the unit to develop the students' thinking skills and their understanding of the character and function of props. Management of learning is a term used by teachers to identify the strategies implemented to maximise students' learning during their time at school, included assisting students to develop higher level thinking skills and facilitating their critical analysis. It also included strategies to determine what the students already knew and to ensure behaviour did not disturb their own or other's learning. Management of learning also included actual transmission of knowledge when appropriate, from either the teacher or external "experts". Also, at times specific strategies were designed and implemented to facilitate student thinking and dialogue about the physical and functional nature of technological outcomes.

The data, summarised in Table 4.6, revealed that at Year 6, 102 key conversations were identified in seven sub-elements. These include: teachers giving students explicit information they needed (Transmission - 29) and asking questions to challenge students' thinking - both inferential questions and higher order thinking (Higher Order Questions - 27). Teachers also used questioning at a lower level to extract predetermined answers from the students (Drawing-out Predetermined Answers - 22). The data also revealed that students managed their own and peers' learning through instructing, challenging each other and giving positive feedback (Peer Discussion - 16). The teachers managed students' behaviour (Managing Behaviour - 3). An external expert was brought in to help students identify with props and their functional relationship with actors (External Expert - 3). Two of the identified key conversations at Year 6 involved the giving of direct instructions for a subsequent activity (Organisation of Learners and Strategy Set-up - 4).

Table 4.6: Summary of Management of Learning Conversations (including combined lessons in brackets)

Sub-elements and sub-sections	**Year 6 (comb.)**	**Year 2**
Transmission *Important Facts* *Instruction and Organisation of Learners*	29 (1)	6
Higher Order Thinking	27 (4)	10
Drawing-out Pre-Determined Answers	22 (7)	8
Peer Discussion *Student to Student Instruction* *Intercognitive Conversation*	16	4
Managing Students' Behaviour *Redirecting* *Positive Reinforcement* *Clearly Focused Viewing*	3	8
External Expert	3(1)	2
Specific Learning Strategy	2	4
Total	102	32

In Year 2, categories were the same as in Year 6. The data revealed that at Year 2 32 key conversations were identified using seven strategies. There were ten examples of Higher Order Questions, and eight examples of Drawing-out Predetermined Answers. There were four conversations in the Peer Discussion category and eight examples of conversation to Managing Behaviour. There were four instances of peer discussion at Year 2 with two extracts in the External Expert category, and there were four instances when the teachers specifically set up learning strategies (Organisation and Learning Strategy Set-up). In the sections below results for each of the above categories will be presented.

Transmission

Transmission, the direct telling of information, played an important part in teaching for both year levels. In total, across both levels there were 36 instances of transmission, 29 at Year 6, six at Year 2 and one in a combined lesson as seen in Table 4.6. In Year 6, 28% of the key conversations in Management of Learning were direct transmission of knowledge and facts to the students at this early stage of the unit. In this sub-element three types of information were given to the students. The first was straight knowledge and facts (Important Facts), the second was explicit instructions, and the organisation of learner (Instructions and Organisation of Learners). Each is explained and illustrated below.

Important Facts

In the early stages of the unit, the students were specifically told what props were by Julian the props manager from a local theatre company. He played an important part in developing the students' concepts about props with the direct giving of information about props. Below is another segment of his talk to the students which demonstrates the transmissive nature of his presentation.

> So props are really, really important in plays because without them the actors would all be sort of miming and when you're miming, you're sort of pretending that there are things there that aren't there. You can bring props from home. Sometimes you can make your own special props.

The information given to the students in this manner was then taken further, and developed through a number of different teaching strategies undertaken in individual classrooms. This is significant to technology education because input from community experts is critical for students to build an understanding of the authentic nature and context of the technical outcomes are they developing.

Instructions and Organisation of Learners

The second form of information given to the students through transmission was to set up learning activities and to give the students instructions on what they were to do. This is illustrated below with two extracts, the first from Clara the Year 6 teacher and the second Fleur the Year 2 teacher.

Clara: Yeah. Just pop up your hand up if you've got something to say. Alright, we need to think about what, what makes a good prop, alright. So you're going to go and in your topic books, I want you to put, write a good prop in the middle and you need five things, five things around the outside that you believe make a good prop. Okay, so just really quickly. So go quietly to your desks. Yeah, topic book because that's the topic that we're working on.

Fleur: What you're going to discuss in your groups, you're going to discuss what was used on the stage for the production. Okay. And you're looking at the backdrop. You may be looking at what sorts of costumes they had on. Okay. So you're going to discuss and then, with your group, and then we're going to have another look and then we're going to go off into our groups again.

Transmission is a method used by teachers in classrooms to ensure students have heard and hopefully know specific information. Transmission does not necessarily require or demand a high level of engagement from the students, however, the next sub-element - Higher Order Thinking - does.

Higher Order Thinking

Table 4.6 shows us that there were 41 instances of higher order thinking recorded in the data. The data suggests that teachers challenged their students' thinking through inferential questions and other higher order questions and activities. The aim of higher order questioning was to get students to think beyond the obvious and to challenge their understanding. This was illustrated in the following quote which occurred after the students watched the video of a stage production performed at the school earlier in the year, when Fleur asked her Year 2 students "What special skills do you think the people needed who made The Magic Island props?''.

Higher Order questioning was also used to assist the Year 6 students engage with reference material provided. These students were using the internet to identify possible props from the Olympic Games era of 1896 to 1936. This questioning sequence with the Researcher facilitated a conversation with Mandy, Teddy and Jay, about the difference between costumes and props.

R:	What have you found out?
Teddy:	Oh, the fashion.
Mandy:	They've got really long dresses and they've got lots of ...
Jay:	And they usually carry something like umm...
Teddy:	Yeah.
Mandy:	A parasol.
R:	So would that could be a good prop, couldn't it?
Mandy:	Yeah.
R:	Because the dresses are the costumes but the umbrella?
Mandy:	Is the prop.
R:	And the feathers, are they props
Mandy:	No. Because they're on the hat. So that would be part of the costume.

The purpose of students' learning to define the function of objects was to assist them in the identification of objects that would make suitable props for their play. Other questioning sequences assisted the students' understanding of the relationship between props and era. The probing strategy occurs when students' answers are accepted but challenged through asking for more, indicating to the students that there are other things not yet mentioned that they needed to consider. Accepting an answer to a question does not signal agreement. Teachers can accept but not agree with a student's response. Probing includes challenging and redirecting students' thinking to assist them in the development of ideas. This is illustrated in the following extract when the Researcher spoke to Minnie, Alan and Dougal, to assist the students' understanding of the difference between real and replica objects.

R: Those are actual photos of, not replica ones. What's the difference between those ones and the replica ones?

Alan: Umm, replica ones are like, remade sort of.

R: Minnie, what do you think?

Minnie: Umm, materials. with.. arh yeah... That's retro colours and stuff like that.

Alan: The clothes.

R: Okay, yeah, and Dougal what do you think?

Dougal: Umm, like it's like a clone, like...

R: So tell me what you mean by a clone?

Dougal: Like, like kind of umm, like ......

Alan: Not the real thing.

Dougal: Yeah, like yeah, fake, yeah.

R: So umm, can you go back one? [indicating visited websites on the computer] Can you just go back to that previous search? Just that, that umm.

Minnie: The retro.

R: The second one down. Have a look at that. Or just even there it all tells you. Like, okay, that's got, it says there, an antique replica radio with a CD player. Now, there's something that makes that a replica as opposed to those other ones. Do you think that in 1936 a radio would have a CD player?

Alan, Minnie, Dougal: No.

Alan: Oh, they've added something to it.

R: Okay. So does this work?

Alan: Probably.

Dougal: Yeah.

Dougal: It just looks like an old radio but inside it's actually got modern….

Alan: Stuff.

Dougal: Yeah.

This extract demonstrated that by continuing a questioning sequence, through accepting answers and probing students for further ideas, the students were also exposed to a number of ideas from their peers and came to understand what a replica was.

In order to develop authentic technological outcomes that meet specific identified needs and opportunities, technologists need to be able to critically analyse existing outcomes. The above extract illustrates how a specific strategy, aimed at the development and implementation of critical thinking skills, assisted students' understanding of the character and function of props. This section illustrated how teachers were able to use a variety of questioning and conversation techniques to assist students. At other times, teachers just need to check that their students know certain facts. Rather than telling them directly, they question the students with the aim of hearing a pre-determined answer.

Drawing-out - Predetermined Answers

There were times when teacher questioning directed students to a predetermined answer the teacher sees as critical for learning and doing. The data suggested that the teachers often did this, with 37 instances recorded in the data set (see Table 4.6). Students were questioned until the expected answer was received, at which point the questioning sequence stopped. In the next extract Clara needed to know that the students understood the role of technological outcomes that they were being asked to develop for their school production. This questioning sequence occurred when the students from Years 6 and 2 were combined. In a number of cases the researcher was not able to identify the individual child (UC) who answered.

Clara: Do you have any other props that you saw? Jake.

Jake: I think I saw a, the curtain in the backdrop.

Clara: Yeah. It had quite a strong backdrop, didn't it? Where do you think the stage play was set? What did it look like? What did they make the stage look like?

UC: [a bedroom]

Clara: Good girl. It looked like a bedroom, didn't it? What helped it look like a child's bedroom?

UC: Beds.

Clara: Beds.

UC: [toys]

Clara: Cool. There's toys sitting on the floor like little boys do in his bedroom. What else? Can you think of something else that's in there?

UC: Curtains.

Clara: Yeah curtains and things that it looked like a child's bedroom.

UC: Drawers and (unint.)…

Clara: Cool, so all the extra bits and pieces that you might have in your bedroom at home. So if you're looking at those sorts of things, what does it help the audience know? What do the props sort of help with? Jake.

Jake: Where it is.

Clara: So where the story is set. So we don't want the actors to sort of have to say where they're, where they are during the play so it helps with those.

UC: What its about.

Clara: What do you mean?

UC: Like, umm, like the story's in the child's bedroom.

Clara: Cool. So it helps with, with the actual story, that it's about children.

UC: Yeah.

Clara: Good. That's probably a key thing, actually. You're all doing really, really well.

Teachers often questioned students with the aim of extracting a predetermined answer. This occurs so that teachers can check that students have specific knowledge required to continue with their learning in a specific context or curriculum learning area.

Peer Discussions

The next sub-element in Management of Learning is Peer Discussions. In total 20 instances of peer discussions were identified as significant, as indicated in Table 4.6. There were two divisions in this sub element. The first, Student-student Instruction, was when students instructed their peers as to what was required of them, and the second was Intercognitive Conversation. This conversation led to new understandings for all the participants. These differ from the physical prompts discussed earlier because these conversations do not have a physical prompt to assist learning.

Student-student Instruction

The data showed that students assisted each other to ensure they were on task and were doing what was required of them. This sometimes included a comment to refocus group members on the activity at hand or assisted students when they were having difficulty. In the extract below Teddy assisted Jay in a Google search on the internet; Mandy also assisted.

Teddy: Bring that down to the wording. No, no, no, bring that down on to there [instructing Jay by pointing finger at screen]. Oh no.

Mandy: It's not going to work. You're going to have to (unint.)… it.

Teddy: This down and that one then just click and it should. We'll do all the layout later. It doesn't matter. Just, ohh, and just go double click. Double click that. Yeah. Open. Yeah, that's right. Bring that one down. Now we've got it. [new screen pops up]. No, I don't reckon we need that Jay, It's Olympics.

Mandy: Paris, 1900.

Teddy: Maybe go into Wikipedia. Wikipedia's pretty good. Exit this and go to Google. No, exit it. Yeah. Go to Google and then go

Wikipedia. There's Wikipedia in there. Wikipedia. Yeah, click that.

Mandy: Aren't we on Google anymore?

Teddy: No we've moved onto another place to look stuff up.

This extract illustrated that the students were able to assist each other when working collaboratively at one computer. In the next extract, Minnie mentioned 'she' and referred to the classroom teacher and the instructions given to the students at the beginning of the activity. Minnie and Dougal discussed the best avenues for research.

Minnie: What kind of, shall we search like the medals that they won? "She" said just do the era.

Dougal: 1936 gold.

Minnie: No Olympic, just Olympic medals.

Dougal: Medals.

Minnie: Because we don't know, just do Olympic medals, not gold.

The establishment of clear understanding of the characteristics of technological outcomes was a vital component of technological practice. The above extract illustrated a conversation which was collaborative in nature and assisted the students' identification of the required task, through articulating their ideas and reiterating the requirements of the task given to them by their teacher.

Intercognitive Conversation

Intercognitive conversation describes conversation in which all participants listen, and take ownership of what the others say and subsequently employ the new knowledge to move their understanding forward. In the first extract Minnie, Alan and Dougal were at a computer and discussed what they were going to search to ensure they were clear about their end goal.

Minnie: What are we doing this for? We need to find out what kind of props, kind of like colours and stuff in the 1936, or 1896 to 1936.

Dougal: Delete, delete, delete: 36. Olympics. Search.

Minnie: We're not searching the Olympics though. Oh, are we?

Dougal: No. We'll just do it, play props. Yeah, and that goes to 1936.

Minnie: We need to search 1936.

Alan: No, we don't want Nazi Olympics.

Minnie: We need to search, guys, we need to search 1936, you know, like things for our play, you know, like we could like, 1936 radios or 1936 Olympic gold medals, Olympic medals or something like...

Dougal: Let's look at radios.

Alan: Yeah.

This extract illustrated how dialogue assisted in the clarification of ideas which culminated in the students determining the direction of the internet search. Minnie, Alan and Dougal all contributed to the group which enabled them to understand that more specificity was needed in their searching and that a radio might be potential prop. Intercognitive conversations assisted the students in making sense of the era in which their designed objects needed to be situated. A form of assistance that teachers offered to their students was the management of their behaviour. This is discussed is the next section.

Managing Students' Behaviour

One of a teacher's significant responsibilities is to manage student behaviour to ensure they are on-task and not disrupting their own or other's learning. Table 4.6 indicates that in Year 6 three instances were recorded and in Year 2, eight. The data presented in this study was not an encompassing data set which explored, or even identified, all the behaviour management strategies used during the study. It merely offers a small insight into the fact that behaviour management was an aspect of managing learning in the classroom. A number of strategies were employed by the teachers to manage students' behaviour; these included redirecting students' attention back to learning, using positive reinforcement and ensuring students were very clear about the purpose of an activity such as watching a video.

Redirecting

In an interview with the researcher the Year 6 teacher mentioned that she had done a lot of work with the class building their independence and their ability to work without close monitoring. The data bore this out. The comment below was typical and aimed at redirecting the students back to their learning. Alan became distracted by information on replica technologies he came across while searching for information on radios from 1896 to 1936. The researcher redirected the group to investigate radios from other dates so that they could be better informed for the designing phase of the project.

R: Okay, so just keep on, what differences you can get across the era because you've got, it has to be something that encompasses all of those eras. You're not just one era. So you're going to have to design a prop that's going across those eras.

This extract illustrated that teacher redirection assisted to focus students' attention back to learning.

Positive Reinforcement

Another strategy for managing student behaviour used in the classroom was the use of positive reinforcement. The comment below typified this. Dougal often doubted himself and his ability during this unit. As a participant researcher in the role of the teacher, this researcher made specific point to compliment Dougal on this skills and knowledge: "You've got fantastic research skills, Dougal". Although not specifically assisting learning in technology, the development of positive self-esteem can assist students' motivation and learning.

The Year 2 students did not work independently on their research like in Year 6, rather did it as a whole class with their teacher. This meant that much of the behaviour management occurred while the students were working as a whole class sitting on the mat. This is the case for the extract below in which Fleur used praise to engage and encourage Adam. They had just watched the video of the "Magic Island" replay and Fleur is ascertaining what the students picked up from the viewing.

Fleur:	What did the magician need to help him?
Adam:	He needed a ball.
Fleur:	Oh, you're fabulous. He needed a ball. Why did he need a ball, Adam?
Adam:	So he can see in it.
Fleur:	And what, fabulous. Say it in a big, loud voice. Be confident in what you're saying. I like those people listening. Why did he need the ball, AJ? Why did he need that big, special ball?
UC:	Umm, to see [Another child attempts to answer]…..
Fleur:	I'm asking Adam. Why did he need the ball?
Adam:	To see where the guy was going
Fleur:	Yes, and to see the, see the what? See the fu...
Adam:	Future.
Fleur:	Future, good boy.

Fleur not only praised Adam for his answer, she also stopped another child from butting in, signalling to Adam that she was interested in and waiting for his next answer.

Clearly Focused Viewing

Before the students watched the video, Fleur gave them a clear focus to assist their viewing and ensured the students were arranged on the mat so that they could see clearly and were not in the way of the equipment.

Fleur: This is our Technology Unit with Room 16, to recognise props used in the stage show and that's what we have done. What we are going to do, is we are going to watch this twice. We've got three questions to think about when we watch this. The first one, what was the story about? Who are the main characters and what do they do?

The above extract demonstrated how the Year 2 classroom teacher endeavoured to ensure the students had a clear focus when viewing the video and that they were organised in a way that maximised the planned learning experience. Another strategy employed by the teachers in this study was to bring in an "external expert" to assist students' developing understanding of the character and function of props.

External Expert

An external expert played an important part in this unit as it helped the students understand that prop development was an authentic activity. Table 4.6 indicated there were six examples considered. Fleur explained to the students that the props manager from a local theatre was going to visit both classes the following day, "one of the managers from the Cabonet Theatre (pseudonym) [is coming tomorrow] and he's going to come and talk to us about props". This quote is also an example of transmission, giving of direct information to the students to ensure they are prepared for the following day. It evidenced that the teachers identified that it was important that the students knew he was coming and that his role was an important part of the whole technological outcome development. In this case Julian presented students with factual information about props illustrated with a range of examples.

Julian: I've brought in a few of the different props that we use in our different shows at the Cabonet Theatre to show you the different sorts of things that they've got there....

The teachers planned for and implemented engagement with a community expert to assist the students in the construction of their conceptual, societal and procedural knowledge of props. Several other new learning strategies were also introduced to the students in this study.

Specific Learning Strategies

A number of new learning strategies were introduced to the students, with the aim of developing a higher level of understanding about the character and function of props. This sub-element overlaps with Transmission, as the students were given instructions for activity engagement and Higher Order Thinking as these learning strategies were aimed at assisting the students' higher order thinking using "props" as a context. Table 4.6 indicates that in Year 6 two examples, and in Year 2 four examples were selected to illustrate this sub-element.

In Year 6, one of these activities included the students looking at pictures of props to identify whether they met the five attributes of props co-constructed as a class earlier in the lesson. This activity was modelled to the students using the picture of a crown as an example. This extract shows Clara giving directions of the activity and stating her expectations of requirements.

> Clara: Alright. So you are going to get one of these sheets each [shows the students the required worksheet]. Now, I would expect to see five annotations out the side. One thing about each of those things. So how, we talked about the crown in detail. You should be able to do that nice and easily but if you go through this taxi cab, how is it easily recognisable? How is it durable? Safe? Culture specific? Ergonomically designed?

This extract illustrated the planned activity and how the teacher set the activity up to assist her students in its implementation. Conversations in this sub-element specifically set up new learning strategies for the students to help ensure their engagement and higher-level thinking. This is critical to successful teaching. The activities themselves require thought and reasoning beyond what is obvious or concrete, thus facilitating students' thinking at a higher level.

In Year 2 the researcher, in the role of teacher, set up an activity in which the students were given a statement with which they had to agree or disagree, and then justify their answers. The activity facilitated student engagement in reasoning and higher level thinking about the character and function of props. The extract also illustrated the use of 'Talking Partners', a learning conversation strategy aimed at assisting students to articulate their thinking to a specific class member who is deemed a 'talking partner' and defined as a person with whom learning can be discussed.

R: What I'm going to get you to do, I'm going to talk to you for a minute, so you just need to listen. I'm going to make a statement. I'm going to tell you something and then I'm going to get you to talk to your talking partner. I'm going to ask you, I'm going to say something and you're going to talk to your talking partner and say whether you agree or disagree. Some of the things I say to you might be true and some of the things I say to you might be not true. Now, remember I might be telling lies or I might be telling the truth and you have to decide whether you agree or disagree. Now, I want one person to say it, to talk at a time, to their partner. So I would like you to decide who's going to go first. Alright. You've decided. Who's going to go first in your partner?......Right, I'm just going to ask anybody, so I want you to think. I'm not just going to ask everybody with their hands up. I just want you to umm, tell me you're you were saying. Emma, the people in your group. What were they thinking about that statement? (Long pause). Did they agree or disagree? Who's your partner, Emma? Ellis. Did Ellis agree or disagree? He agreed. Why did he agree? There's no right or wrong answer. I just want to know.

This activity assisted the students' understanding of props and the teacher gained insight into students' learning in technology. The following extract illustrated Fleur's enhanced understanding.

Fleur: And the other thing that surprised me was, instead of asking questions, asking them a statement and makes them think about why they've chosen that answer.

R: Can you explain what we did there?

Fleur: For example, when we looked at good and bad props after the Cabonet Theatre, we said, this is a statement and the children had to agree or disagree and tell us why they agree or disagree and that enabled us to see how they think in technology.

The main purpose of the early lessons in the unit was to develop students' understanding of the character and function of props. Teachers in this study did this using a number of strategies to ensure students developed a clear understanding of the character and function of props. The extent to which this was achieved is illustrated in the students understanding of the conceptual, societal and procedural technological knowledge.

Relevant technological knowledge includes identification of key attributes of technological outcomes, in this case props, and the understanding of functionality and its relationship to materials. Throughout the initial lessons of the unit, teachers took opportunities to check students were developing the key knowledge and skills around the character and function of props. Both groups of students were specifically introduced to strategies to engage higher thinking. Year 6 students continued to use these strategies independently, whereas Year 2 students undertook the activities with considerable teacher input. The same trend as above continued for the drawing out of predetermined answers. The researcher suggests that some difference between the two year levels can be accounted for through the way data were collected. Not all aspects of the entire unit in each classroom were recorded, and the researcher suspects that some whole class teaching at Year 2 that was not recorded did in fact include this method of questioning. One other notable difference between Year 6 and Year 2 was the number of instances of peer discussion. The Year 6 students previously had a focus on working collaboratively and co-operatively during the year and were given multiple opportunities to discuss ideas in their groups. Working co-operatively in teacher determined groups was a newly introduced skill for the students in Year 2. This may also have accounted for the greater number of instances of managed behaviour at Year 2 than at Year 6. These were the main discernible differences between Year 6 and Year 2. Other differences reported were only minor.

4.4 Technology Knowledge and Skills

During the first stage of the unit the students began their learning journey by building up an understanding of the character and function of props. It was critical for students to have clear conceptual, societal and procedural knowledge before they undertook any technological development. As suggested in Table 4.1, the evidence shows 17 examples in which the students gained knowledge and skills at Year 6; these came in two sub-elements. The first with 15 examples, was evidence that the students understood attributes of props for a stage play - this was related to characteristics of a technological outcome (Attributes). The second sub-element was the role and place materials play in the production and function of props (Materials - Role and Function), with two examples.

In Year 2, excluding the initial lessons which were combined with Year 6, there were 11 examples of recorded conversation that evidenced the students' knowledge in technology. The sub-element most significantly represented in this section was the recognition and understanding of the physical and functions attributes of props, with 10 examples (Attributes). One conversation identified the role materials play in prop development and function (Materials - Role and Function). Both sub-elements are discussed in the following two sections.

Attributes

The purpose of the initial stage of the unit was to develop the students' understanding of the character and function of props. This section of the unit culminated in the co-construction (with the whole class and classroom teacher) of a number of attributes for the props students were about to develop. Building up a clear understanding of the nature of technological outcomes to be developed is critical to success in technology.

There were 15 references to prop attributes at Year 6 and 10 at Year 2. Following the viewing of two videos of stage plays, in which the students identified and discussed the props, and the visit from a local theatre's props manager, students returned to working in their own classroom and with their teachers co-constructed some key desirable attributes for props. At Year 6 the identified attributes were that props needed to:

- be durable to last through practice and multiple performances,
- be safe for the actors to use,
- be easily recognisable,
- be seen by the audience,
- be ergonomically designed,
- be era specific (Researcher Journal, 1 September 2008).

Attributes identified by the Year 2 students were as follows. Props need to:

- look like the real thing,
- be durable - hard and cannot break,
- be large so the audience can see them,
- be colourful,

- be light-weight so we can move them easily (Researcher Journal, 26 August 2008).

In Year 6, the classroom teacher assisted the students' understanding of attributes with an activity aimed at getting the students to recognise attributes in existing props. This was illustrated in the extract below, in which Clara had given the students a range of pictures of stage props *in situ* and asked them to identify which attributes each displayed. They did this activity in groups. The researcher approached Alan's group and inquired about their conversation.

R:	What are you talking about here?
Alan:	[what makes] good props.
R:	Okay, so you've written there, ergonomical. How do you know that that's, what makes you know that that's [pointing to picture of taxi] ergonomical?
Alan:	Umm, because they're [taxis] made to fit.
R:	Fit what?
Alan:	Made to fit the person that's going to use it.

In this extract Alan demonstrated his understanding of the relationship between a technological outcome and the human form or ergonomics.

The extract below evidenced the Year 2 students' emerging understanding of these attributes. In an activity the students were asked to agree or disagree with a range of statements about props. This was a specific learning strategy implemented to facilitate students' higher level thinking about the attributes of props. The students worked in their usual groups of three initially, then returned to the mat, when the extract below occurred. Both Clara and the researcher facilitated the conversation.

Fleur:	Jayne, do our props need to be durable? Agree or disagree?
Jayne:	Agree.
Fleur:	Why do you agree?

Jayne: Because if they break on stage they'll think it's boring if it broke.

Fleur: Elenora, do you agree or disagree that props need to be big?

Elenora: I agree.

Fleur: Why?

Elenora: Because the audience needs to see it so they know what it is.

R: Props must be always look real. Now, I want you to talk to your partner and tell me whether you agree with that or whether you disagree. She didn't? Okay. What was your, what did you think?

Debby: I disagree because our fish props didn't look real and umm, it didn't look real because it's got, like that some people's fish have got lumps on them and the other thing is that real fish won't be right next to each other.

R: Right, thank you. I like your, I like your reasoning. A pirate's eye patch is a prop. Do you, now, do you agree or disagree and I would like the other person in your group to go first.

The extract above illustrated that the Year 2 students were able to articulate some understandings of the attributes of props. Both extracts also illustrated that a specific activity designed to develop higher-level thinking, facilitated students emerging understanding of required attributes of props. The students also needed to understand the role that construction materials played in the character and function of props. This idea is explored in the next section.

Materials - Role and Function

In Year 6 there were two examples, and in Year 2 there was one example, indicating that students understood the significance of materials in the construction of props as seen in Table 4.2. In Year 6 the students discovered through their activities, and listening to their guest speaker, that materials played a huge role in the functionality of props. This first extract illustrates that what materials props are made from plays an important role in how props meet the identified attributes. The students were on the mat having explored a range of photographs of props. Clara, the Year 6 classroom teacher used open questions to assist the students understanding of the attributes of props.

Clara:	How does it look like it's ergonomically designed? How would that be comfortable?
Jake:	It's made out of wood.
Clara:	It's made out of wood. What it's made out of again. Materials are really important, aren't they? They keep coming up.

The extract illustrated that Clara had noticed and acknowledged that the students made frequent reference to materials when discussing desirable attributes of props. The next extract occurred when the students were working independently in their groups of three. This group had identified that an early 1900s radio was needed as a prop for the play. Minnie asks Alan and Dougal the other members of her group about materials used to make radios of this era.

Minnie:	So what kind of materials does it look like it has?
Alan:	Wood.
Dougal:	Wood.
Minnie:	Yeah.
Alan:	Wood, wood and more wood.
Minnie:	It's got wood. What else?
Alan:	Glass.
Minnie:	Yeah, that's with that one.
Alan:	Screws. durgh!
Dougal:	Umm, metal.
Alan:	Yeah, it looks like some brass or copper or something.
Minnie:	Yeah. Shall we put, shall we say copper?
Alan:	Yeah, that would look good.

This extract illustrated that these students understand the importance construction materials play in the development of props as they spend considerable time discussing the various materials used in existing props.

In Year 2 the students were not given a choice of construction materials or techniques as the classroom teacher had decided their props would be made from papier-mâché. This might have accounted for the low instances of reference to construction materials in Year 2 in the data. In the one example where materials were mentioned, the Year 2 teacher, Fleur, asked the students what props were used in the show the students previously viewed. Jayne and Adam appeared to confuse this question with 'What materials are used to make the props in the show?' It is relevant to note that the props manager did mention some construction materials in his talk.

Fleur:	Jayne, what props were used in this show? What sort of things did they need Adam, can you give me one thing that was used in this show, please?
Adam:	Umm, they used wood, no, not wood.
Jayne:	Yes, they did and plastic.
Adam:	Cardboard.
Jayne:	It is wood.
Adam:	It's wood and cardboard.

The above extracts illustrated an emerging understanding that materials play an important role in the functionality and characteristics of props at Year 2, and a more sophisticated understanding of the role and function of materials at Year 6.

In summary, during this stage of the unit most of the evidenced learning was that the students developed an understanding of a range of aspects to do with the character and function of props. In both years, the data and trends are similar. Most numerous was evidence of the students' developing understanding of the attributes of props, which was the intended purpose of the initial lessons in the unit. There was also some evidence that students were beginning to understand the role materials play in contributing to the character and function of props.

4.5 Stage 2: Planning

The purpose of the lessons in the 'Planning' stage of the unit was for students to develop a plan of their intended technological outcomes, in this case props for their class items in the school productions, one in the junior school and another in the senior school. In Year 2, these were stuffed and papier-mâchéd flying fish to support a traditional Taiwanese tale about a fisherman. In Year 6 the theme was Olympic Games from 1898 to1936. Two of the students in the class wrote the script for their section of the production, in which two radio commentators from the era discussed Olympic highlights. These were acted on stage as the commentary occurred. One of the two Year 6 participant groups developed a 1930s microphone and the other a 1930s standing radio. The Year 6 students also took part in planning their own practice to ensure their props were developed in time for the first dress rehearsal.

Again key conversations were classified and analysed in each of the four elements: Funds of Knowledge, Connections and Links, Managing Learning and Technological Knowledge and Skills, at both Years 6 and 2. This section discusses each element in turn, with identification of sub-elements and in some cases sections. Each sub-element concludes by noting the differences between Years 2 and 6. The section conclusion gives an overview of the elements and notes the differences with the same elements in the Character and Function stage.

4.5.1 Funds of Knowledge

While learning about and developing their own planning skills the students again brought knowledge from activities at home or in their community to their learning. In the Funds of Knowledge element, the same two sub-elements as in Character and Function appear: 'Passive Observation' and 'Participatory Enculturation'. These are summarised in Table 4.7.

Table 4.7: Summary Funds of Knowledge Conversations

Sub-elements and Sub-sections	**Year 6**
Passive Observation *Artefacts* *Processes and Procedures*	8
Participatory Enculturation *Parents' Occupation or Activity* *Design Features of Artefacts* *Family Social and Cooperative Skills*	8
Total	16

In Year 6, 16 key conversations were identified in the Funds of Knowledge element. Of these, eight were classified as Passive Observation and eight as Participatory Enculturation. Passive Observation was gained through watching but not engaging with material, while Participatory Enculturation involved interaction and two-way engagement with the material and people. In Year 2 there was only one key conversation in this section of the unit that demonstrated students' deployment of Funds of Knowledge and this was in Participatory Observation. The data illustrates that Year 6 students are deploying information from their culture and community to assist them in making sense of their learning. It appears that this is less likely to occur at Year 2.

Passive Observation

In the planning section of the unit, the students determined their design, sketched it, identified construction materials, size and other attributes. The Year 6 students were researching both the Olympic Games and the era of 1896 to 1936. The students learned information about artefacts and processes and procedures.

Artefacts

The data suggests that in this section they drew on information about artefacts gained outside of school mainly from movies or videos. The students brought this information to their research. This is illustrated in the following extract. The researcher (R) asked Alan and Dougal how they knew the shape of microphones from the early 1900s. They indicated that they had seen them on television or at the movies.

R: So how did you know that microphones looked like this?

Alan: Because umm, I saw a thing on TV.

Dougal: Yeah, like on movies and stuff.

This extract illustrated that the students brought knowledge gained at home through passive observation of an artefact used *in situ* to assist with their design ideas. Watching television, and going to movies were recreational pastimes these children engage in as a normal part of their culture. This was interesting because it evidenced that students deployed knowledge from their home culture without specific references or prompts from teachers.

Processes and Procedures

The students also deployed knowledge of processes and procedures through passive observation to assist with skill development. The next extract illustrated this. Minnie, Alan and Dougal, slightly off-task, were discussing the correct way to hold a pencil. Minnie was drawing their group's plan for an early 1900s microphone and Dougal suggested that she needed to hold her pencil correctly. It is relevant to note that a specific way to hold a pencil is taught to children in New Zealand in their first years at school. Minnie acknowledged that she does need to change her grip but Alan disputes the need to conform as he had observed table tennis players using an 'abnormal' grip.

Dougal: Yep. Oh that looks great.

Minnie: Thanks.

Dougal: You have to learn how to hold a pencil right.

Minnie: I know.

Alan: How do you hold it?

Dougal: Like this! [demonstrates to Alan how Minnie holds her pencil]. It's really scary, eh?

Alan: Nah, ah people are allowed to do things differently. I know people who play ping-pong and grab the rackets like that [demonstrates an 'abnormal' grip]. Well there's Olympics. The Olympic people play ping-pong like this [demonstrates 'normal' grip].

Alan suggested that if people playing table tennis could use an unusual grip, then the same could apply to holding a pencil. This extract was interesting because Alan was transferring knowledge from an observation he had made in table tennis to the manner which people should grip a pencil. This is relevant to technology as the comment indicated Alan's ability to transfer knowledge of the way in which one technology is used on to another, and the skill of holding a pencil, an important skill required for sketching design ideas and drawing plans of intended outcomes. The use of drawing tools is a fundamental skill employed in technology education to facilitate the sharing of design ideas.

There were no examples of Passive Observation in Year 2. The researcher is feels she is unable to make wider comment here as the data captured aspects of the students' practice, not their entire practice, so possible links may not have been captured. Another possibility was that, in Year 2, students were less likely to make connections between the viewed and the real world as they tend to be more family-centric. Another possible explanation for this is lack of opportunity. The Year 2 students undertook their technology practice over a period of one week, studying technology all day, every day. In Year 6 the unit occurred over a period of five weeks with two to three technology sessions weekly. This may have given the Year 6 students more opportunity to consider aspects relevant to the study.

Participatory Enculturation

The second sub-element involved Funds of Knowledge derived from being enculturated into an activity through active participation and engagement. As can be seen in Table 4.7, in Year 6 there were eight examples of Participatory Enculturation, and in Year 2 only one. The data illustrated the unprompted nature of the contribution. Students in Year 6 appeared keen to contribute to their group and employed information from a range of situations and experiences they had experienced. In Year 2, again it is difficult to comment due to the nature of the study, but again the fact that there is only one example in this sub-element could be age related as students in Year 6 may be more likely to be involved in independent activities. There were three methods of Participatory Enculturation evidenced in the data. The first was the significance of the role of parents' occupations or activity in what the students bring to their learning, and that students use their funds of knowledge to position themselves as an expert and to gain respect or 'mana' (a Māori term used to describe a person who has status and respect in their community) from their peers. The second was the role of design features in actual artefacts engaged with at home, and the third was the deployment of family social and co-operative skills to assist collaborative design processes. Each is illustrated below with one example from the data.

Parents' Occupation or Activity

The significance of parents' occupations and or regular activity was illustrated by the three children in the Year 6 'microphone' group who were discussing suitable materials for their microphone. Alan's Dad was a racing car designer and has a workshop at home. Dougal chipped into the conversation in a competitive manner explaining that his Dad has much more than blocks of wood because he works in the construction industry. They decided that the head of the microphone could be made from wood. Alan and Dougal then enter into a conversation about what their fathers have at home.

Alan:	My dad's got heaps of blocks of wood.
Minnie:	So?
Dougal:	My dad owns a whole yard of everything. He's got like, (unint.)… He's got lots of things, yeah. He's a drain layer. He's an excavation worker. He's a construction builder. He has a yard, a whole yard.

This conversation illustrated that students used their funds of knowledge to position themselves as experts and to gain respect or 'mana' from their peers. Alan stated that he had wood at home - we knew from previous conversations that Alan's Dad was a racing car designer and had a workshop at home. Mana was an important aspect of Dougal's Māori culture, hence his striving to be better than Alan. Understanding potential construction materials was a significant aspect to planning technological outcomes.

Design Features of Artefacts

The students also deployed knowledge gained through interaction with artefacts in the home environment. This was illustrated when Minnie and Dougal were problem solving how to hold the head of the microphone at the correct angle before attaching it to the stand. Dougal's photograph in Figure 4.3 shows Minnie holding the mocked-up version of this. The researcher approached them and asked what they are working on. When trying to explain to the researcher what they were doing, Dougal used an example from his home computer - a docking station as illustrated in Figure 4.4. However he refers to this as a 'whaling' station by mistake (Personal Interview, 10 October 2011).

R:	How are you going to attach, so what is this going to be?
Dougal:	The bass
Minnie:	It's the base } together
R:	I know it's the base and it's to make it stand up but what does it actually do?
Dougal:	It's going to be like a whaling station at the back and um it's like, its going to have like glue around it to stand by itself.

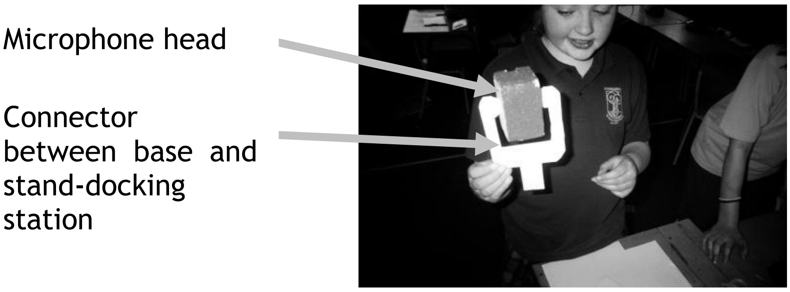


Figure 4.3: Dougal's autophotograph of Minnie holding his microphone head and docking station (holder).

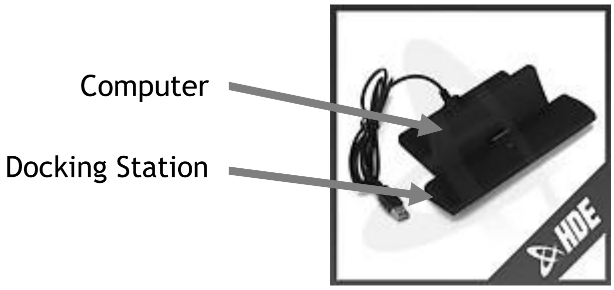


Figure 4.4: An example of a computer docking station image from http://shop.ebay.com.au/items. Downloaded 21 September 2011.

This extract and associated illustrations demonstrated how students made use of artefacts they knew, understood and used at home and in their community to make sense of learning undertaken at school. In this case, Dougal employed an idea of one thing slotting into a specific place designed to hold it, to assist his design concepts and his explanation of his and Minnie's design.

Family Social and Cooperative Skills

Funds of Knowledge deployed by students were not only artefact and process knowledge and skills directly linked to home and community culture, but they also deployed their community and family social skills and knowledge. This was relevant to planning design ideas in technology education, because frequently students were required to design technological outcomes co-operatively and collaboratively. The next extract was a case in point, as these three Year 2 students had to agree on one final design. Rex deployed social Funds of Knowledge as he worked with Issy and Debby on the plan of their fish. Issy and

Debby were having trouble deciding on the colours of their flying fish, and who decided what. Rex attempted peacemaking by deploying a strategy his father used at home.

Debby: I like the blue one.

Issy: I like the green one.

Rex: You can have the blue wings, the one there. The one of yours but just the wings. What one do you like?

Issy: I want the body.....

Debby: But that one, yeah, have the body but not the face and I'll have the face and the...

Issy: But I'm drawing the face. I'm drawing the face.

Rex: No, that one. That one, eh.

Debby: No.

Rex: That one.

Issy: Yeah.

Debby: No.

Issy: Yes. We like it so there's cause...

(Discussion)

Rex: What I used to do is if you there was two and there was one, so I did this, because my dad always says, 'which one' and then the other two wanted two and then if there's one person who likes it, then we, we don't like it though,

Issy: [very softly] you just have to do it.

This extract demonstrated that Funds of Knowledge employed by students were not only factual content knowledge and skills directly linked to home and community culture, but they also deployed their community and family social skills and knowledge. This comment was relevant to planning design ideas in technology education because frequently students are required to co-operatively and collaboratively plan technological outcomes. This was a case in point as these three students had to agree on one final design.

When undertaking planning of their technological outcomes, students drew on their Funds of Knowledge, which included knowledge from their homes, activities associated with their culture and wider communities to assist their learning. In Year 6, this occurred through observation and participatory enculturation. The data presented for Year 2 suggests participatory enculturation was used. The researcher acknowledges that these groups of students had different classroom teachers. Therefore, the data indicated that Year 2 may not have had an opportunity to employ Funds of Knowledge in both sub-elements as opposed to indicating an inability to do so.

Table 4.8: Summary of Making Connections Conversations

Sub-elements and Sub-sections	Year 6	Year 2
Knowledge - Other Disciplines	6	3
Making Temporal Connections	3	0
New Technology Knowledge *Student Initiated* *Teacher Initiated*	2	0
Total	11	3

Knowledge - Other Disciplines

It is interesting that students deployed knowledge from other disciplines. In many cases, particularly in Year 6, knowledge deployed was from mathematics. These students were required to plan their props to scale. Their teacher did not appear to make direct reference to skills learned in mathematics and the students did this without prompting. In Year 2 Anne employed geometric knowledge as opposed to number knowledge. It is important to note that the Year 2 students were not given the ‘scale’ requirement. That is, to make their plan a scaled drawing of their outcome. This would have most likely been beyond their mathematical capability and experience.

Mathematics played an important role in the students' ability to draw their plans for their technological outcome. In Year 6, four of the six key conversations identified in 'Planning' were from mathematics. This was not surprising, as these students were required to consider scale and dimensions for their designs. However they were not given direct instruction in terms of the meaning of scale nor how to do it. The extract below illustrated the use of mathematics in the planning process. Alan, Minnie and Dougal were considering dimensions for their design.

Alan:	Hang on. We'll work out the dimensions.
Minnie:	How big is it going to be?
Dougal:	We could have it that that big.
Alan:	Four centimetres by five centimetres. Four centimetres by five centimetres by eight centimetres, probably.

The Year 2 students were not required to put dimensions on their fish plans but made a link to mathematics on one occasion and science on two. In the next extract, Anne made reference to geometry the term 'oval' to describe the shape of her fish.

Anne:	Well the shape of our body will be an oval.
Ellis:	Yes.

These conversations were interesting because they demonstrated that students were able to draw on discipline knowledge from one curriculum area and transfer it to their design ideas. Sometimes teachers facilitated these links, but in others, the students themselves instigated them. Students from both Years 6 and 2 drew on knowledge from other disciplines. Year 6 students also used knowledge learned from earlier in their current unit.

Making Temporal Connections

There were three examples of explicit connections to learning in the previous technology unit, all in Year 6. In the earlier unit, students designed space stations for a self-determined specific need (e.g. as Earth's prison or as a holiday resort). The teachers made explicit links to the process the students undertook to facilitate their understanding of the design process and task identification for this unit.

Clara: Alright on your own, you are going to go away and think about, we came up with this timeline for all the things we need to have finished before Week 10, when the production starts. In your topic book, I want you to think purely about the props. Okay. We've got to go through a lot of stages before we can get to making the props and having the final prop. You think about what you did when it came to the Space Station. We've already done the research part of it. We've done that. Once you had your research, what did you have to do next? Isobel.

Isobel: Design.

Clara: Yeah, so you came up with some initial design, didn't you? What did you do after that? Anyone remember? Jacob.

Jacob: [We] talked about your design.

Clara: So we had our initial design and then, it was a while ago though. A lot happens in between those two terms. Can you think of anything else? Minnie?

Minnie: Looking at our individual designs and putting our ideas together.

Clara: Good girl.

Minnie: Showed our specifications that are needed.

This extract demonstrated that the students were able to recall the technology design process and its collaborative nature. This section demonstrated the value of running consecutive technology units and drawing the students' attention to the first in order to increase their independence in subsequent units. It illustrated that students were able to extract technological knowledge from content knowledge, to carry on to other technology learning.

New Technology Knowledge

As the unit progressed so did the opportunity for teachers and students to make links to prior learning within the unit. As soon as the students had been exposed to new concepts and knowledge about props they also began to deploy this new found knowledge. In 'Planning' this meant direct links to the 'Character and Function' stage. Table 4.8 indicates that in Year 6 there were two examples of this. This data illustrates the importance of the careful sequencing of planned activities, to enable students to develop knowledge and skills to ensure the increased likelihood of success when planning and constructing their final outcomes. There are two sections to this sub-element. The first, connections initiated by the students without prompting and the second, connections made through teacher directed questioning.

Student Initiated

Students initiated connections to learning earlier in the unit. This demonstrated that the knowledge acquired in earlier sessions was applied to later lessons as intended. This was illustrated in next the extract. Sophie, a Year 6 child in conversation with Clara, her teacher, made explicit links to what the visitor speaker from the local theatre had said about functionality and durability of props.

Clara:	They [the props] need to last. For example, we're going to have three production shows. They need to last for all three shows.
Sophie:	Yeah, like that umm, Cabonet Theatre, they have it for weeks and they have to be really careful.
Clara:	Yeah, if they go away on the show, they have to look after them, don't they, because they don't have anyone up there to be able to fix things.

This extract illustrated Sophie's understanding of the authentic need for props to be durable and last through a number of productions. The example given by Clara was for the students' school production item but Sophie made the connection to Julian's talk earlier in the unit.

Teacher Initiated

The Year 6 teacher made explicit connections to prior learning in the unit thus demonstrating their usefulness and justifying their inclusion and delivery sequence. By making specific connections to the earlier lesson, when Julian spoke to both classes, Clara assisted students' identification of key attributes for their own designs through the identification of key attributes of existing props. Identification of key attributes is an important aspect of technology practice.

> Clara: Because remember, the prop guy from the Cabonet Theatre was talking about, they just had that bucket. Alright. That was an existing thing that we didn't need to umm, we wouldn't need to make. So in terms of the cleaning equipment, we could probably find one of each. We don't need microphones because the umm, sound guys are going to give our main speakers, probably microphones that are on their gear, okay.

Clara made explicit links to the fact that the coal bucket is in actual fact an authentic artefact, illustrating the fact that sometimes props just need to be sourced rather than made.

In the second extract, Clara requested that the students to think back to the character and function lessons in which students identified the characteristics of successful props. She then asked the students to consider these when determining their own designs.

Clara: Now if you think back to the beginning of the week when we kicked off technology and I got you to look at all the different props. What were the sorts of specifications, they were really the specifications that we were looking at, when you had the pictures of the props and you came off and you annotated those drawings. So what were those sort of specifications there? We did them again yesterday.

In both cases above, Clara made very explicit connections to earlier lessons in the unit drawing her students' attention to important aspects, and therefore assisting students in their knowledge transfer from one stage of the unit to another.

The Making Connections element saw a difference between Year 2 and 6. Knowledge of other disciplines remained for both year levels but a new sub-element emerged; explicit links to learning in the previous stage in the current unit. This replaced explicit and implicit links to prompts. Another new sub-element in this stage, temporal connections or explicit links back to the previous unit emerged in Year 6 but not in Year 2. This demonstrated commonalities in the design phase between units. It is difficult to draw conclusions from fact that this knowledge was absent from Year 2 because, as stated previously, the units were delivered in slightly different timeframes leaving more opportunity and time for the Year 6 students to explore connections. Another possible explanation for this is that, this was the first technology unit that Fleur, the Year 2 teacher, had taught and she was trained in technology using the draft technology curriculum (Ministry of Education, 1993b). On the other hand, Clara, the Year 6 teacher, had previously taught technology in the classroom and was trained at a different institution using the 1995 Technology in the New Zealand Curriculum (Ministry of Education, 1995).

4.5.2 Management of Learning

The element of Management of Learning in the planning section of the unit had a number of new sub-elements when compared to Character and Function. A number of management strategies to assist learning were implemented throughout the unit, aimed at developing students' thinking skills as well as developing their understanding of planning technological outcomes. These are summarised in Table 4.9.

The data revealed that in Year 6 104 key conversations were identified in six sub-elements. These included: comments designed to assist students' learning through teacher comments and the implementation of specific learning strategies with instructions. Twenty six examples involved setting up specific learning strategies, six of which were directing the students to do further research to assist their design development (Assisted Learning), and there were 23 examples of teachers asking questions to challenge students' thinking - both inferential questions and higher order thinking (Higher Order Questions). The students were also involved in collaborative discussion when working out the details of their planning; there were 19 examples of peer discussion in Year 6 (Peer Discussion). Teachers also gave students explicit information they needed (Transmission - 12 examples).

There were also 12 examples of the teacher speaking to students to elicit specific information (Eliciting Specific Information), and both teachers and students assisted students to manage their behaviour (Managing Behaviour - 12, six teacher-to-student and six student-to-student).

In Year 2, categories were the same as in Year 6 but totalled only 51. The sub-element with the greatest number of comments was Peer Discussion with 17, then Assisted Learning with 15 examples. Managing student behaviour had 11 examples (Managing Behaviour). There were four instances of Higher Order Thinking, three of eliciting specific information and only one example of direct Transmission. The sub-elements are discussed below and illustrated with examples from the data.

Table 4.9: Summary of Management of Learning Conversations

Sub-elements and Sub-sections	Year 6	Year 2
Assisted Learning (includes specific instructions) *Recall Previous Technology Practice* *Modelling Process and Subsequent Prompts* *Just in Time Assistance* *Working Collaboratively*	26	15
Higher Order Thinking	23	4
Peer Discussion *Clarification of Understanding* *Working Collaboratively*	19	17
Transmission *Time Saving* *Consistency and Clarity*	12	1
Eliciting Specific Information *Reasons for Actions* *Questions with Pre-determined Answers*	12	3
Managing Students' Behaviour *Student / Student* *Teacher / Student*	12	11
Total	104	51

Assisted Learning

The nature of the lessons changed at this stage in the unit, as the students began to work independently on their own designs. This meant that strategies to assist learning focussed on developing understanding and skills in students' technological practice and their design ideas. The data reveals a number of strategies were implemented to assist students' learning; these included: recall of previous technology practice, modelling technology practice, just in time assistance and assistance with working collaboratively.

Recall of Previous Technology Practice

In Year 6 this focus was initially to develop students' understanding of and independence in the undertaking of their whole technological process. Clara prompted her students to use graphic organisers and other taught strategies to organise and record their thinking and to work independently on the task. She did not specify one strategy to be used, but reminded students of a range and then gave them the opportunity to choose the one that best suited their needs. She also assisted the students to build their understanding of the sequencing of tasks, or planning their own technological practice, to ensure their outcomes were completed within the given timeframe. The extract below demonstrated Clara making explicit connections to the practice undertaken in their previous 'Space Stations' unit to assist the students in the development of a list of key tasks that need to be undertaken.

Clara:	we're saying we've done our research. What are we going to have to do next? Dougal.
Dougal:	Plan our design.
Clara:	Yeah, but even before that.
Dougal:	Choose what prop we're going to make
Clara:	Right we need to decide.
Marco:	Initial ideas, think about some ideas about what we could make.
Clara:	Great. So we're going to plan individually. Right. Then if you think about it in terms of Space Stations you have your individual design so what do you come together and do, Brianne?
Brianne:	planned the space station.
Clara:	Not quite yet.
Charlie:	We chose our final designs.
Clara:	Good. So you've chosen your final design. So you chose your design that you choose design from group [writing idea in whiteboard]. Now, some of you have a design that one person

has developed. Some of you chose to combine sort of three designs together with your Space Station and include bits and pieces from everyone's Space Stations. So then you chose your design it and you designed it, really, didn't you and came up with the, the next piece. So you need an initial brief. Yeah, and we developed our prop through sketches and things like that. You did floor plans. Umm, going to have to do sketches. As well as your sketches, what else are you going to have to think about?

Charlie: Material.

Clara: Have a think in your, put your hands down. Remember, we're trying to do non-hands up. There's no right or wrong answer for this.

Jake: We are making the paper mock-up (unint.)…

Clara: In the mock up stage. Good idea. Okay. So maybe in here we might check with our stakeholders.

Alan: Maybe after we've made the mock up then we could make a secondary mock up.

Clara: If necessary, yeah, then we could make some changes if we needed to based on what our stakeholders said. Yes, I think that's a great idea. Well done, that looks pretty good according to my thing here. Well done. So what we need to do now is thinking in terms of our production, what are the props we're going to need in order to get our message across? So what will we need? Some of you were here and some of you will know and Minnie and Marco, you'll have an even greater knowledge of them due the fact that you wrote the script.

Planning for practice is an important component, and an authentic aspect of technological practice. The above extract illustrated how Clara facilitated students' understanding of task identification and sequencing by reminding them of the stages used in their previous unit, which was explicitly scaffolded for the students.

Modelling Process and Subsequent Prompts

In Year 2, conversation at this stage was more focussed on the actual planning stage, rather than in Year 6 understanding the sequence of task and where planning technological outcomes fitted in. This is shown in Table 4.9 with only 15 examples compared to 26 at Year 6. In Year 2, learning was more structured and clearly modelled for students to assist their understanding. In the first extract Fleur, the Year 2 teacher talked to the whole class and made explicit links to the researcher's (R) modelled example of a plan.

Fleur: Have a look at Wendy's plan. What has she done that you need to do?

This extract illustrated the use of a modelled outcome. The researcher worked on a technological solution in parallel but slightly ahead of the Year 2 students. By making explicit links to the modelled plan Fleur assisted her students' to understand what a plan is and how it was made.

Another form of modelling used was the modelling of a process. The following extract demonstrates the researcher (R), in the role of the classroom teacher, modelling the process of explicitly evaluating and modifying an initial plan using previously identified criteria (attributes) to the Year 2 students.

R: Look at me as I do mine and it might help you. So this is my plan and now I have got to think to myself. Does my plan look like the real thing? Do I think it looks like a really flying fish? Yes I think I am quite happy so I think yep my plan meets that criteria. The next one is be durable, hard and cannot break. Now I am a bit worried that this tail is a bit delicate and might break so I think that I will make this a bit thicker [modifies plan to give a thicker tail on her plan], because I found that when I was cutting them. If they were too narrow that they were too difficult to stuff so I have decided that I am going to change my plan, just a little bit, and make it a little bit fatter there so it is more durable. And I think I'm going, make my wings, inside my wings I am going to have some sticks to make them tough because I thought the wings flopped around a bit. See how the wings are all flopping? See how I have added that in a different colour, so that's it. And my fin I think I am going to make that hard with cardboard or cartridge paper So I am going to add that in so that's nice a durable. Can you see that fish. Emma, you go to the back of the room and tell me if that if it was in pen and not in pencil. Is this fish is going to be big enough? Can you see it from the back of the room. You go down there and imagine that you are in the audience and my fish was on stage. Can see most of that? Can you see the fish?

Emma: Yes.

R: Can you see the tail, is that big enough to see. So it's this long.

Fleur: Do you think that is big enough to see Emma?

Emma: No.

R: So you think that needs to be a wee bit bigger. Okay, thanks Emma, okay. So I am just going to come around here [adjusts plan]. Right, here's my new plan, can you see that now. So what I have done is that I have taken my plan which was our first idea and we looked at the criteria that we made together. These are the criteria.

In the above extract the researcher, in a teacher role was very explicit about the process of evaluating a design using the previously identified attributes. Very explicit articulation of her thinking assisted the students' ability to see and hear the evaluation process. This extract from the researcher's journal explains the process undertaken above.

R: "I modelled changing plan to match the criteria. Chn. [children] then modified their plans to meet the criteria. Made changes in vivid [marker pen] so we could see them. Chn then discussed the changes. Could see clear links to the criteria set on the board" (WF-T field notes 28 Aug'09).

These extracts demonstrated the specific strategy of modelling used to enhance students' understanding of the design process and of planning and evaluating a technological outcome.

Just in Time Assistance

In Year 2 assisted learning also occurred as the students worked independently on their planning. During this process the researcher and classroom teacher circulated among the students to guide them through the process and with their practice. This assistance was called 'Just in Time Assistance' as it was given as and when required to individuals or groups rather than whole class teaching. This was illustrated in the next extract, in which the researcher was assisting Rex's group annotate their plan.

R: This is just the plan. What you've got to do now is stick some labels on.

Rex: What are labels?

R: Name the parts of the fish.

Rex: Ohh, like the words.

R: You have to write what it is there.

Rex: Like a key.

This extract demonstrated the explicit nature of assistance given to assist Rex's understanding of the technological process and that he is aware of nature of annotation.

Working Collaboratively

Another way teachers assisted students was with strategies for working collaboratively and co-operatively. In the following extract the researcher is suggesting that Rex, Issy and Debby talk through their ideas with each other.

R: Debby and Issy and Rex you need to talk to each other and agree with what you're going to put there.

Working collaboratively on the development of a single technological outcome is an authentic method of technological practice. This unit was the first time these children worked with people not of their choice. The above extract illustrates that specific strategies were introduced to the students to assist them to work collaboratively.

Assisted Learning occurred frequently throughout units in both Year 2 and 6, as can be seen in Table 4.9. This is significant because, although the groups of students were developing their own designs, and as such working independently, their learning was still managed by their teachers using a range of strategies. To increase the students' ability to develop a quality outcome in groups of three, co-operation, and collaboration were critical. Teachers also used strategies to ensure students were thinking critically about their designs and learning to work independently.

Higher Order Thinking

Throughout the 'Props' unit, teachers of both Year 6 and 2 purposefully introduced learning strategies to enhance students' thinking, including Stage 2. Table 4.9 shows us that there were more examples in Year 6 than in Year 2. Development of critical thinking empowers students to make decisions based on their own skills and knowledge, and therefore fosters independence. The Year 6 students were required to critically appraise their design ideas. They did this by completing a 'Pros and Cons' activity. The aim of this activity was to assist students when selecting their final design idea from a range. They were requested to look at their three initial design ideas to identify as many pros and cons for each. The researcher assisted Alan, Minnie and Dougal in their discussion of the 'cons' to 'pros' for their designs.

R:	Think about what are all the good things and then what are the cons. Because what you're coming up with is a cons. A con is all the bad things of a design. First I want you to think of all the good things about the design that you re going to make.
Minnie:	The materials are cheap.
Alan:	Um, What else?
R:	I want you to think about, it says here from as many points of view as possible. So what are the pros of your design, say, for the, for the teachers or the umm, stagehands, people who are taking things on and off stage?
Alan:	Yeah.
R:	Good. That's a really good point.
Minnie:	It's quite simple, like it is not that complex so it won't take us ages to make so like we've got like plenty of time coming up and like if we are really behind like it won't take ages to catch up.
R:	What would be the alternatives?
Alan:	Well, the teachers don't really need to do much because...
R:	So you are saying that you have done it for them? So I would call that a pro.
Alan:	Yes.
Dougal:	Teachers don't need to do anything, really.
Alan:	Have a break.
R:	What about the audience?
Alan:	It's obviously, obviously an old school microphone.

The above extract demonstrated how implementing a specific strategy facilitated students' higher thinking skills by encouraging them to consider positive and negative aspects of their designs and to think from a range of views, not just their own.

Following their initial designs, and the researcher's modelling of the modification of design ideas to accommodate the identified attributes, the Year 2 students went back to their own designs and made modifications if they thought they were necessary. The following extract demonstrates how higher order questioning evidences students' ability to understand design evaluation against identified attributes. One of the attributes determined by the year 2 students was that the props need to be big enough to see. Rex and Debby realised the need to change the fins, tail and eyes of their design to ensure the final outcome is big enough for the audience to see.

Rex:	Oh and we did the fins a bit bigger.
R:	Why did you make the changes?
Rex:	Because we couldn't really see them because they were really, really small so we need to make them a bit bigger.
R:	Did you change anything else?
Rex:	And we made the tail and the eyes a bit bigger.
Issy:	and the wings.

In technology education, students need to be able to evaluate and critique their designs using a given set of attributes. The above two extracts illustrated that in following the modelling of the planned activity, these Year 2 students were able to do this for one attribute. They understood that their fish and its features needed to be big enough for an audience to see and increased the size of their fish's fins, tail and eyes.

This section demonstrated that students' thinking was challenged and ideas developed through the implementation of specific strategies and techniques. Students also challenged and facilitated their learning with each other. As Table 4.9 suggests the Year 6 students provided more examples. It appeared that in Year

6 the students were able to consider a range of attributes in their critique, while in Year 2, as suggested in the previous section, 'size' associated with the attribute 'big enough for the audience to see" was the attribute that most frequently appears in the data.

Peer Discussion

While completing the planning of their practice and planning technological outcomes (props) the students in both Years 6 and 2, worked collaboratively in groups of three. As seen in Table 4.9, the data suggests that students used dialogue to convey their ideas, to challenge others' thinking, and to assist each other with the formation of ideas and understanding about what their group's outcome would be like (Clarification of Understanding) and to assist working collaboratively. In Year 2 there were 17 instances of peer discussion which is the most frequently populated sub-element at this level.

Clarification of Understanding

The use of peer discussion assisting students in the clarification of their ideas is best illustrated in the following extract. Mandy, Teddy and Jay shared and discussed their design ideas and potential materials for their prop, a large 1890 to 1930s radio. The discussion included a debate about the suitability of papier-mâché. The discussion also assisted Jay to fully understand the scope of the project. This was evidenced when he says 'Oh that tall?'.

Mandy: My one's just made out of a cardboard box, like from a dryer umm, and we just, like paint it and then use wire for the umm, speaker or something or we could use like, you know how the juniors do stuff in the hall,

Teddy: Yeah.

Mandy: They've got wooden boxes and we could use them for umm, and we could just cover them in umm, a bit of cardboard painted brown

Teddy: Oh yeah.

Mandy: and that would work because they'd be quite strong.

Jay: My ideas like the cardboard, like the boxes for the radio because there's like, a box, you could like, put little graphics.

Mandy: It's meant to be a big radio, like this tall.

Jay: Oh, that tall?

Mandy: Yeah, one of those big ones.

Teddy: Yeah it's meant to be really big. It'll be really good.

Jay: Okay go Teddy.

Teddy: I haven't done the materials for mine but umm,

Mandy: Well what do you think?

Teddy: That's mine [show others his sketch].

Mandy: What do you want it to be made out of?

Teddy: I think maybe like a, some sort of box with, I haven't really thought of my materials yet but I just drew it.

Jay: I reckon, personally, paper maché could be good.

Mandy: How are we going to get a balloon to go that big?

Teddy: You don't need a balloon.

Mandy: Yeah, you do. Okay. What are you going to paper maché it over? You need a structure.

Teddy: Yeah.

Mandy: For the paper maché.

Teddy: You just get a box.

Mandy: And then paper maché the box.

Teddy: Yeah.

Mandy: Okay, that could be an idea and then...

Teddy: Well that would be difficult...

Clara: But it would be weird because what if the box collapsed because of the wetness of the glue?

Jay: Yeah, well, we just let it dry

Mandy: No no, no, no, when you put the glue on.

Jay: You'd still have, you'd still have the things to support it? But you would...

Mandy: but when you actually make it.

Understanding the suitability and impact of a range of materials and processes on design is a critical aspect of technology practice. Mandy's initial concept of papier-mâché was that the paper mixture was supported by a balloon. However, through dialogue with the boys she is able to build on her conceptual understandings by expanding her notion of a supportive structure. This extract demonstrated the student's understanding that materials impact on the physical and functional features of a technological outcome and that identification of materials is part of the planning process.

Working Collaboratively

As stated earlier working collaboratively was an integral part of this technological practice as discussion and consensus were critical. When working in groups of three to develop a single technological outcome, collaboration and co-operation were essential to facilitate the design ideas of a single outcome. The data suggested that the students were able to acknowledge others' good ideas and assisted each other to work collaboratively. One aspect of working collaboratively was ensuring all group members have a say. Group discussion can facilitate this. Sometimes one group member likes to dominate all proceedings as in this case: Ellis was an intelligent, articulate boy who liked his ideas to be adopted, sometimes to the detriment of Adam who was less confident. In the next extract the researcher approached Anne, Adam and Ellis and asked them about their designs.

R: Okay, Adam, tell me a bit, about the parts you've got down here.

Anne: I don't think Adam knows.

Adam: There's one there, and one there.

Ellis: Yeah, That's a fin and that's a fin.

Adam: No, that's a wing.

Ellis: That's a fin.

Anne: Adam drew this so he decides. Adam drew it so he decides what it is.

Ellis: What is it, a wing or a fin?

Adam: Wing, it's a wing.

Anne used her authority in the group to support Adam with his ideas. It was reasonable to assume that Adam was more likely to contribute his ideas if they were valued and this was likely to advantage the groups' ability to develop a quality final outcome.

The data suggested that students' used dialogue among each other to advance their ideas, thinking and understanding when planning a technological outcome, and to assist each other in working collaboratively. The direct giving of information also had its place in the management of students' learning at this stage. This is discussed in the next section.

Transmission

The definition of a transmissive teaching approach is one that is teacher directed and involves the direct giving of information. In this study, as in all classrooms, aspects of transmission were employed for a variety of reasons. The data suggested two main reasons at this stage of the unit. Information through transmission is often easier and quicker for students as they did not have to engage higher-level thinking or spend time searching for information. Teachers also identified key information that students needed. Giving students this information directly ensured consistency and clarity.

Time Saving

The following extract demonstrated the students seeking specific knowledge from their classroom teacher rather than spending time searching for the information.

This conversation followed on from this earlier conversation in which the researcher challenged Mandy, Teddy and Jay to find the term used to describe the distance between circle's centre and its side.

R:	What measurement do you need to know?
Mandy:	You need to know the diameter.
R:	The diameter. You can put the pin of the compass in the middle. How do you know the measurement from the pin to the pencil? What's that measurement called?
Mandy:	The pin measurement?
R:	If you have your circle here and you rub this out and then you put your pin in there and you have the pencil there, so you need to know this measurement. What's that called? This is the diameter, right across. So what, what is it from the edge of the circle right to the middle? It starts with R. It's half the diameter, is called the
Mandy:	Re.
Teddy:	It's re something.
R:	Right. That's something that you need to research because you have to know that because to draw the circle, you need to know how far from the middle to the outside.
Mandy:	Rejerk.
Teddy:	Raydawn.
R:	No. Okay. You need to research. Half the diameter.
Teddy:	Okay Jay you can do that } together
Mandy:	raymetre } together
R:	Okay Jay you go and find that out. What is half the diameter?...

After the researcher left Jay went to research the term at the classroom computer. While he was away the classroom teacher approached Mandy and Teddy. The students asked her for the answer.

Clara: Great. Well done. That's perfectly drawn. Do you think you'll be able to make your mock up, start making a mock up today?

Teddy: No.

Clara: No, that's okay.

Mandy: Maybe.

Clara: Just see how you go.

Mandy: Because we need to know, the bit from here to the middle of the circle which is.

Clara: Yeah, the diameter.

Mandy: Umm, no, because it's the diameter all the way across but to the centre of the circle.

Clara: Okay.

Teddy: Do you know what it's called, Miss XXXX?

Clara: Pardon.

Teddy: Do you know what it's called?

Clara: The radius.

Teddy: Ohh, radius...

Mandy: Go and get Jay back.

Teddy: Nagh, just leave him on there [laughs].

The students clearly felt they needed this term so that they were able to annotate their designs accurately thus contributing to the detail presented in their planning. Mandy and Teddy seized the opportunity to extract the information from their classroom teacher, rather than having to wait for Jay who was away researching the correct term. It appears that for these students and their teacher the direct giving of information was desirable to save time.

Consistency and Clarity

The classroom teachers also used transmission to ensure a consistency and clarity of information. By giving clear guidelines regarding instructions, teachers ensured that all students were getting the same information. In this extract Clara recapped the stages to be completed and told Year 6 students that their plans need to be annotated.

Clara: So let's just do a quick recap on where we are at. So all of you, I believe, have finished your initial brief and you've come up with your, with your specifications that were to do with your particular prop and you had started drawing your final plans. Alright, and we need to make sure on your final plans that you are annotating them. So it's putting little lines and explaining exactly what it is you're going to use to make them, what colours they're going to be. Umm, whether you're using papier-mâché or what processes you're going to use.

The above section demonstrated that at times it was useful or desirable for teachers and or students to give direct information, rather facilitating students' finding the information themselves. At other times teachers needed to establish an understanding of what students already knew in order to move them onto the next learning step. They did this through using questioning techniques to elicit and extend students' understanding.

Eliciting Specific Information

The nature of formative assessment, means that teachers need to have a clear understanding of their students' learning in order identify next step learning. A range of different strategies, from formal diagnostic testing to informal observation, was used to do this. The data from this study suggested two reasons for eliciting information in this sub-element. The first was to find out what the students knew (Reasons for Actions) and the second was to ensure that students knew key information (Questions with Pre-determined Answers).

Reasons for Actions

One strategy used in this study was direct questioning about what students were doing and why. Understanding the reasoning behind students' action assisted teachers to determine levels of understanding and best next step learning. Using a

'Tell me' technique the teachers were able to identify the students' awareness of critical aspects of their design and that all requirements were met. For example "Adam, tell me about the parts you've got down here". This was best illustrated when the researcher in the role of teacher questioned Minnie, Dougal and Alan from Year 6, about their microphone planning.

R:	Tell me what you've done down here, on each side here.
Minnie:	We've added the scale.
R:	Right you've got the scale down there and Dougal what are you drawing?
Dougal:	The microphone. Yep.
R:	and Alan, you're drawing?
Minnie:	He's drawing the other one.
Alan:	The scale.
R:	Yeah, after the scale, and then, what's on that side?
Alan:	Umm, then we'll be going with the big microphone, the actual, the whole one with the stand about that big [indicates height of just over a metre off the floor].
R:	So one down there for the actual microphone, one down there for the stand and another one down that end for the ....
Alan:	whole thing, yeah.

This was a technique designed to facilitate student talk and at the same time enabled the questioner to assess students' level of understanding at that point. The instructions given to the Year 6 students for their planning included that designs needed to be to scale. Using the above technique, the research was able to determine these students were able to understand the concept of scale and draw their designs using an appropriate scale.

Questions with Pre-determined Answers

Teachers used questioning with specific answers in mind to ensure that all children knew specific content or procedural knowledge. This technique does not necessarily challenge students' thinking, as teachers tend to ask students' who have their hands up indicating that they may know the answers. This was clearly illustrated in the following extract. Fleur, the Year 2 teacher used this technique to secure a list of components needed in the plan.

Fleur: Yeah, so what do we call that, what do we call that? What do we call that? Rex, what do we call that? A, something of a fish. What do we call it? Lauren had that word. A ske...?.

Children: Sketch.

Fleur: A sketch and what we need, will have what? What do we have to have? We have to have, a sketch and lab...

Children: Labels.

Fleur: Labels.

In the above extract, Fleur had an existing list in mind of who the stakeholders were, and subsequently used questioning to draw this information from her students or direct them to it. The data showed that at both levels there are two main reasons teachers elicited specific information from the students. The first was to determine what they already knew and understood so that next learning steps could be identified. The second was to ensure all students knew specific information that the teachers had already determined was needed by the students. Rather than telling students directly, Fleur used questioning to draw from the students the answers she required. Another strategy to maximise learning, was to ensure students were on task and not disturbing learning. Strategies used to manage student behaviour during this stage of the study are discussed in the next section.

Managing Students' Behaviour

The final sub-element in Management of Learning is conversation directed at managing students' behaviour. There were two sections in this sub-element. In the first, students were managing each other's behaviour, and the second, teachers managed their students' behaviour. In Year 6, of the 12 key conversations in this sub-element, six were student- student behaviour management and six were teacher-student. In Year 2, there were 11 examples of behaviour management; six were student-student and five were teacher- student. It was interesting to note that, in this sub-section, both types of behaviour management were reasonably evenly represented. Each of these sections is illustrated below with one extract from each year group.

Student-student

There were a number of occasions when the students managed each others' behaviour. These usually occurred when the students were working independently in their groups. In Year 6 the students were required to determine a list of suitable construction materials for their design. In the first example Alan and Dougal were working on the identification of suitable materials for their microphone, following the idea that wood may have been suitable. Dougal went off task to talk about his father who had a yard full of wood. Alan drew him back to the task at hand.

Dougal: He has a yard, a whole yard.

Alan: Umm back on topic. Yeah, so a big block of wood rounded off at the edges.

This was interesting because Alan was engaged in the planning process, which included the identification of potential materials for the final outcome. When Dougal went off task Alan quickly attempted to rectify the situation by requesting Dougal come back on task. Clara, the Year 6 teacher, frequently asked the students to remain "on task", thus possibly accounting for the terminology used by Alan. The next extract was from Year 2. Issy and Debby were continuing to argue about the colours and patterns to be put on their fish. Rex attempted to get the girls to talk to him instead of arguing with each other.

Issy: You don't know what way it is.

Debby: I know what I'm going to do.

Rex: I know what way.

Issy: Debby.

Rex: Talk to me okay?

The above extracts illustrated that students attempted to keep their peers on task. The numbers of key comments identified in this stage in which students manage or at least attempt to manage their peers was surprising. As mentioned above, this suggested that students were engaged with the project, and motivated to continue with their given tasks. The next section looks at how teachers also managed behaviour of their students.

Teacher-student

One of the tasks considered necessary in teaching is to manage students' behaviour so that students do not waste their own or others' learning time. One strategy commonly used is the use of positive comments and specific praise for desirable behaviours. The first extract illustrates this. In Year 6, Mandy and Jay were working collaboratively while deciding which construction method to use. The researcher observed this behaviour and commented positively on the way the students were working.

Mandy: Well, you could do wire or paint.

Jay Yeah, probably paint.

Mandy: Wire would look really effective.

R: It's good that everybody's contributing and thinking about some things.

Another strategy used for the management of behaviour was developing the students' skills of working collaboratively and co-operatively with their peers. The following Year 2 extract comes from a transcript of Debby, Rex and Issy attempting to work collaboratively on the plan of their fish. At the beginning of the session the researcher named the students for the benefit of the recording, and then reminded the students that in order to work collaboratively they needed to communicate with each other. This proved difficult for the group, so the researcher intervened again by teaching the students about compromising their own ideas.

R:	This is Debby, Issy and Rex and they're doing the plan of their fish. So you need to talk to each other and agree with what you're going to put there.
Debby:	We're doing a fish.
Issy:	You don't know what way it is.
Debby:	I know what I'm going to do. No, (unint.)… the blue one. Yeah, that one, that one.
Issy:	No, we don't like that.
Debby:	I do.
Issy:	I like that one.
Debby:	I don't.
Issy:	Ohh, we're not doing that one.
Debby:	Yeah.
Rex:	No, let's do, let's do a fish.
Issy:	I like that.
Debby:	I don't want to do that one.
Rex:	How about we do one we all want?
R:	How are you going to organise that?
Debby:	I don't like (unint.)…, I only like the blue one.
R:	Sometimes you might have to compromise.
Debby:	Compromise?
R:	It means take some ideas from everybody and put them together to make [one idea].

The above extracted illustrated that throughout the planning stage of this unit, different strategies were implemented to maximise opportunities for students' learning by teachers' management of behaviour.

In summary, Management of Learning was the most frequently populated element in this stage with six sub-elements at both Years 6 and 2, illustrated with 165 examples. Management of learning in a variety of forms was pervasive throughout the planning stage. Assisted Learning and Peer Discussion were the most prolific sub-elements at both levels. Higher order thinking had a higher number of incidences in Year 6 than at Year 2. Management of Behaviour had a similar number in both Year 2 and 6 and was in the mid-range of incidences. In Year 2 there was only one example of transmission yet in Year 6 there were 12 incidences. Eliciting Specific Information was similar, except with three incidences in Year 2.

4.5.3 Technology Knowledge and Skills

Relevant technological knowledge at the Planning stage included identification and use of key attributes of props within the planned designs, links to the required physical and functional features of the planned props, knowledge of the process of planning, the physical skills required to draw a plan and the understanding of the suitability of potential materials for their designs. In Year 6 the students were also taught to complete a timeline of their intended practice or planning for practice. Table 4.10 summarises these results.

Table 4.10: Summary of Technological Skills and Knowledge

Sub-elements and Sub-sections	Year 6	Year 2
Attributes -Physical Features	28	9
Process of Planning (practice & outcomes)	28	5
Materials - identification of and function	13	0
Attributes - Functional Features	13	0
Planned Outcome - physical skills *Annotations* *Planning Views* *Scale*	10	5
Totals	92	19

In Year 6, there were 92 examples of evidence of knowledge and understanding of the planning process and associated skills. These fitted into five sub-elements the first of which was the consideration of specified physical features (Attributes - physical) with 28 examples. There were also 28 examples of explicit commentary demonstrating an understanding of the process of planning (Process of Planning).

The identification of materials and the impact these may have on the attributes and function was another sub-element with 13 examples (Materials - identification and function). Identification of specified functional features also had 13 examples, and there were 10 examples of physical skills and knowledge of drawing plans (Planned Outcomes - physical skills).

In Year 2, there were fewer, with only 19 extracts in three sub-elements, identified as evidence of technological knowledge and skills in planning. There were nine instances evidencing knowledge of the physical attributes of the designed outcome (Attributes - physical). There were five examples of evidence of the physical skills of planning (Planned Outcomes - skills) and understanding the planning process (Process of Planning). The data suggests that students considered neither suitable materials nor the functional features of their props in the planning stage in Year 2.

Attributes - Physical Features

In this stage, attributes fitted into two subgroups: those about the physical features of the props discussed in this section, and others about the functional features of props. This section evidences that students' consideration of the physical attributes influenced their planned outcomes. Physical attributes included how the outcome looked and the materials used for constructed. In both Year 2 and 6, students co-constructed attributes for their props at the conclusion of the Character and Function stage of the unit. In Year 6 the physical attributes included: era specific - meaning the prop's physical features needed to demonstrate the 1896 to 1936 era; easily recognisable as the item it was representing by the audience (researcher notes 1 Sept. 2008).

Teddy, Jay and Mandy spent considerable time researching radios from the designated era in the early sessions. In the first extract they were discussing whether their radio should include tuner and volume control dials. They admitted they were not sure and Jay suggested more research to ensure accuracy for the era.

Teddy:	Yeah, I don't reckon they have tuners but you could do that.
Jay:	No they could. Yeah, we're not sure. We'd have to research that.
Teddy:	Yeah, we have to research that one. I reckon that would be really good.
Jay:	We need something that has the volume up some and down some.
Teddy:	Yeah, that's these things.
Jay:	Yeah, but what's this?
Mandy:	That's a dial.
Jay:	Oh, yeah.
Mandy:	No, because they didn't have things for volume. You couldn't turn the volume up or down.
Jay:	Why not? Then how did you do it?
Mandy:	Well that must mean that they couldn't tune it then.
Teddy:	Eh
Mandy:	Umm, well that must mean, they needed one dial to control everything. So it was either to control sound or tuner.
Jay:	Yeah.
Teddy:	No, I reckon they had three dials.
Mandy:	No! they didn't have three dials. I know that much!

This extract illustrated that the inclusion of appropriate physical features was important to the three students. It also demonstrated how dialogue assisted students in the clarification of their design ideas and their ability to compromise. All three students were clear about the fact that their radio needed to look realistic and therefore spent a considerable amount of time ensuring they had the physical details of their design correct.

In Year 2 the physical attributes included: looking realistic, being large enough for the audience to see and being colourful (researcher notes 26 August 2008). The data suggests that the students took some of these criteria into consideration when they were asked to evaluate their plans using the criteria. In the first extract, Ellis is able to tell the researcher (R) that the changes they are making to their plan relate to the size of their prop and the ability of the audience to see it.

R:	Ellis, what change are you going to make to the wing?
Ellis:	Make them a bit bigger.
R:	Why are you making them bigger?
Ellis:	Cos they need to be bigger because umm....
Anne:	The audience need to see it.
Ellis:	See it.

It is interesting to note that all of the key examples identified in Year 2 were about the size of their fish. At this stage they did not articulate their understanding of the other two physical attributes: aesthetics and realism.

The above section illustrated that the students in Years 6 and 2 demonstrated an understanding of the planning process, as they were able to consider the required physical attributes when planning their designed technological outcomes, although in Year 2 fewer attributes appeared to be considered at one time. The next section illustrates that the students understood technological practice timelines and process.

Process of Planning - Practice and Outcomes

During the unit the students were required to draw a detailed plan of their designs, and in Year 6 they were also involved in identifying and planning their tasks to ensure their props were completed before the dress rehearsal of their production item.

Planning for Practice

Planning of their technological practice is one of the three components of Technological Practice identified in *The New Zealand Curriculum* (Ministry of Education, 2007). Understanding the scope of their task is an important part of this. In the first extract, Marco demonstrated understanding of the scope of the project in relation to the role of the final outcome during a conversation with his teacher, Clara.

> Marco: It’s kind of random how it takes three weeks to make [props for] a five minute play.
>
> Clara: I know. It is, isn’t it? But we’ve got to have it polished. Okay. It’s taken five weeks as well. More than that.

Planning for practice included the identification and sequencing of a task, identification of materials and the ability to ensure technological outcomes are completed on time. In this stage of the unit the students were made aware that props did require considerable time to plan and construct. Understanding authentic practice is critical in technology education, and in this instance understanding the time it takes to develop quality, culturally and historically situated props assisted Marco’s understanding of this.

Task identification and sequencing was also another critical aspect of planning for practice. In the next extract the Year 6 teacher, Clara, led a discussion to assist the students in the identification and sequence of the required tasks. This extract starts half way through the conversation as she worked though an activity asking the students to consider the tasks. The class as a whole have already identified a number of tasks and now they contribute to the addition of two more.

Clara: So if we come back to, we've decided on our materials. We've done our initial [brief], we've chosen our designs. We've come up with our initial brief. We've got sketches. What do we do then?

Mandy: Come together with all our ideas.

Clara: Good, so we've come up with our, we've chosen our design from our group. So we're combined in here. We've got our final design that we've come up together in a group and what do we do with that? Thomas, what do we do when we had a final design with the Space Stations? What did you make first of all before you went ahead and made the Space Station?

Thomas: Final brief.

Clara: Yeah. What do we do even we didn't have a final brief just yet? Sam.

Sam: A paper mock-up.

The extract above illustrated that Clara was aware of the technology process and articulated this understanding to her students. She almost made explicit links to a previous technology process undertaken by the students. As well as planning for practice the data suggested that students also learned how to plan their technological outcomes.

Planning Outcomes

In the development of films and plays, attention to detail with props assists in the quality of the production. Students became familiar with and used the design terminology. In the next extract, Teddy, Jay and Mandy continued their discussion about the features of their design to be included in their plan. They were discussing colour; demonstrating their understanding that their radio needed to look realistic and easily recognisable. This demonstrated their understanding that information such as colour needs to be included in planning.

Jay: What colours shall we paint it?

Teddy:	I reckon like a cream.
Jay:	What about black?
Mandy:	I reckon black, black or brown.

As above, this extract illustrated the students emerging understanding of the importance of detail in planning outcomes. In Year 2 the process of drawing a plan was modelled to the students. The modelled example was displayed in the classroom during this stage of the unit. In the next extract, the researcher approached Anne, Ellis and Adam and inquired what they were doing. Anne explained she was adding detail to her plan. By 'stuff' in the first instance, she meant labels and fish features such as eyes, gills and scales [Researcher Notes 26 August 2008].

R:	So Anne and Adam and Ellis are now, what are you doing, Anne?
Anne:	We're umm, making umm, we're adding stuff into our fish, our plan.
R:	Why are you adding stuff on your plan?
Anne:	Umm, just to see if, so...
R:	What are the things on the board that we've been talking about?
Anne:	We've been talking like, it has to look like a real thing and it needs to be durable hard and can't break and stuff like that.

The extract demonstrated that Anne's planned outcome was influenced by the class co-constructed attributes and that she understood the need for details to be added to planning. This section demonstrated that the students were developing an understanding of the process of planning their practice and their outcomes in Year 6, and just their outcomes in Year 2. In Year 6 this included the identification of materials. The next section evidenced learning in this area.

Materials - Identification and Function

An important aspect of developing a plan for an intended outcome was the identification of materials and their suitability for the intended design. This was best exemplified in the following extract, in which Alan, Minnie and Dougal identified materials they would like to use to form the head of their microphone.

Alan: Yeah, I'm pretty sure we'll do the old style mike…

Minnie: And what should we use for that?

Alan: Oh, I thought we'd make a big block of wood or ...

Dougal: Like, yeah a big block of wood.

Alan: And then maybe get something, wire or something?

Minnie: Yeah wire would get...

Dougal: Yeah, I thought wire umm......

Alan: And I thought probably a big block of wood and wire or something crisscrossed over the whole bit and then painted black.

Dougal: And not put tin foil on it?

Alan: No, you'd put tinfoil over all the other bits, then it would make it look shiny.

Minnie: What colour should it be.

Dougal: Oh yeah over all.

Alan: But before you'd, like you'd need to do quite a few layers of tinfoil.

Dougal: Yeah! and so it will be silver, the tinfoil?

Minnie: Yeah, we could sort of papier-mâché it maybe?

Dougal: No, you wouldn't, we couldn't, we couldn't papier-mâché it.

Alan: You could probably use like a craft knife and cut grooves in that.

Dougal: Yeah.

Alan: Yeah, you could just cut grooves with a craft knife.

Dougal: It would be more likely you'd need a pocket knife because craft knives aren't that strong.

Minnie: Yeah, something like that or something but then you would also need something that actually comes out there. So we probably want lots of like, tinfoil or something.

Dougal: Yeah. Or you could just completely paint the wood black and just put tinfoil over it.

Alan: Yeah, and then put lots of layers of tinfoil over it.

Dougal: Yeah.

Minnie: Yeah. What about the disc bits?

Dougal: We could just drop it into black paint.

Minnie: Whereabouts would we get the stuff from?

Dougal: Use doweling.

Alan: We've got doweling here.

Dougal: Yeah. Tinfoil's easy to get and so is umm,

Alan: Yeah, so a big block of wood rounded off at the edges though.

Dougal: Yeah right.

The extract illustrated that the group had insight into a variety of materials some of which they intended to use in their final design. Subsequently, the Year 6 students were given a thinking tool to assist them to critique their planned designs. The tool, 'Pros and Cons', required the students to look at their design and consider the good aspects of the design and possible disadvantages of their design. The next extract demonstrated that during the critique of their design, Minnie, Teddy and Jay considered possible construction materials.

R: Think about what are all the good things and then what are the cons. Because what you're coming up with is a cons. A con is all the bad things of a design. First I want you to think of all the good things about the design that you re going to make.

Minnie: Right, umm, what else is there?

Alan: Umm, materials are easy to get. That's the materials there.

Dougal: No, but they're easy to get as well.

Alan: We're not using, we're not using too much materials.

Minnie: Yeah.

Alan: Not too many materials.

Dougal: Not too many, umm, not, not a heap of

Minnie: Okay, what, what else?

Alan: Umm, easy to get the materials.

Dougal: That's the same thing as materials are cheap.

Alan: No. cheap is different.

Minnie: Umm, small usage of materials.

The above extracts demonstrated that at Year 6 students were able to consider potential materials and related impacts on their designs. They also demonstrated how all group members contributed to thinking about built concepts and design ideas of planned outcomes.

The Year 2 students were not required to identify appropriate materials for their designs, as the classroom teacher determined that the students would papier-mâché their flying fish. It was important to note here that the researcher was stating that these students were not involved in material selection, not that they were unable to consider suitable materials. Materials, and a number of other aspects of design, contributed to the functional nature of an outcome. In the section below the impact of functional attributes on designs is explored.

Attributes - Functional Features

The functional attributes identified by the Year 6 students included the need for the design to be safe to use and durable enough to last through a dress rehearsal and two shows (researcher notes 1 Sept. 2008). The data suggested evidence that the Year 6 students did consider these attributes when planning. For example, Mandy demonstrated her understanding that her group's designs needed to be durable by suggesting that papier-mâché would add strength to the final outcome.

Mandy: Okay. So it's going to be quite easy to make because we just need a big box and wire and it's not going to be made out of papier-mâché so it's not going to, so it's not going to take too long to dry. Okay. So easy to make. Not long to dry. Umm, it'll be easy to move.

Teddy: Yeah, easy to move if we put wheels on it.

Mandy: Yeah. But what type? Would we want wheels on it because we could just use them and then cover it with umm, a cardboard box and then it will stay strong. It's not going to collapse and umm, it's going to be like, easy because the boxes are hollow.

Clearly the need for their structure to be strong enough to last both performances and the dress rehearsal was important to Mandy; this illustrates that she was aware of and used the agreed attributes to guide her decision making. The 'Pros and cons' exercise was followed by the modification of design plans.

In Year 2 functional attributes also included durability and the need for the props to be lightweight and easy to move around (researcher notes 26 August 2008). There was no evidence that the students considered functional features while planning their designs. Again this could be for a number of reasons; one that these students, because of their age were less able to consider a range of attributes or that durability was a concept harder to grasp than other commonly considered attributes at Year 2. However, both groups of students developed specific skills for drawing a plan. These are discussed in the next and final section in this stage.

Planned Outcomes - Physical Skills

The final sub-element in the Planning stage was evidence of physical skills or technical knowledge. The students needed to draw a plan of their designs. As stated in Table 4.10, there were 10 examples of evidence of planning skills and knowledge in Year 6 and five in Year 2. Planning skills applicable in Year 2 included drawing the intended outcome and labelling the components. In Year 6, as well as the skills mentioned above, the students were also asked to draw from a range of views and draw and annotate designs to scale with measurements also noting materials. Identification of materials is evidenced in the 'Materials - Identification and Function' section above. Annotations, planning views and scale are discussed below.

Annotations

As a part of the planning process all students were required to draw and label their intended outcomes. Drawing annotated plans was a new concept for the Year 2 students. They were asked to draw what they intend to make and annotate important features of their design. Their ability to do this was best exemplified in the following autophotograph and associated extract. It illustrates a Year 2 student's knowledge and skill at planning their outcome. One of the photographs Rex took (Figure 4.5) was of his group's completed plan. During his Stimulated Recall interview the conversation about his plan indicated he understood how to annotate his designs.

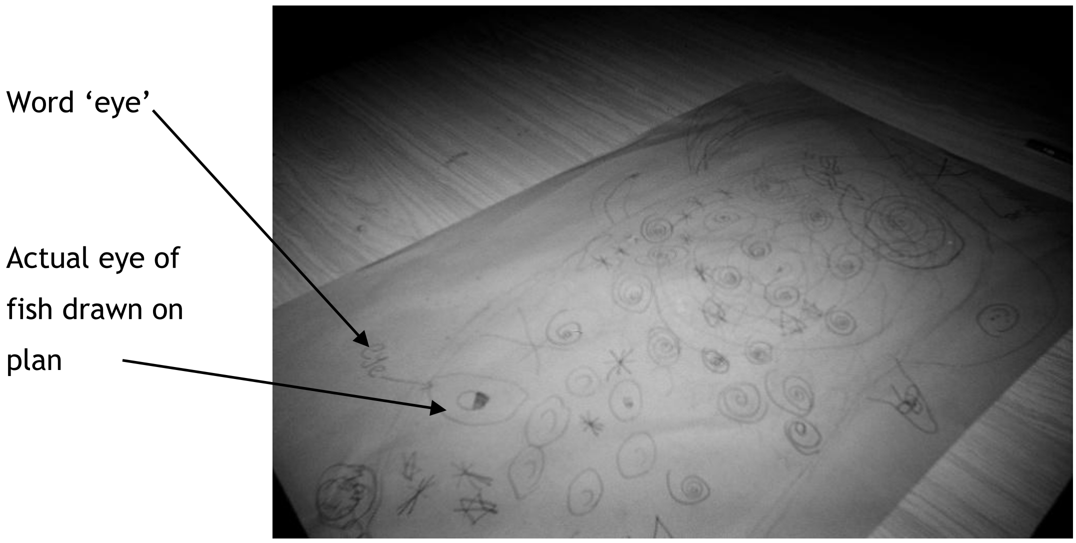


Figure 4.5: Rex's autophotograph of his planned design

R: So the first one that you drew, what was that called? It was called the...

Rex: Plan.

R: Tell me if I could look at your plan, what things would it tell me?

Rex:	It would tell you, umm, what, what it looks like.
R:	Okay, what's this part of the fish?
Rex:	It's the eye.
R:	And so what's this word here?
Rex:	Eye.
R:	So why have you got that word written there?
Rex:	Well, we write eye there and then we do a, a point where umm, where the eye is [Stimulated Recall Interview 12 September 2008].

The evidence suggested that the Year 2 students understood that the purpose of their plan was to give information about their intended outcome, to assist in the process of construction, and that they were able to draw their intended outcomes from one view or aspect and annotate main the features.

Planning Views

In Year 6 the students' work indicated that they were able to draw designs form a variety of aspects or views. This is best evidenced by Mandy who indicates her skill and understanding of, and ability to draw her design from three different aspects, front on, side on and top down when she talked to the researcher.

R:	What's something you can do is, while Teddy's drawing like a front view, somebody might be able to do a side view.
Mandy:	That's what this is.
R:	And it shows the dials, how they stick out.
Mandy:	Yeah. That's the top view, coming down from the top so you can see how the speaker fits in.

Scale

Students work at Year 6 also indicated that they understood and were able to use an appropriate scale in their planning. The next extract came from Alan's stimulated recall interview. During the planning stage of the unit he requested that someone photograph him drawing a scale up the side of their planning paper (Figure 4.6).

Alan:	And that was doing our plan of the props.
R:	Tell me about the details that you put on your plan.
Alan:	We put like scale and yeah, just all that sort of stuff.
R:	So how did you know to put all that stuff on a plan?
Alan:	Well just because plans have like scales and all that.
R:	So how did you know that?
Alan:	Because I've seen, like, plans that my Dad makes and stuff.
R:	So does your Dad deal with plans quite a bit?
Alan:	He designs, like, rally cars and stuff.
R:	So you've seen plans before.
Alan:	Mmm [Stimulated Recall Interview 26 September 2008].

Figure 4.6: Autophotograph of Alan drawing a scale down the side of his planning paper

Alan added the scale to his plan in this manner at his own initiative. The class had previously been involved in a discussion about scale, but no instructions were given as to how to do this. This extract was significant because it demonstrated that Alan was able to transfer a skill has obtained from his father, who is a designer, to his technology project.

This sub-element demonstrated a range of skills and knowledge the students gained and implemented in planning their intended outcomes. The students clearly demonstrated the relationship between attributes established through engagement in the Character and Function stage of the unit and the planning of their intended outcomes. The data suggested that the Year 6 students considered a wider range of factors when planning their intended outcomes. The most significant area of focus for the Year 2 students was the inclusion of the required physical attributes, such as it looking realistic and the necessity for the outcome to be easily seen by the audience. The Year 6 students, on the other hand, were able to consider a wider range of features including suitable materials and their relationship to the physical and functional features. They also included more sophisticated planning techniques such as scale, dimensions and planning form a variety of aspects or views.

4.5.4 Comparison Between Stages

This section compares the data across this stage and the same element in the first stage, Character and Function. The same four elements identified in the Character and Function stage were used to analyse the data in this stage. Each element was divided into sub elements. While the differences between years are reported after each sub-element, this section will report the differences between the stages Character and Function and Planning. The section will be divided into four further paragraphs one for each element

In the element Funds of Knowledge the same two sub-elements emerged from the data: Passive Observation and Enculturated Participation. Incidences within each were similar. In Year 6 the number of incidences in which Funds of Knowledge were employed was similar across both stages. In Year 2 incidences in the first stage were considerably more frequent than they were in this stage.

In the element Making Connections, the categories differed slightly from those in Character and Function. ‘Prior Technology Learning’ in the Character and Function Stage was divided into two in the Planning Stage: ‘Making Temporal Connections’ which included use of the knowledge learned in the previous technology unit, and ‘New Knowledge Learned’, the application of knowledge learned earlier in the current unit. ‘Physical Prompts - real artefacts or images’ from Character and Function were not identified separately, but subsumed into the new sub-element, ‘New Knowledge Learned’. This was because links were made to learning through the use of prompts in the current unit and to develop understanding as well. The remaining category, Knowledge - Other Disciplines is the same as in the Character and Function section. The data also showed that both teachers and students drew on knowledge from other disciplines in both stages.

In the Management of Learning element, both Character and Function and Planning stages feature the facilitation of Higher Order thinking, peer discussion, and transmission clearly in the data. In Character and Function, the drawing out of predetermined answers was demonstrated frequently. When questioning in Planning, teachers checked for students’ understanding rather than requiring a specific response. Another difference noted between stages in the sub-elements of the unit, was that external experts were only brought into work with the students in the initial stages of the unit, so did not feature in the Planning stage, although they are referred to on occasions. The final difference noted was that, in Character and Function, a number of specific strategies were introduced to engage students in critical thinking and focussed conversation.

In the Technological Skills and Knowledge element, conversations about desirable attributes of props feature prominently in each stage. In the Planning stage the physical and function features of props are evident in Year 6, while Year 2 students only consider the physical features. Consideration of suitable materials is common to both stages in Year 6 while less important in Year 2. In the Planning stage, students demonstrated knowledge of planning skills and the planning of their practice, where as they did not in the Character and Function stage. While the elements remain constant between the two stages, the sub-elements differ as the focus of the unit changes as technological practice progressed.

4.6 Chapter Conclusion

This section concludes this results chapter in which the researcher reported findings from data gathered during the implementation of a technology unit in an urban primary school in both Year 2 and 6. This chapter presented the results for the first and second stages of the props technology unit in which the students developed an understanding of the character and function of props (Stage 1) and learned to plan a technological outcome (Stage 2).

Stage 1 of the unit required the students build up an understanding of the nature of props, the roles they play in a stage production and desirable attributes for props. The students in both classes undertook a series of planned activities, some together and some separate, to facilitate the development of understanding the character and function of props. Stage 2 required the students to plan their intended outcome - props for their school production item. In Year 6 this included props from the 1896 to 1936 Olympic Games, and in Year 2 flying fish to illustrate a Taiwanese fishing tale. This chapter investigated, in-depth, the data as the students undertook these first two stages. At both stages in each element, sub-elements were identified and discussed with illustrations. At the conclusion of each element a comparison between Years 2 and 6 was made. The chapter concluded with a comparison between sub-elements in Stages 1 and 2.

There were several exciting findings in the data in this chapter that enabled insight to learning in technology education. The data presented showed that students were able to deploy knowledge from their cultural, home and community based activities to assist them in developing an understanding of the character and function of props. Students did this in an unprompted manner, and clearly used their home and cultural knowledge and experiences to assist in developing key understanding and skills about the nature of, and planning technological outcomes . Funds of Knowledge (Gonzalez, et al., 2005) were also deployed in a more practical way when the students were planning their technological outcomes. Links were made to physical skills and knowledge of planning technical outcomes experienced either directly or indirectly. It is also interesting to note that, students not only deployed knowledge and skills in which they had direct and first-hand experience of, but also deployed knowledge gained through passive means.

Students also deployed knowledge gained at school from previous technology and other curriculum learning areas to assist in building up an understanding of props, and in the planning of their proposed technological outcomes. In both stages, at times connections to prior school-based learning was intended and specifically planned for by the teachers. However, at other times students made connections to prior school-based learning with little or no prompting. Students appeared motivated to develop quality props for their class production items, and therefore drew on knowledge from a variety of sources to assist their practice.

Data presented in this section suggests that teachers and students used a variety of strategies to manage learning. These included direct transmission of information, to implementation of specific strategies to engage higher level thinking. One of the surprising findings of the data in these stages, was the level of student engagement at times when working independently, and that students frequently managed each others' behaviour to ensure peers were on task and contributing. The data presents a range of specific strategies that were implemented to assist students' higher level understanding at both stages. These strategies appeared to be effective, as the fourth element at both stages provides evidence that the students clearly understood the character and function of props and were able to effective plan their intended technological outcomes.

The final element at this stage evidences the effectiveness of technological learning throughout these initial stages. The data suggests that the students gained a very good understanding of the character and function of props, and that they were able to plan suitable technological outcomes. The students were able to co-construct the development of desirable attributes and were able to refer to these attributes during the planning stage. Students at both levels appeared to understand the concept of planning a technological outcome, and in Year 6 the students were able to identify suitable materials and recognise that planning needed some form of scale.

In this chapter the researcher has reported findings from data gathered during the implementation of the initial two stages: Stages 1 and 2, of a technology unit taught in a urban primary school in both Year 2 and 6. The next chapter, Chapter 5 will discuss results for the concluding two stages: Stage 3, Mock-up and Stage 4 Construction.

Chapter 5. Results - Mock-up and Construction

5.1 Introduction

This chapter evidences the technology learning within the students' practice across all four elements in the second two stages: Mocking Up and Construction, as outlined in Tables 5.1 and 5.2. The third stage 'Mock-up', involved the development of a three dimensional representation of their design using inexpensive materials. The fourth stage, 'Construction' saw the students construct and evaluate their props. As in Chapter 4 and outlined in Table 4.2, further sub-sections are identified later in this chapter within each sub-element and outlined in

Table 5.1: Overview of Elements and Sub-elements in Stage 3 Mock-up

Stage	Elements	Sub-elements (SE)	Yr 6	Yr 2
3: Mock-up	Funds of Knowledge	Passive Observation	0	0
		Participatory Enculturation	1	6
	Making Connections	New Technology Knowledge	7	6
	Management of Learning	Students Managing Students' Behaviour and Learning incorporating Peer Discussion	10	5
		Assisted Learning (includes specific instructions and Higher Order Thinking)	10	8
		Teacher Assisting Collaboration	4	2
		Transmission	3	1
	Technology Knowledge and Skills	Understanding Purpose of Developing a Mock-up	20	12
		Understanding Technology Process	3	1
		Working Collaboratively including Task Allocation	2	2

additional tables where applicable. In Chapter 6 the research questions are answered using detailed discussion of elements and stages.

This chapter details key conversations in both Years 2 and 6 in all four elements. Conversations are classified, analysed and illustrated where applicable. An overview of the lessons in each stage was presented at the beginning of Chapter 4.

Table 5.2: Overview of Elements and Sub-elements in Stage 4 Construction

Stage	Elements	Sub-elements (SE)	Yr 6	Yr 2
4: Construction	Funds of Knowledge	Passive Observation	2	0
		Participatory Enculturation	11	2
	Making Connections	New Technology Knowledge incl. Links to Attributes	9	7
		Knowledge - Other Disciplines	2	0
	Management of Learning	Teacher Assistance with Construction	25	8
		Assisted Learning (incl Higher Order Thinking)	13	21
		Student Facilitation of Construction	8	1
		Task Management Prompts	7	5
		Managing Students' Behaviour (teachers)	5	6
	Technology Knowledge and Skills	Emerging Construction Ideas	31	8
		Construction Skills	9	10
		Suitability of Materials	6	0
		Task Allocation	6	22
		Understanding Technology Process including links between construction and attributes	2	16
		Product Evaluation	2	16

5.2 Stage 3: Mock-Up

Developing a mock-up of their designs was an important part of the students' technological practice. Mocking up an intended design as form of functional modelling, helps the students understand and evaluate the physical and functional natures of their designs. Through technological modelling, evidence is gathered to justify decision making within technological practice. Such modelling is crucial for the exploration of influences on the development of the proposed outcome, and for the informed prediction of the possible and probable consequences of the proposed outcome. Technological modelling is underpinned by both functional and practical reasoning. Functional reasoning focuses on 'how to make it happen' and 'how it is happening'. Practical reasoning focuses on 'should we make it happen?' and 'should it be happening?' (V. Compton, 2010, p. 1).

The purpose of the lessons in the ‘Mock-up’ stage of the unit was for students to develop a three dimensional model of their intended technological outcomes, to assist them in the evaluation of their designs. Students were required to develop a mock-up model of their design and undertake evaluation by obtaining stakeholder feedback and considering the required attributes. They then made any necessary modifications to their design before completing their final props.

This section explores the conversations that took place during this stage of the unit. It is divided into discussion in the key elements the framework: Funds of Knowledge, Making Connections, and Management of Learning, and Technological Knowledge and Skills.

5.2.1 Overview of Lessons

The mock-up section consisted of three lessons with the learning intentions “create a mock-up for identified technological outcome”, “present ideas to stakeholders and note feedback” and “evaluate and react to feedback making prop more effective” (Teachers’ Props Design Unit Plan, Appendix 15). This occurred subsequent to the drawn plans of their designs and prior to the construction of the props. Developing a mock-up is identified in *The New Zealand Curriculum* (Ministry of Education, 2007) as an aspect of functional modelling. *Technological modelling* refers to modelling practices used to enhance technological developments and includes functional modelling and prototyping. *Functional* *modelling* allows for the ongoing testing of design concepts for yet-to-be-realised technological outcomes (Ministry of Education, 2009a, p. 1). Developing a mocked-up design is one aspect of functional modelling.

In the first of these lessons the students constructed a version of the planned outcome using paper, staples, ice-cream sticks, cardboard and hot glue. The models were to scale. In Year 6 they were smaller than the intended outcome and in Year 2 the models were the same size as the intended final outcome.

Three-dimensional mock-ups using easily manipulated material such as clay, cardboard, styrodur, and CAD software, are often used to enable design ideas to be evaluated in terms of appearance and function (Ministry of Education, 2009a, p. 2). Therefore, functional modelling should occur extensively in the early stages of technological practice, when establishing whether the design concept being developed has worth (in its widest social sense) and when 'what if?' questions need to be asked and explored. Early stages of functional modelling often employ 'guestimation', based on similar technological outcomes and developments and/or drawing from other 'known' situations or past problems/issues (Ministry of Education, 2009a, p. 2).

Although developing a mock-up is an integral part of the planning process, it was identified as a separate theme in this study because the data indicated, through their self-taken photographs, that the students clearly identified their mocked-up designs as a significant part of their process.

The second of the lessons was implemented quite differently in each level. In Year 6 the students took their mocked-up designs to stakeholders - potential audience members and staff in the school. They recorded feedback from both the students and teachers of other classes in their syndicate. In Year 2, the main stakeholders were identified as themselves and their classroom teacher. She facilitated a self-evaluation process with the students using the co-constructed attributes listed in the previous stage. The third lesson in both classes involved the students making modifications to their designs based on the stakeholder feedback and the co-constructed attributes for props.

As in the previous two stages, the key conversations were classified and analysed in each of the first three elements: Funds of Knowledge, Connections and Links and Managing Learning in both Years 6 and 2. This section identifies and discusses each element in turn, with identification of sub-elements and sub-sections in each element. Each sub-element concludes by noting the differences between Year 2 and 6. The section conclusion gives an overview of the elements and notes the differences with the same elements in the Character and Function and Planning stages.

5.2.2 Funds of Knowledge

In the Mock-up stage of the unit the students developed three dimensional models of their designs using cardboard and other easily obtainable and inexpensive materials. This element explores how students used their Funds of Knowledge to construct and evaluate a mock-up of their designs. At this stage, only one sub-element; Participatory Enculturation occurred. In Year 2, there were six examples of Participatory Enculturation and in Year 6 there was only one example of use of Funds of Knowledge, and this was in Participatory Enculturation. These results are summarised in Table 5.1.

The first sub-element, Participatory Enculturation involves being enculturated into an activity through engagement. This engagement included active participation, where a child was actively involved in the activity, and peripheral participation where the child was on the periphery of the activity but able to engage in the activity through questions and conversation.

In this element, as in Stage 2 Funds of Knowledge, parents' activity played a role in knowledge brought to the task by the students. Students used experiences from home to assist their understanding of what they were doing. Parent activity influenced Dougal's knowledge of suitable materials in the construction of their design; this is illustrated in the following extract. Initial identification of construction materials was a component of the mock-up phase of the unit. In the extract, the Researcher was talking with Alan and Dougal about a suitable material for the stand of the microphone. Dowelling came up as a possible option but the Researcher was not sure how large (in diameter) it could be obtained. Dougal mentioned that his dad has some quite large dowelling, which Alan likened to a broom handle.

R:	I'm not sure how big it comes.
Dougal:	My Dad had stuff about that big [indicates circle approximately 25mm using thumb and first finger].
Alan:	Yeah broom handles are large dowelling.

The Year 6 extract illustrates how activities and practices of parents influence the students' knowledge and their ability to contribute to problem-solving situations. Dougal is able to contribute to the conversation as he drew on knowledge from the materials his father had available at home, which Alan compared to a broom handle.

In this stage, this sub-element is somewhat expanded to include recreational pastime activities of other caregivers. This is best illustrated through a series of two extracts from Year 2. The first conversation occurred between Anne, Ellis and Adam as they were constructing their mocked up flying fish. The students were required to cut two copies of their fish back-to back and staple them together, leaving a gap in the belly of the fish for stuffing (scrunched newspaper) to be inserted. While stuffing the paper into the belly of their fish, Ellis relays a story told to him by his grandfather about catching a large fish while participating in a fishing contest.

Ellis:	[My Granddad] caught a salmon and it was one of the, he went in this contest and umm, the biggest, umm, it was the second biggest salmon.
Anne:	Was your Granddad's fish the second biggest fish?

Ellis: Yeah.

Adam: Woo.

Ellis: It was massive. It was about this, that big. It was massive.

This perhaps in isolation this appears irrelevant to the mock-up stage of a design, however, it illustrates that Ellis understands fishing as an authentic activity. It also helps understanding of the following extract and second example of the use of Participatory Enculturation in Year 2. In this extract, Ellis and Anne were comparing the process of stuffing their mock-up with paper in order to get a three dimensional effect with the process of gutting and or filleting a fish. Ellis suggested that rather than removing salmon flesh from the fish they were, in-fact, adding to the fish. Anne agreed but used the more general term 'meat' rather than salmon.

Ellis: Yeah, like we're actually putting all the salmon into the fish.

Anne: All the meat into the fish and not all meat out of the fish.

This extract indicated that both Anne and Ellis had knowledge of gutting and filleting fish. At aged 6 these are activities that would be done with adults. Taking children fishing is common practice for grandparents and parents in the students' community and culture. The data illustrated that the students' were able to deploy their knowledge of gutting fish to the activity of stuffing their own fish to make them realistic; it was evidence of their conceptual knowledge of a three dimensional fish and that the insides of fish were responsible for aspects of its shape, thus authenticating the activity for them.

This data above suggests that both Year 2 and 6 students used Participatory Enculturation in the mock-up stage of the unit, although Year 6 not as frequently as Year 2. In Year 2, students drew on community knowledge and experiences to make sense of the activities they were doing in class. This was also demonstrated in Year 6 but only once.

5.2.3 Making Connections and Links

In order to situate learning and to assist students in their understanding, teachers made explicit links and connections to prior school-based learning and experiences they knew their students had shared. This element differs from the equivalent sections in Character and Function and Planning Stages in that there were connections in only one sub-element: New Technology Knowledge. This data is summarised in Table 5.1.

New Technology Knowledge

As the unit progressed so did the opportunity for teachers and students to make links to prior learning within this unit, as opposed to Making Temporal Connections, which was seen in Stages 1 and 2, and which refers to knowledge from previous technology units. In the 'Mock-Up' Stage this meant direct links to learning in either the 'Character and Function' or 'Planning' stages. In Year 6, of the seven examples of Making Temporal Connections, two came from learning in the Character and Function stage and the other five came from the Planning stage. The students referred to their plans to inform the development of their mock-up more than they referred to the learning undertaken in Stage 1 Character and Function. This is not surprising as the students would have been more likely to refer to the Character and Function Stage when they were developing their plans. Once accomplished, the plans would then become the main point of reference to prior learning. The extract selected to illustrate this came from Mandy in Year 6, during her Stimulated Recall interview. Mandy explained one of her autophotographs which can be seen in Figure 5.1.

In the discussion about the photograph, Mandy states that she used information gained in internet research undertaken in Stage 1. She also referred to one of the attributes - 'needs to be strong and durable' determined at the end of Stage 1.

Figure 5.1: Mandy's autophotograph of her mock-up radio

Mandy: That's the inner structure and then we've got the paper bit that goes over the top that was made of cardboard and that was, and then made of wood

R: How did you come up with that design and shape?

Mandy: Well it kind of needed to be strong, so it would be the strongest if you kind of had something to support it. So an inner structure, and then you needed to make it look like a radio so we put a cover thing over the top.

R: Now when you, when you were doing your planning, how did you learn about what an old, well first of all, the radio, where did it, what era did it have to come from?

Mandy: 1930s.

R: How did you go about finding out what a 1930s, because by the look of it, you understand here that it needs to look like a radio. So how did you know what it was going to look like?

Mandy: We went on the internet and we searched pictures of old radios and in books as well and so we knew kind of roughly what size they were compared to the other things in the picture. And what colours.

R: When you said other things in the picture, so [what did you mean]?

Mandy: Like just say there was a chair in the picture, like an average sized chair and the radio was taller than it, then we can just measure against a chair.

This extract illustrated that relevant aspects of earlier lessons were used to inform current learning in the Stage 3-Mock-up. In Year 6 more connections to Stage 2 were made than to Stage 1. In Year 2 this was reversed. Four of the extracts in Year 2 were informed by Stage 1 learning and two by Stage 2 learning. The first example occurred as the students were beginning to construct their mock-up. The Researcher was talking to Anne, Ellis and Adam about the features of their mocked-up design. Anne immediately recognised that the information she needed was on the model plan the Researcher had developed in a Stage 2 lesson, and Ellis and Adam were also able to recall features of flying fish from Character and Function or Stage 1 lessons.

R: Yesterday, what were you looking at to help you know what the flying fish had?

Anne: Your plan.

R: Yes, my plan.

Anne: And you put wings on them and fins.

R: What else did you see yesterday that helped you?

Ellis: That video over there, the video that we had.

R: Tell me about that?

Ellis: Well, there was lots of flying fishes and flying fishes in that video.

R: Great. Thank you. Adam, what have you learned about flying fish?

Adam: That fish can fly.

This extract also illustrated that teacher questioning facilitated links to prior learning within a unit. It was intended that this questioning sequence would assist the students' mock-up because it assisted recall of a visual image of their intended outcome.

The obvious difference in this element between Year 2 and 6 was the stage from which lessons were recalled. Given that the Year 6 students worked independently on their mock-up, informed by their planning, it is not surprising that they deployed more knowledge gained in Stage 2. In contrast, the Year 2 students needed assistance to develop a mock-up using knowledge gained from images of their intended outcomes learned in Stage 1 more than Stage 2. Through this stage, a range of strategies continued to be used to assist students' learning. These are discussed in the next section.

5.2.4 Management of Learning

A number of management strategies to assist learning were implemented throughout the Mock-up stage of the unit. As in the other stages, these aimed to develop students' thinking skills as well as developing their understanding of constructing a mock-up to evaluate a planned technological outcome. In Year 6 there were 27 relevant examples in Management of Learning, and in Year 2 there were 17 in five different sub-elements as seen in Table 5.3.

The first of these was 'Students Management of Behaviour', which at this stage included peer discussion. The students in both Year 6 and 2 used talk to refocus their peers and keep them on task. In Year 6 there were 10 examples, and in Year 2 five. The second sub-element is Assisted Learning - including specific instructions and Higher Order Thinking, with 10 examples in Year 6 and eight in Year 2. The next frequently populated sub-element in Year 6 was Teacher Assisting Collaboration, with four examples with two examples of each in Year 2. The final sub-element at this stage was Transmission with three examples in Year 6 and two in Year 2.

Table 5.3: Summary of Management of Learning

Sub-elements	Year 6	Year 2
Students Managing Students' Behaviour and Learning incorporating Peer Discussion	10	5
Assisted Learning (includes specific instructions and Higher Order thinking) *Teacher Assistance* *Student Assistance*	10	8
Teacher Assisting Collaboration	4	2
Transmission	3	2
Total	27	17

In the sections below, the sub-elements are discussed and illustrated with examples from the data. In some cases sub-elements are further divided into sub-sections.

Students Managing Students' Behaviour Incorporating Peer Discussion

While constructing their mock-up designs all students worked within their allocated groups of three. One of the surprising aspects found in the data at this stage, was the extent to which both Year 6 and 2 students managed their own behaviour and that of their peers. A number of students were aware of group tensions and attempted to solve related problems. The students recognised and reacted to what appeared to be non-collaboration. The extracts selected show a number of strategies used by one team in an attempt to solve conflict. In the first, Minnie attempts to understand why Dougal had difficulty working with Alan. The second goes some way to explaining the differences between Alan and Dougal - different design ideas and that Dougal was able to let his idea go and proceed with Alan's design. In the third Minnie used a direct technique by asking Alan to work with the group.

In the first extract Minnie and Dougal were talking about the building of their mock-up. Dougal was frustrated with Alan and Minnie attempted to get to the bottom of the problem and then reported it to their classroom teacher Clara.

Minnie: We are really going to have to suss this out. Don't you like Alan running everything? [Dougal shakes head] Why not?

Dougal: Because he doesn't listen.

Minnie: Yeah, [to classroom teacher] Dougal's really upset because he doesn't like Alan's [attitude] and they're not talking.

Clara: Oh no that's no good.

One of the tensions between Alan and Dougal was that Dougal believed that Alan did not listen to his design ideas. Dougal and Alan had very different design ideas for their microphone stand, as can be seen in Figures 5.2 and 5.3. The idea presented in Alan's design, Figure 5.3 was the one selected for the final design.

Figure 5.2: Dougal's autophotograph of his mock-up stand for a microphone

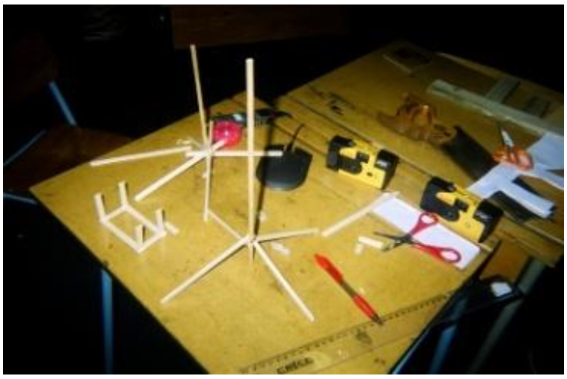


Figure 5.3: Alan's autophotograph of his mock-up stand for a microphone

In the study the students were each given a disposable camera and asked to photograph aspects of the unit that were important to their learning. It can be seen in Figure 5.2 and 5.3 that Dougal and Alan thought enough of their mock-up designs to warrant taking a photograph. However, at his Stimualted Recall interview with his autophotographs Dougal suggested that he chose not to pursue his design further, indicating he was happy with Alan's design.

Dougal:	That's my stand and yeah.
R:	So tell me about what happened with your stand?
Dougal:	Well, it kind of broke and yeah.
R:	What did you think of the design?
Dougal:	Well, I thought it was sort of good but, yeah.
R:	Why did the team go with this stand instead of your stand in the end? Do you know why?
Dougal:	Because I chose to.
R:	Pardon
Dougal:	I chose, yeah.

This illustrated that although Dougal was very frustrated with the way he perceived he was treated by Alan, he was ultimately happy to go with what he thought to be the better design, suggesting that it is not whose design was selected but rather how the process was undertaken that was a source of frustration. It is interesting to note that after this stage in the process this group split into two sub-groups. Alan continued to work on the construction of the stand and Dougal and Minnie worked on the microphone head. The saga of conflict continued and later Minnie and Dougal attempted to get Alan to work with them.

Dougal:	This one's not perfect.
Minnie:	Yeah, it's not good, but I like that one.
Alan:	No, because it's just too much work and we're way behind. I need to cut this, then I can get,
Minnie:	No, Alan. Work with us.
Dougal:	Come on Alan.
Minnie:	Do you think this looks appropriate for our 1930s microphone?

Alan: Yeah. Okay. Come on, you guys. Okay, well you, could you design an actual survey while I finish this off? [Pointing to his mock-up stand]

During the mock-up stage of the unit, students realised the necessity of working collaboratively and attempted to engage each other.

Assisted Learning

Table 5.1 tells us that there were 10 instances of assisted learning in the Mock-up stage of the unit in Year 6 and eight in Year 2. Assisted learning is a term used to describe when a teacher or a student assisted fellow students to move on in their thinking and or practice. It included the giving of instructions and strategies to facilitate High Order Thinking.

Teacher Assistance

A variety of strategies were used by the teachers to assist learning. It is interesting to note that many of the instances in Year 6 focused on the students working independently through their design process. Independence was a characteristic that the Year 6 teacher, Clara valued in her students. This was a skill which she had worked on throughout the year, “I’d rather let the kids experience it for themselves and if I can set them up with interesting tasks or, and like this is fantastic and it’s right up my alley”. Facilitating independence to assist students was illustrated in the extract below. Clara recapped some of the tasks students had done, and at the same time reminded those falling behind what was to be done. She also took this opportunity to reinforce the value of constructing a mock-up design before the final outcome was constructed and finally asked one of the students to articulate his experience of visiting a stakeholder, and to discuss the subsequent changes made to his design.

Clara: Oh, but it’s part of your group so that’s the other thing. It would be good if you were to take responsibility for your group work. I wrote two things up here to remind myself to talk to you about them because I think we realised, today, that it's highly important to make a mock-up. Once you've got your mock-up, also we learned a few things from our, visiting our stakeholders. So who's made some changes after looking at their mock-up? Yeah. Lots of people. Certain things didn't work or it didn't look quite right or you thought maybe a little bit hard to make that. Okay. You guys should have had your hands up because you had to change your mock-up, after you visited your stakeholders. Marco, can you explain to us what happened when you took your mock-up to visit the stakeholders and who did you go to see?

The above extract illustrated three strategies Clara used to assist student learning. Firstly she reminded her students about the importance of working independently and taking responsibility for their work. Secondly, she explained what some of the students had done, thus reminding those who had not finished what to do next. She then facilitated the sharing of some post-stakeholder feedback modification by a student, and she reinforced the value of the mock-up stage in the technological process.

In Year 2, the Researcher in the role of classroom teacher, used modelling to assist the students to create three dimensional models from the two dimensional plan. This was undertaken because of previous experiences the Researcher had had working with six classes of Year 4 students in the same city. She noted that many of the Year 4 students struggled with the concept of making a three dimensional model from a paper plan until the process was actually modelled to them.

R: No, no wings. This is just the fish's body. So, so once you've done your plan, and, and we'll maybe do this after lunch, then you start to do your mock up. To do your mock up you draw the shape just of the body and then you cut out two of them. So you, I had two pieces together and I cut around them. Okay. Once they're cut out, then you go and staple around the edge but I've left a bit of a hole so we can finish stapling but I thought we could leave, whoops, a little bit of a hole. Why do you think I might leave a bit of a hole? Put your hands down. Everybody think. Moke, why do you think I might have left this hole? [Undertaken while demonstrating the process to the students].

This extract illustrated modelling, an important strategy used to assist learning in technology. Assistance continued from the teacher and the Researcher as they rotated around the groups as the Year 2 students attempted to work independently on the construction of their mock-up. It could be argued that modelling assisted the students as it assisted them to move beyond what they were currently capable of.

Higher Order Thinking

Teacher Assistance also included dialogue with students, to facilitate student higher order thinking about the role of a mock-up and design by not telling the students the answers, but rather by facilitating their thinking to assist them in understanding and justifying their design decisions. This was exemplified in the extract below as the Researcher challenged Mandy to consider how materials in her final design might be joined.

R: Have you thought how you're going to join?

Mandy: Umm, yeah, we'll probably just use hot glue, wait for it to dry and then nails it as well and if we can get hold of bracing, then we might put that there…

R: Tell me about bracing. What's that?

Mandy: Umm, well it's metal and it's got holes in it. You can put nails through it and it will bend so you can fix the corners together.

Joining is often an aspect of technology practice that is over looked or assumed. The above extract illustrated how the Researcher facilitated students' thinking about joining techniques, mechanisms and substances.

Student Assistance

In Year 2, the process of developing a mock-up included drawing the body of the fish, then cutting out two copies. These were stapled together, decorated and stuffed. After the body was completed, coloured wings and fins were also drawn, cut-out (two of each) and attached to the fish body. The final mock-up for one Year 2 group can be seen in Figure 5.4. During this process the students also used what they had learned to assist their group members. This is best illustrated in the extract below. Adam's task was to draw and cut out the wings for the mock-up. He wanted to copy the one that the Researcher had done as a model for the students, Anne and Ellis thought that they needed to do their own design so Anne offered a strategy that she perceived would assist Adam complete his task.

Adam:	What about that?
Ellis:	No, we're doing it.
Adam:	Why don't we do it? How? I am going to copy that [points to Researcher mock-up]? I won't be able to [do it by myself].
Ellis:	You're not, you do it your own way.
Anne:	That does not look right.
Adam:	No, I'm doing…
Anne:	No, Adam I'll show you how a wing can look like and then I'll rub it out and then you have a try .How about that?
Adam:	No. What are you doing?
Anne:	Yeah, that looks like a wing. It might need to be slightly bigger though.
Ellis:	It does, it does
Adam:	Hey, I'm doing that.

Figure 5.4: Anne's autophotograph of her groups' mock-up

This extract illustrated a willingness on Anne's part to assist Adam so that he would be able to contribute to the group's mock-up by drawing the wings independently. It is interesting to note that she did not offer to do the whole task for Adam, but rather drew him some 'guidelines' to enable him to complete the task.

Teacher Assisting Collaboration

In order to successfully complete one outcome per group of three, the students needed to demonstrate co-operation and compromise. Very clear expectations were set by the teachers that the students needed to work collaboratively. At times this proved difficult for a number of groups and teacher intervention was needed. In Year 6 there for four instances of teacher assisting collaboration, and in Year 2 there were two. Although the data numbers are not high in this section the relevance cannot be underestimated. Even a single intervention with one group had the potential of influencing all future practice for that group. This was exemplified when the Researcher reminded Alan that although he had a good idea he needed to articulate it carefully to his group members so that they understood where he was coming from: "Alan, if you've got a good idea in your head, you need to explain it to him. Maybe you can show him by making a mock-up of it." This extract demonstrated explicit instruction to a student to assist the level of collaboration within the group. In another example, Clara the Year 6 teacher continued to assist the same group with their co-operation skills. Alan, Minnie and

Dougal were getting ready to show their mocked-up designs to stake holders. Alan took longer to complete the second mock-up of the microphone stand, than the other two did the microphone head. He had suggested that they determine some questions to ask the stakeholders. Minnie and Dougal were reluctant to do that without Alan. Clara intervened when she inquired about their progress.

Clara:	All right guys how are you going?
Alan:	I don't want to ask anything because they [Minnie and Dougal] haven't done a survey or anything, about in the designing of anything and they don't know what they are asking.
Minnie:	We can ask if our mike is appropriate for the era.
Alan:	But that sounds geeky and weird.
Clara:	What would you like to say?
Alan:	[No reply, shakes his head]
Clara:	Well, there you go. You haven't got anything. You can't say that sounds geeky and weird and not have something else to offer.

Illustrated in this extract is that fact that this teacher did not let the students get away with blaming and putting others' ideas down if they did not have something better to contribute. In this way she gave a clear message to the students that they were expected to contribute. The last Year 2 extract typifies comments by the teachers, "You need to talk to each other, okay. It's not one person's idea. It's three people's ideas". This extract illustrates that the teachers actively taught collaborative skills as a part of their assistance to students. Transmission of information also played a role in the Mock-up stage of the unit and is discussed in the section below.

Transmission

Table 5.3 shows that there were five instances of transmission in total in this stage, three in Year 6 and two in Year 2. As in the two previous stages, transmission describes instances when students are given direct information by their teachers. In Year 6 this tended to be a list of instructions for aspects that needed to be covered in the lesson as in the extracts below by Clara, the Year 6 teacher.

Clara: So today, you really need to be getting to your mock-ups so that we're going to have work hard to finish off your plans, check them with me so I can see that, yeah, you've thought everything through. Go back and check on your initial brief to see whether on your plans, you have outlined how you're going to meet those specifications that you decided on. When you make your mock-ups, you'll have to think about what materials you want to use. We've talked a little bit about making your mock-up to a particular scale just so we can get a general idea of what it's going to look like, especially if you are using some kind of mechanism. So make sure you detail those sorts of things really, really well. Alright, and when you make it, you could just show us how that's going to work because there's no point in not getting it right in the mock-up stage and getting halfway through making it and get to the final point and it doesn't [work]. So that's why we need to go through this mock-up stage now. Once you've made your mock-up, you need to check with our stakeholders.

This data illustrated that the Year 6 teacher gave explicit expectations about what was to be covered in the lesson to follow. In Year 2, transmission occurred during the modelling process as the Researcher, again in the role of teacher, articulated and demonstrated to the students what they had to do. The students' 'fish bodies' were cut and stapled ready for colouring.

R: Right, good. So what I did is, I coloured this in. So I drew the eyes on. I drew the gills. I thought about the colours that I wanted and this is just a mock-up. It's not the real thing. This is just a practice so you can sort of see what it looks like. And then you've got to colour in both sides. Now, I would like your fish to be the same on both sides. But I just did this

> differently so you can see different ways of colouring it in. Once it's coloured in, then you can stuff it and make it look round and then you can cut out the fins. I've just stuck the fins in there and stapled them on and I cut out the big wings out of paper.

This illustrated that in Year 2 information given through transmission was accompanied with a visual display, in this case the modelling by the Researcher of the mocked-up construction process. In Year 2 the process was modelled in two sections, with the students starting their mock-up in between and then returning to the mat for further instruction and demonstration. This was when the extract above occurred.

The most obvious difference between Year 2 and Year 6 in this section was the form of assistance given. In Year 2 it was visual, very explicit and involved modelling the mock-up process. At Year 6 it involved setting the students up and assisting them to work independently. The data suggested that both year groups used dialogue to assist their peers, including managing their behaviour. It also suggested that this occurred more frequently in Year 6 than in Year 2. This may be explained through the personal teaching philosophy of the Year 6 teacher who valued students working independently. During the Mock-up stage of the unit the classroom teachers and students assisted learning when necessary. The next section discusses the findings in the element Technology Knowledge and Skills that were demonstrated in the Mock-up stage of the unit.

5.2.5 Comparison between Stages

This section will compare the data across this stage with the first and second stages, Character and Function and Planning. The same four elements identified in the Character and Function, and Planning stages were used to analyse the data in this stage. Each element was divided into sub elements and in some cases further sub-sections. While the differences between years are reported after each sub-element, this section will report the differences between the stages Character and

Function, Planning and Mock-up. The section is be divided into four further paragraphs one for each element.

In this stage the sub-elements in the Funds of Knowledge element remained the same, with Participatory Enculturation and Passive Observation as the other two stages. However in Year 6, at this stage, there were no incidents of Passive Observation and only one in Participatory Enculturation. This was a decrease when compared to the previous two stages. In Year 2 the instances of Participatory Enculturation were similar to the first stage and greater than the second stage (see Tables 4.2 & 4.3 and. 5.1). Passive Observation was less than in Stage 1 but similar to Stage 2. One of the main differences between this stage and the two previous stages, was that this stage was essentially practical as the students constructed their mock-up designs. This may have accounted for the decrease in reliance on Funds of Knowledge in Year 6, as the students may well have deployed skills and knowledge from their culture and community without actually articulating this fact. In Year 2 the students' comments related to experiences around fishing while they were constructing, and therefore these conversations were captured in the data gathering process.

The Making Connections element was considerably different in this stage when compared to Stages 1 and 2 (Tables 4.2 & 4.3 and. 5.1). In this stage there was only one sub-element - New Knowledge Learned - with only one instance in Year 6 and five in Year 2. Missing from this section was knowledge employed from other curriculum areas and making temporal connections. Students did deploy knowledge they had learning in the current unit. Again like the previous section other knowledge may well have been deployed in a physical sense but not articulated and therefore not captured in the data set.

Management of Learning continued to be the biggest element in this section as with the other two stages, with total numbers remaining higher than the other elements in the stage, but lower than the number of instances in the previous two stages, as illustrated in Tables 4.2 & 4.3 and 5.1. Sub-elements that were in this stage that appeared in both the previous stages, include Higher Order Thinking and Transmission. Assisted Learning continues from Stage 2. Teacher Behaviour Management from the previous two stages becomes exclusively about teachers' assisting collaboration in the stage. Students' Managing Student Behaviour and Peer Discussion were still present in this stage but combined, as all instances of peer discussion captured in this section related to the students managing their own or their peers' behaviour and or tasks. At this stage in the unit students needed to be working on the development of a single outcome so collaboration became impossible to avoid. This may have accounted for the increased focus on teachers and students' conversations about staying on task and working together.

5.2.6 Conclusion

This section has presented the results for the third stage of the props technology unit in which the students developed a mock-up version of their design, evaluated them using stakeholder feedback and modified their designs if necessary. The data suggested that students were able to construct a mock-up of a planned design and modify their design according to feedback given. The data also showed that the same four elements that were relevant in Stages 1 and 2 continued to be relevant in this stage. However sub-elements did vary in some cases. The next section in this chapter reports on data from the final stage Construction.

5.2.7 Technology Knowledge and Skills

Technological Knowledge and Skills learned by the students in the mock-up stage of the unit included the students understanding of why a mock-up needed to be constructed, construction skills, collaborative skills and the ability to evaluate their design idea through obtaining stakeholder feedback. At this stage in the unit, the element was divided into three sub-elements. In Year 6 there were 25 examples across the four sub-elements and in Year 2 there were 15, and these are summarised in Table 5.4.

Table 5.4: Summary of Technological Skills and Knowledge

Sub-elements	Year 6	Year 2
Understanding purpose and Process of Developing a Mock-up *Design Evaluation* *Consensual and Collaborative* *Competitive*	20	12
Understanding Technology Process	3	1
Working Collaboratively including Task Allocation	2	2
Total	25	15

The first sub-element was the ability to evaluate a design through creating a mock-up, [Understanding Purpose (Design Evaluation) of Mock-up] with 20 examples in Year 6 and 12 in Year 2. The second was evidence that students understood technology practice and process [Understanding Technology Purpose], with three examples in Year 6 and one in Year 2. The final sub-element in the Mock-up Stage in Technology Skills and Knowledge was the ability to work collaboratively and undertake task allocation [Working Collaboratively including Task Allocation) with two examples each in Year 6 and Year 2.

Understanding Purpose and Process (Design Evaluation) of Mock-up

One of the main purposes of developing a mock-up was to evaluate the design in the three dimensional form. The data also suggested that the mock-up process was undertaken in different ways. The first was a part of a consensual and collaborative process to determine the best design. The second was a more competitive model with individuals with students independently mocking up their own designs and then arguing for the better design.

Design Evaluation

Teddy gave the following response when asked at his exit interview to explain a mock-up. “sort of like a model of it. Yes, because people can have a visual idea of what it's like". Having a three dimensional model to look at assisted the students in the evaluation of their design ideas. This was evidenced during their practice. Rex, Year 2, articulated the improvements he would make between the mock-up design and his final design.

R:	Okay. When you come to do your final fish are there any changes that you want to make?
Rex:	Umm, [3 second pause] not that messy.
R:	Tell me know what you mean by that.
Rex:	Like all of that stuff.
R:	So your final fish is going to be painted, how will that make it different?
Rex:	It will be more like, you won't see the paper.

This extract illustrated that Rex understood that improvements could be made to his design when the final fish was constructed. His evaluation was linked to two of the class's co-constructed attributes: The flying fish needs to be colourful and to look good. The final two quotes in this subsection some from the final Stimulated Recall interviews with the Year 2 children. Both Rex and Debby respond to the question "What is a Mock-up?" Rex: "It's the thing where what you're going to do. Or like your plan, you make it then you make another one which is the one," and Debby: "A mock up is a pretend fish" The children clearly understood the temporary nature of the mock-up, Rex's understanding appeared more sophisticated than Debby's as he articulated that the next construction to be made is the "one". This demonstrated that he understood the mock-up was not the final design.

Consensual and Collaborative.

In both Year 2 and 6, the students were able to collaboratively develop a mocked-up design from their planning with the purpose of evaluating their final designs. In Year 2 evaluation appeared to be about whether the students liked the design or not. In the extract below, the Researcher talked to Debby and Rex about an aspect of the mock-up, the tail.

R:	Are you happy with this tail Debby?
Debby:	No, I'm not, I'm not happy it.
R:	Tell them how you feel [about it].
Debby:	It's because I want it to go that way. I didn't want it to go that way.
Rex:	The face is over there
Debby:	I like the tail like that. It's going to go, is it like that one? [Referring to plan]

Illustrated in this extract was Debby's knowledge that she was able to use her mock-up to compare it with the group's original plan. It illustrated that she understood that the mock-up initially reflected planned ideas.

In Year 6, this process appeared to be more complex as the students were able to critique two mock-ups through testing to determine which would be better. In the following extract the Researcher asked Teddy, Mandy and Jay if they were ready to develop their mock-up. They informed her that they were going to do two types of mock-up to enable them to have a better idea about their final design. They then undertook testing to determine which design to take further.

R:	[Are] You set up to [make] the mock up now?
Teddy:	Two we're doing two.
R:	Two mock ups?
Teddy:	Yeah, because one's going to be a box.
Mandy:	No because one going to be like a frame.
Jay:	'cause we've both got different ideas.
Mandy:	This way we may get a better idea.
Jay:	'and this way.

R: Have you got ideas for the final thing or your mock?

Mandy: The mock-up. We have a number of ideas.

This extract illustrated that these students understood that by constructing two different mock-ups they were in a better position to evaluate which idea was better. The extract also indicated that all three students were in agreement with the process.

Competitive

The data also suggested that the students used the mock-up process in an attempt to convince other group members that their ideas were better than the other ideas offered. In the other Year 6 group, Alan and Dougal both developed a mock-up for their design of the stand for their microphone (Figures 5.31 and 5.32 a & b). In this group the two mock-ups were designed because both boys thought their design worthy of construction. Each made the mock-up without consultation with the other. In this extract all three team members discuss which design was better.

Alan: If we just make a base out of cardboard, it won't hold.

Dougal: Yeah, exactly. That's why we 're not going to do it.

Alan: Yeah.

Dougal: Yeah, not your way.

Alan: No! But yours is made out of cardboard and MINE is made of real wood.

Dougal: This one's not perfect.

Minnie: Yeah it's not good, but I like that one.

Alan: No, because it's just too much work and we're way behind. I need to cut this, then I can get,

Dougal: No, Alan. Work with us. Come on Alan (Discussion).

Minnie: Do you think this looks appropriate for our 1930s microphone?

Alan: Yeah. Okay.

The extract illustrated that the students understood that they were able to use their mock-up design to evaluate the pros and cons of each. Alan continued to work on his design, undertaking some problem-solving to ensure the legs of the stand could be folded away when the stand was not in use.

The data suggested that students in both Year 6 and 2 understood the purpose of developing a mock-up was to evaluate design. In Year 6 both groups developed two versions of a mock-up of an aspect of their design, and used it to problem-solve and select the better design. In Year 2, the data suggested that the mock- up was assessed as a whole and that the students understood that changes could be made before construction of the final outcome.

Understanding Technology Process

The other aspect of technological knowledge and skills that emerged from the data in Stage 3, was the students emerging understanding of the wider technological process. As can be seen in Table 5.4, in Year 6 there were three examples and in Year 2 only one. In Year 6 the students were also required to get stakeholder feedback. The next extract occurred in Year 6 while the students were on the mat. Their teacher Clara ensured the students were aware of the term stakeholder and who their stakeholders were.

Clara:	Can you remember who the stakeholders might be? Hands down. Just have a think in your head and I'll ask you people what, who they think a stakeholder might be. There was a whole list of them. So we should be able to think of somebody.
Roanne:	The Actors.
Clara:	Good, Roanne?
Roanne:	The audience.
Clara:	Great. Alan.
Alan:	Producers.
Clara:	Fantastic. Thomas?

Thomas: Parents.

Clara: Great. Alan. Any ideas?

Alan: Can you come back?

Clara: That's okay. Isabel?.

Isabel: Children.

Clara: Yeah. The children were really important so the scenes work. Bridget?

Bridget: Maybe Wendy.

Clara: Yeah, you could check with Wendy. She's been an expert, isn't she? Definitely. Alan.

Alan: Principal.

Clara: Yeah, great. Well done. You've covered pretty much all of them. That's fantastic. Really good. Jacob?

Jake: The lighting person or someone.

The extract above illustrated that the students were aware of who their stakeholders were in this technological practice. There was some evidence that the Year 6 students were also beginning to think about the wider aspect of technological practice. In this unsolicited conversation, Alan asked the Researcher if a mock-up might be constructed and then not actually turned in to a final outcome.

Alan: Well, we'll ask. Can a design be made into a mock-up, like this, even if it's not going to be the official one?

R: Ask me that question again?

Alan: Well, if you've got a design and you want to make, make it so people understand it better you can put it, you can make sure like this, could you [has mock-up of his design in hands].

R: Yeah. It's sort of like a model of it.

Alan: Yes.

R: Yes, because people can get a visual idea of what it's like

Alan: Yeah.

This extract illustrated Alan's wider understanding of technological practice in that he realised that not all mock-up designs will eventuate into a final technological outcome. This emerging understanding was only evidenced once in Year 6. The Year 2 students in the next extract appeared to be gaining an emerging understanding of skill specialisation. Anne, Ellis and Adam talk while they construct their mock-up.

Anne:	Yeah. We'll just cut them out.
Anne:	Okay. Now, Ellis's just going to cut the fish and then we'll get into, and then we'll get.
Ellis:	Hey, he's the expert at cutting (pointing to Adam).
Adam:	Oh, this is boring.
Ellis:	Is not.
Anne:	It's fun, doing technology.

The extract above illustrated that at least some of the Year 2 students were developing an understanding that some tasks are better completed by people with the relevant skill set, therefore task allocation emerged. The final interview between the teachers and the Researcher, when the Researcher asked both Clara and Fleur about the most successful aspect of the Technology units taught, also exemplified aspects of students' learning from the teachers' perspective.

Clara:	Probably following a process, learning a process of how to and the importance of planning and the importance of, of the process and not just racing in, coming up with your design and thinking you know the best idea straight away. Actually doing the research and, and coming up with better ways of doing things and, yeah, learning to slow down.
R:	For the children?
Clara:	Yeah, and, how to complete a task to the best of their ability and not just, doing it, basically, for the sake of doing it.

R: Fleur, what about you?

Fleur: The success? Getting children to work in groups of different abilities and like Clare, having, learning about the process because in the first unit, the children tend[ed] to rush and weren't so sure about the process but when we came down to the second unit, the children were a lot more aware and they actually took a wee bit more time on each section of the process. So I think the outcome was actually probably better than the first outcome.

Clara: I'd agree. They realised the importance of each step?

Fleur: And they actually realised that you've got to do all that research of the flying fish or the importance of looking at the pictures and looking at the different aspects of each fish and then reflecting and then putting it into their own plans.

As well as understanding the broader technological process in this stage, the students also continued to develop their collaborative skills, including task allocation in Year 2. In Year 6 there was more evidence that the students understood wider aspects of technological practice than in Year 2. While talking on the mat, a range of Year 6 students contributed to the conversation on potential stakeholders and the evidence suggests a more complex understanding of modelling emerging in some cases. In Year 2 the only evidence of knowledge of wider technological practice is an emerging understanding of the skill specialisation of technology practice.

Working Collaboratively Including Task Allocation

To ensure a group of three students was able to successfully complete one technological outcome collaboration, task allocation became increasing important in the Mock-up stage of the unit. The captured data suggested that at this stage there were two examples of this in both Year 6 and Year 2. The students in Year 6 were able to work collaboratively as a whole group, discussing and debating in order to reach agreement. When done well, this facilitated group ownership and the group were able to reach a consensus. In the extract below Minnie, Dougal and Alan discussed the dimensions of the mock-up head of the microphone. Minnie asked for assistance from the boys to determine its measurements.

Minnie:	Okay, we need the measurements now.
Dougal:	Isn't the measurement just 12?
Minnie:	No. It is 14 centimetres, 14 and a half centimetres
Dougal:	It's meant to be eight.
Minnie:	I know but eight, it would be too box like.
Dougal:	No.
Alan:	No, because you can make that five and then you made that eight.

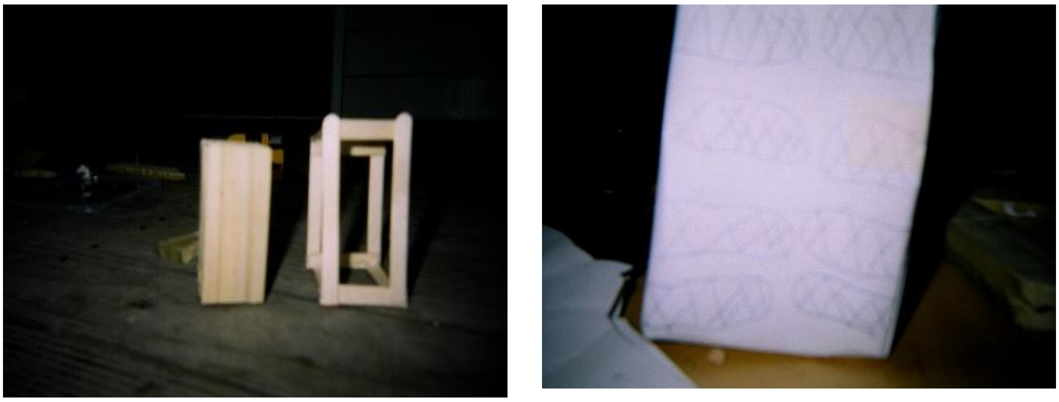


Figure 5.5: Minnie's autophotographs of her mock-up microphone head

This extract led to a rare consensus for this group for the measurements of the mock-up microphone head of 12 x 8 x 5 cm, which Minnie went on to construct as is evidenced in the next extract. Minnie's autophotographs of her mock-up microphone head can be seen in Figure 5.5.

Clara:	Are you making your mock-up?
Minnie:	Yeah, we are. I'm making, we need paper. Go get some paper.
Alan:	Can I design my idea at the base thing?
Minnie:	Yep. I'm doing the top of the microphone.

This extract illustrated that at this stage Minnie and Alan undertook task allocation. Minnie continued to work on the microphone head and Alan, the stand. In Year 2 the only example of collaborative working and task allocation came when Anne and Ellis identified Adam as the expert cutter and they asked him to perform cutting tasks for the group.

Students in both Year 6 and 2 continued to develop collaborative skills as they worked through the mock-up stage of the unit. At this stage in the unit, both Year 2 and 6 students began to undertake some degree of task allocation, although this was more prominent in Year 6.

5.2.8 Comparison Between Stages

The fourth element, Technological Knowledge and Skills, changed significantly in this stage compared to the previous two stages (see Tables 4.2 & 4.3 and 5.1). The main focus on technology learning centred on the purpose of a mock-up and the ability to use it to evaluate designs. At this stage, students also began to show an emerging understanding of technological practice. Neither of these two sub-elements was present in the previous two stages as they had different foci of learning: building an understanding of the character and function of props, and the role of and drawing plans of a technological outcome. Therefore, one would expect a different focus in this element at each stage. For the same reason as mentioned in the third element, working collaboratively and allocating different tasks to different students became an essential skill in this stage, and therefore featured in this element. Although technically not technological knowledge, the Researcher identified working collaboratively and task allocation as a skill because of the critical nature of collaboration within this technology project.

5.3 Stage 4: Construction

In these lessons the students continued the development of their technological outcomes following the evaluation of their mock-up design by constructing their final props for their class items in two school productions, one in the junior school and one in the senior school. In Year 2, flying fish for a traditional Taiwanese Tale, and in Year 6, props for a stage show of the Olympic Games from 1898 to1936.

Although construction consisted of only two lessons with two learning intentions - construction of the prop and on-going product evaluation - it took place over a number of sessions or periods of time in the classroom. Prop construction was time consuming, and mock-up evaluation occurred just prior to the final construction process beginning. This section is also organised so as to report conversations identified in each of the key elements: Funds of Knowledge, Making Connections and Links, Management of Learning and Technology Knowledge and Skills.

5.3.1 Overview of Lessons

A successful result of technological practice is the realisation of a technological outcome (that is, a technological product or system) that is fit for purpose as described in the brief. This stage focussed on the production and evaluation practices involved in the creation of a conceptual design for a potential technological outcome, and the final production of that outcome.

Level 1 Indicators of Achievement suggest that students are able to develop their outcomes in line with established attributes; "produce an outcome in keeping with identified attributes". At Level 3 students are able to evaluate and select appropriate materials and components to inform the final construction of their outcome before its construction, "Evaluate suitability of materials/components, based on their performance properties to select those appropriate for use in the production of the outcome" and "produce an outcome that addresses the brief". A range of skills and knowledge was required to enable students to undertake this section of their practice.

> Outcome development and evaluation relies on the use and/or development of construction skills and knowledge - including those associated with communicating design concepts and working with materials/components.

Their learning intentions for the lessons were "create their final design" and "undertake evaluation of constructed outcome" (Extract from Teachers planning, Appendix 15).

The key conversations were classified and analysed in each of the four elements: Funds of Knowledge, Connections and Links, Managing Learning and Technological Knowledge and Skills, in both Years 6 and 2. This section discusses each element in turn, with identification of sub-elements and in some cases sub-sections, with relevant extracts in each. Each sub-element concludes by noting the differences between Year 2 and 6. The section concludes an overview of the differences with the same elements in the Character and Function, Planning and Mock-up stages.

5.3.2 Funds of Knowledge

Students in both Year 6 and 2 deployed Funds of Knowledge during the construction stage of the unit. In Year 6 there were 13 instances and in Year 2, two. The same sub-elements as in previous stages were identified: Participatory Enculturation and Passive Observation. In Year 6 there were 11 instances in Participatory Enculturation and two instances in Passive Observation. In Year 2 there were two instances in Passive Observation and none in Participatory Enculturation. These findings are summarised in Table 5.2.

Participatory Enculturation

In Year 6 there were 11 instances of students deploying Funds of Knowledge gathered from Participatory Enculturation. Students were able to deploy techniques and materials that they had observed being used in their home environment. This put them in a situation in which they were able to contribute successfully to the construction of the outcome. In the first extract, Mandy was talking to the Researcher about ways of joining framing timber for her group's radio. The research ignited the conversation with a question about possible options for the joining.

R:	Okay. Have you thought [about how] you're going to join?
Mandy:	Umm, yeah, we'll probably just use hot glue, wait for it to dry and then nails it as well.
R:	Okay.
Mandy:	And if we can get hold of bracing, then we might put that there…
R:	Tell me about bracing. What's that?
Mandy:	Umm, well it's metal and it's got holes in it. You can put nails through it and it will bend so you can fix the corners together.
R:	Oh, right.
Mandy:	Securely.
R:	So where might you get that?
Clara:	Umm, well, we could get it from like…
Jay:	Oh, like Mitre 10.
R:	Okay. How did you know about this stuff?
Mandy:	Umm, my Dad used it on our tree hut.

In the above extract Mandy considered a range of joining options and remembered that her father had used bracing in her tree hut at home. This illustrated that Mandy made the connection from what her father used on her tree hut to her being able to use the same joining technique on their frame. Figure 5.6 shows Mandy's autophotograph of her attaching the bracing, beside which is what she said about the photograph during her Stimulated Recall Interview. This illustrated that she did in fact use the bracing and found it successful.

Figure 5.6: : Mandy's autophotograph of bracing and associated interview quote

Mandy: And that one is putting on the bracing.

R: How did you find the bracing?

Mandy: Oh, it was quite easy really 'cause there were no nails involved the nails were kind of built into it.

In Year 2 there were no recorded examples of students using Participatory Enculturation. This could be explained in several ways. These students are younger and perhaps less likely to participate in independent activities and hobbies at home. A second possibility is that the teacher determined the construction technique in Year 2 and the students may not have experienced papier-mâché at home. However, students in both Year 2 and 6 did deploy funds of knowledge through observation.

5.3.3 Making Connections and Links

Making Connections described students making connections to school learning. At this stage of the unit there were only two sub-elements in this element. These were: New Technology Knowledge, which was links to technology learning in prior units, including links to attributes and links Knowledge-Other Disciplines. In Year 6 there was a total of 11 instances, and in Year 2, seven as seen in Table 5.2.

At this stage in the unit the Researcher had included the previous sub-element Links to Attributes into the sub-element 'New Technology Knowledge' which are links made to technology learning in the current unit. In Year 6 there were nine instances of New Technology Knowledge and at Year 2 seven. Links to other discipline areas is evidenced through two examples in Year 6 and none in Year 2. Both sub-elements are discussed in turn.

New Technology Knowledge (including links to attributes)

Given that one of the main purposes of the Character and Function stage of the unit was for the students to understand desirable attributes of props, then it stands to reason that at this stage 'links to attributes' be included in New Technology Knowledge. During the construction of their designs the students in Year 6 were able to articulate how their designs meet the co-constructed attributes. The data suggests that the students frequently referred to the attributes and were able to article how their outcomes met the required attributes. In the first extract, Alan and Dougal were discussing the design features of the stand that Alan was constructing. Dougal made a suggestion to Alan about a problem with the legs of the stand. Alan rejected Dougal's suggestion because it would affect the authentic nature of the final outcome because 'to look realistic' was one of the desirable attributes identified by the class.

Dougal: Because when you put up that this one is going to come down like that.

Alan: Yeah, but you're going to be able to see that though and that'll make it look unauthentic.

The data illustrated that in Year 6 the students were able to refer to the attributes and were able to articulate how their outcomes meet the required attributes.

In Year 2 the students also made links to new technology knowledge including links to attributes. In the first extract, Debby is responded to the Researcher's question about the colours of their final fish.

R: Debby, what are you doing now?

Debby: We're painting.

R: Tell me about the colours you used and why you're using these colours.

Debby: Because we want to make it a good fish so the audience can see it and so it will camouflage.

This extract illustrated that the design choices the students made were influenced by the co-constructed attributes determined for the fish, which included looking realistic, large enough for the audience to see and to 'look good'. In a small number of instances the students also articulated connections to other curriculum areas during construction.

Knowledge - Other Disciplines

As can be seen in Table 5.2 the Year 6 students articulated connections to other curriculum areas on two occasions and the Year 2 students none. In the first extract Clara and one of the boys in the class (Jake) deploy mathematical skills to sketch one of the Olympic Country's flags. They did this in a collaborative fashion with their teacher giving assistance and direction to her students.

Jake:	We divide it by four or something. See how much this is.
Clara:	Well, we've got this amount of space and we need how many stripes?
Jake:	13.
Clara:	So we're going to have to divide that by.
Jake:	13.
Clara:	So it's about 45. So we've got 13 stripes. So 45 divided by 13. So you might need a calculator or do you want to work it out with long division?

The above extract illustrated the students' awareness of the need to use mathematical skills; this occurred on a number of occasions. The data reported in this section just refers to the oral data gathered which indicated the students' awareness of the use of other curriculum areas. This does not suggest that knowledge from other curriculum areas was not deployed. It is important to note that the very process of developing an outcome, using a variety of construction methods, does call on knowledge from other curriculum areas. For example, some of the Year 6 and all of the Year 2 students used papier-mâché to construct their props and all props were painted. This included knowledge in the visual arts, but this was not evidenced through this method of data capture - recording of oral conversation. However, it was captured in the Researcher's and students' photographs.

The difference between the data in Year 6 and Year 2 in this sub-element, was that no evidence was captured in Year 2. However, this must be considered in light of the statement made above, as again these Year 2 students employed papier-mâché as a construction method. As with the other stages a variety of strategies were also used to manage the learning in this stage and these are reported in the next section.

5.3.4 Management of Learning

A number of management strategies to assist learning were implemented throughout the final construction stage of the unit aimed at developing students' thinking skills as well as developing their understanding of, and ability in, constructing technological outcomes. These are summarised in Table 5.5.

Table 5.5: Summary of Management of Learning

Sub-elements	**Year 6**	**Year 2**
Teacher Assistance with Construction *'Just in time' Skill Development* *Design Features*	25	8
Assisted Learning (incl Higher Order Thinking)	13	21
Student Facilitation of Construction	8	1
Task Management Prompts	7	5
Teacher Behaviour Management	5	6
Total	58	41

The data indicated that in Year 6 there were five sub-elements with 53 examples. These were as follows: Teacher Assistance with Construction with 25 relevant extracts, Assisted Learning including Higher Order Thinking with 13, Student Facilitation of Construction with eight, Task Management Prompts with seven and Teacher Behaviour Management.

In Year 2 the same five sub-elements were evidenced, with 41 instances recorded. There were 21 examples of Assisted Learning including Higher Order Thinking, eight examples of Teacher Assistance, one example of Students Facilitation of Construction, five examples of Task Management Prompts, and in Teacher Behaviour Management there were six examples.

Teacher Assistance with Construction

In Year 6 the most frequently populated sub-element was Teacher Assistance with Construction. The Year 6 students made a range of props including the two made by the participants in this study: a microphone and radio both from the early 1900s. In Year 2 there were eight examples of teacher assistance (see Table 5.5). Assistance with construction strategies and clarifying design features were necessary, especially in cases where students were not aware of specific skills and techniques.

Just in Time Skill Development

Much skill development at this stage in the unit was to assist students with a specific task in hand. This approach is a 'just-in time' approach to skill development and differs from traditional approaches, as skills are taught as they are required rather than to a set curriculum. In the first extract, the Researcher was assisting Mandy's understanding of measuring for a covering material, taking into consideration the thickness of the material on other sections.

R:	How wide is this, you want it 50cm apart and the whole this, how many cm? You're going to have your cardboard on the outside. Do you see what I'm saying? There's a little bit of a gap there. So if you look over here, when you come to put these cards on that side.
Mandy:	There'd be a gap.
R:	Yeah, and what could be a solution?

Mandy was learning from the Researcher that the thickness of covering must be taken into consideration when measuring the covering for a box-like construction with material such as cardboard or coreflute. Evidence is presented in the next section that Mandy was able to later implement this skill.

In Year 2, the Researcher in the role of the teacher, also implemented 'just in time' skill development. Having stapled the two sides of the base fish of the final construction, and determined where they wanted the hole left open for stuffing, she then taught them how to stuff the fish effectively.

R:	Right now you need some stuffing. The newspaper is best paper for the stuffing because it is not so hard........Hey Rex don't put so much in at one time. You need to put just a little bit in at a time. Don't forget to do right down into the tail. Woo, stop. Get little bits like that and then push them down and it opens it up. It opens it up and then you can stuff it up.
Rex:	Tiny little pieces.

The Researcher gave construction tips to improve the quality of construction. These extracts illustrate the teacher introducing new concepts to the students using the 'just in time' approach.

Design Features

The data suggested that, as the students began construction of their final outcome design, problems emerged and last minute changes were made to accommodate arising issues. This was best exemplified in the next extract. Jake and his group were in the process of constructing three Olympic medals, gold, silver and bronze. Jake inquired about the type and colour of ribbon on the medals. His teacher, Clara, assisted by suggesting that he do more research. He discovered that in 1936 the medals did not have ribbons.

Clara:	Yellow. Yellow. Should we look up the 1936 Olympic medals, Jake, quickly? Go to Google, Bud.

Jake: 1936?

Clara: Olympic medals. Put Olympic medals. Oh, it's gone to there. Do you want to do images or do you want to…

Jake: Argh yeah images. They didn't have [ribbons].

Clara: Well, those ones don't, do they?

Jake: Oh, yeah, because when, these are the ribbons of the medals we were going to do. This one, and they didn't have a ribbon.

Clara: So that didn't have a ribbon on it.

Jake: So they're holding them.

Clara: Okay, cool. So you don't need ribbon.

Jake: Yeah. I'm glad we did that.

Clara: Yeah, I know. Good work, you guys.

This extract illustrated assistance of another variety. Clara did not pretend to know the answer to Jake's inquiry and instead directed and supported him in further research. Jake's comment at the end - "Yeah. I'm glad we did that" - suggested that he found the process quite empowering, perhaps because he discovered something no one else in the class appeared to be aware of.

Assisted Learning (including Higher Order Thinking)

Throughout the unit teachers implemented a range of strategies aimed at facilitating student thinking, and assisting their ability understand key concepts and components of technology practice. Some strategies continued into the construction phase, but at this stage were evidenced in conversation as opposed to a specific activity designed to extend students understanding, such as those implemented in the first two stages. There was one exception to this; as an evaluative tool following the completion of their flying fish, the Year 2 students partook in an activity aimed at evaluating their knowledge of technology education (see below). In Year 2 there were 21 instances of specific strategies to engaged students learning. This large number was accounted for as both groups were recorded while undertaking the final evaluative activity. The activity is outlined in the extract below, which was an information sheet given to the teachers by the Researcher.

Strategy Four: Icon Prompt (Analysis)

Icon Prompt is used to engage children in debatable topics and allows them to see issues from a variety of perspectives. A different icon is used for each perspective. The children were given an icon and need to take that particular point of view in any debate undertaken

☺ Who stands to gain or benefit? Who is happy about the current situation?

Who stands to lose? Who is unhappy with the present situation?

? What are the unasked/unanswered questions? Are there any other issues linked to this topic/ situation? How does this affect me?

♥ How does this link to what I already know?

In this Icon Prompt activity (*Innovative Teachers' Companion*, 2006) the students worked in their groups of three. In the first extract, Fleur and the Researcher set the activity, which was a specific learning strategy to facilitate students' evaluation of their final outcome. The Researcher prompted the students to use the criteria when evaluating their prop.

Fleur: Looking, this is what we call evaluation of what we think about how we have made our fish. So your happy face. Can you all find your happy face, please? You are going to discuss in your group for a couple of minutes things that you liked about your prop, things that you liked about your flying fish. Go.

R: Maybe you should just put those ones down. Right. What you liked about your fish. Remember, look at the criteria. What's good about it?

The following extracts are comments from the Year 2 students engaged in the activity. The icons in front of each statement indicates from which perspective the comment comes.

☺	Jayda: The wings we made them ourselves.
☺	Anne: Because looking at the criteria we have achieved.
☹	Lauren: Change the other side so that it was the same
☹	Moke: The edge because it is messy.
☺	Anne: The wings to make them the same and make the tail a bit stronger.
☹	Cassidy: I found it really hard to decided what colour we chose.
☹	Lauren: Cutting out the fins.
?	Debby: Everyone wanted different shaped fins and it was hard.
?	Jayda: Wings paint them and make them straight.
?	Finn: Not working by myself.
♥	Finn: I feel happy because the biggest challenge was not working by myself.
♥	Rex: I am feeling happy because we made it big so the audience could see it.
♥	Jesse: Happy because I really liked papier-mâchéing.
♥	Jayda: I feel happy because we all worked as a team.

The above extract illustrates the use of a specific learning strategy to facilitate students' evaluation of their final outcome. This is a significant shift in the approach previously used in the classroom. Below, Ellis's response to one of Fleur's higher order questions suggested that this approach was one that was new to him.

Fleur:	Explain why you have put the things [features of the fish] where you have.
Ellis:	Why do we have to explain everything?

This extract illustrates a students' insight into the change of approach to learning in this unit. Ellis was a student who liked to answer all questions and always have his say.

Table 5. 5 shows that there were 13 instances of learning stategies in Year 6, many of which were the facilitation of higher order thinking through teacher questioning. The first extract illustrated this. The Researcher in the role of the teacher questioned Mandy about her choice of joining method.

R:	So why are you gluing it first?
Mandy:	Umm, to make it stronger and so it holds in place while we put the nails in.

This extract illustrated the use of questioning to facilitate students thinking. The question forced Mandy to think about her joining method and justify its use. The answer enabled both Mandy and the Researcher to determine that she was able to do this and that her reasoning was sound.

Another aspect of managed learning in this element was that the students assisted each other during the construction process, discussed in the next section.

Student Facilitation of Construction

Data in this sub-element suggested that not only did the teachers facilitate the construction process but that the students assisted each other also. Table 5.5 indicates that there were eight examples of students' facilitation of construction in Year 6. Alan, Minnie and Dougal assisted each other in deciding the final dimensions of the microphone head.

Dougal:	Yeah, I know. It's too small.
Alan:	Make it 10 centimetres. 10 by five, 10 by eight.

Minnie: No that's real good. 10 by eight by eight.

Alan: No eight by five by five. Okay.

Dougal: Or eight. We agreed that.

Alan: True.

Dougal: It doesn't matter. It doesn't concern you.

Alan: Yes, it does. Yes it does.

Minnie: You're allowed to give ideas. Dougal has the final say.

This extract demonstrates the tensions in the group between construction responsibility and allowing input into other components. Alan had earlier suggested that different group members take responsibility for separate components, "Oh! You guys design a top. I'll do the bottom. We need, like the stand, the pole, the head". However he believed that he should be able to have input into the dimensions of the component he was not responsible for. Dougal thought otherwise. Minnie assisted the group by suggesting that Alan was allowed to make suggestions but Dougal should make the final decisions.

Task Management Prompts

Table 5.5 indicates that there were seven instances of teachers and or students assisting with task management in Year 6 and five in Year 2. The data suggests the students understood that task allocation could assist in the construction process. Ensuring that the students understood the idea of identifying and managing tasks, to ensure the props were completed before the dress rehearsal, was critical to the success of this project. In the first extract, Mandy and Jay talked to Clara about the materials they needed for the construction of their radio.

Mandy: We've got thick cardboard, wood, nails, paint and maybe wire.

Jay: Yeah, that's probably about it.

Clara: Okay, and so what's the next thing you're going to do? Are you going to do anything else today, do you think? You need the stuff.

Jay: We probably need the stuff.

Mandy: We might be able to measure the wood today.

Clara: I could get you the stuff I can work that in for you.

Mandy: Cardboard, you could get if from, South City [shopping mall].

Clara: Yeah.

Mandy: They like have washing machines and the cardboard.

Clara: So keep working on that list and then see, have you got measurements so you know what length of things I need to get, what size of things I need to get.

This extract demonstrated the dialogue between teacher and students about the materials that were needed and how they were going to be obtained. The conclusion of the extract also demonstrated that Clara trusted her students to identify the quantities of required materials and that she was willing to support her students in the procuring of them. Students also assisted each other with task allocation. As mentioned in the previous section, the microphone group split first into two groups at the mock-up stage and then into three, one for each component. This signified Alan's understanding of the need for a three-way split, one for each component when he realised that the microphone head was actually two components the head and the structure to attach the head to the stand.

In Year 2, the teachers were very explicit about the tasks the students were required to do in the initial stages of each lesson, and continued to remind the students of their task as they circulated around the room during construction. In the first extract, Fleur clearly identified the tasks ahead.

Fleur: This morning, we will be making our own one, our real ones which we will use for the show and what I'm going to do, what do we need to remember on our plan? I'm, have a talk to the person beside you and think what you need to and I'm going to ask somebody to come and I'm going to pick somebody.

In this extract Fleur signalled the task ahead and asked the students to think about aspects on their plan. This illustrated that the teacher made a direct link between what was on their plans and the construction of the prop.

Teacher Behaviour Management

Throughout the construction process teachers continued to use a range of other behaviour management strategies to ensure students were on task. Table 5.5 shows that in Year 6 there were five incidents of teacher behaviour management strategies being implemented and in Year 2 there were six. The strategy most commonly used was positive reinforcement. While the students were constructing their props the teachers circulated and frequently used purposeful positive reinforcement to encourage the students and appreciate what they have achieved. The first extract was from Year 6, as the Researcher in the role of teacher was explicit about the positive features of Dougal's design.

R: It's looking fantastic, Dougal. I'm very impressed. I like the way you've done the tinfoil around the edge so you can see the black on the top and now you're doing the black.

In the next extract, the Year 2 teacher asked Rex about the design of the wings on his group's fish.

Rex: Well, everyone wanted different shaped fins so it was very hard to get the right wings. We finally got the right ones.

Fleur: Fabulous. So you had to compromise and come to a decision that you all agreed on. Is that right, Debby?

This extract illustrates the teacher's positivity toward Rex and the explicit nature of the feedback in relation to working collaboratively.

A difference between Year 6 and Year 2 in this element, was the nature of the facilitation of learning strategies. In Year 6, most took the form of higher level questioning to facilitate students thinking and explanation about their practice. In Year 2, this also occurred, but in addition a specific facilitation strategy was implemented to assist the students' product evaluation. Another difference is the students' ability to assist each other and the increased teacher assistance required by Year 6 students, possibly due to more complex construction methods and techniques used.

5.3.5 Technology Knowledge and Skills

The fourth element in this final stage of the unit evidenced learning in technology by the students. Technology Knowledge and skills in the construction stage of the unit was centred on selection of appropriate materials and resources, selection and implementation of the construction skills and techniques, and the ability to evaluate the final technological outcome. In this case: props for the school production. The data suggests that there were six sub-elements in Year 6, and 4 in Year 2. These findings are summarised in Table 5.6. This table introduces a number of sub-sections within the sub-elements Emerging Construction Ideas, Construction Skills and Understanding Technology Process.

In Year 6 the sub-elements included: Emerging Construction Ideas with 31 examples, Construction Skills with nine examples, Suitability of Materials; Task Allocation; and Understanding Technology Process all with six examples, and Product Evaluation with two examples. In Year 2 there were four sub-elements; Emerging Construction Ideas with eight examples, Construction Skills with 10, Understanding Technology Process 22, and Product Evaluation with 16. Discussed in the section below are the emerging construction skills of the students, illustrated with extracts from the data.

Table 5.6: Summary of Technological Skills and Knowledge

Sub-elements	**Year 6**	**Year 2**
Emerging Construction Ideas *Articulation of Design Process*	31	8
Construction Skills *skill development* *design alteration* *new skill acquisition*	9	10
Suitability of Materials	6	0
Task Allocation	6	0
Understanding Technology Process *Links to Attributes* *Working Collaboratively*	6	22
Product Evaluation	2	16
Total	58	56

Emerging Construction Ideas

Following the construction of their mock-up designs most students appeared to have a reasonable idea about their designs and how they might be constructed. As the construction process started, however, problems emerged which changed initial construction ideas. This was best illustrated in the following extract: Alan talked to the Researcher about a design problem he had. Together they discussed a possible solution.

Alan: I'm just not sure whether it would be strong enough and not wobble.

R: Have you got all four going up?

Alan: Yeah.

R: Right.

Alan: Hammer.

R: How many productions does it have to last for?

Alan: Three. I'm thinking screws, right. They come out now and then. You can just whack it in.

R: I just don't know, if you have all four screws, oh no, you're going to have two screws opposite each other, aren't you, on that dowel, like this, what might happen? If you've got two screws coming in there to the dowel and two screws coming in here down to the dowel, what might happen?

Alan: It could split the dowel.

R: It might. I'm just, that's what I don't know.

Alan: Yeah, maybe smaller screws. Hang on. Where did that other one go?

R: It's quite a fat screw.

Alan: Oh, don't tell me.

R: The screw's there in the, I can see, yeah. Woo, just, excuse me. Stop. Pick that screw up because that's very dangerous left like that. Okay, how might, right, okay. That's okay. Why can't you do what you've done there?

Alan: Umm, just because it doesn't really (unint.)…

R: But you're not going around and around and around, are you? For the amount of use that it gets, it's not around and around and around. You're going up and back, up and back. Down and up, I mean. Okay, you need to make a decision. Can you see the, can you glue the string on these without deciding this until you've done a bit more to that?

Alan: Umm, yeah, probably.

R: So why don't you do that? See that's going to take a lot of unscrewing. I like your washer. I think your washer's really great.

The extract illustrated that problem solving was an on-going phenomena and that students modified designs through the construction phase.

Articulation of Design Process

In Year 2 data on the emerging construction ideas was evidenced through the students being able to articulate the construction process, rather than on-going design change. In the extract below Anne and Ellis explain to the Researcher how they constructed the wings of their fish. This method was demonstrated to the students and then they undertook it independently with their designed wings.

R:	Tell me what, how you made your wings?
Anne:	Well, umm, I put two pieces of paper and we drew four pieces of paper. One went on umm, two pieces of paper and then the other and umm, then these are wings and then we cut it out and then we had to umm, put sticks in the middle of it and then we put glue on the sticks and then we umm, put the sticks and the paper on top.
R:	Ellis, why did you put the sticks in the middle?
Ellis:	So that they wouldn't flop everywhere. So that the wings wouldn't flop everywhere.
R:	And this morning we looked at some criteria. What criteria does that help?
Ellis:	Umm, it helps be durable, hard and can't break…

The extract above illustrates that the students were able to articulate their construction process and that Ellis understood the reason for the strengthening technique they undertook, and was able to link the practice to one of the co-constructed attributes.

Construction Skills

As the students began the construction process it became clear that a number of different skills were required, particularly in Year 6 because the outcomes developed by the students varied. In Year 2 all students designed and developed a papier-mâché flying fish. Table 5.6 states that there were nine instances of construction skills in Year 6 and 10 in Year 2. This sub-element was divided into three sections: skill development, design alteration and new skill acquisition.

Skill Improvement

The following extract from the Researcher journal signalled some acknowledgement of the need for skill development, but it also recognised that teachers can overlook the need for skill development on the assumption that students already have the necessary skills. It is important to note that in this study, other skill development teaching and learning may have occurred but not captured as auditory data.

> Had a conversation with Clara today about students' papier-mâché skills. I told her that in the space unit I was surprised at the lack of the papier-mâchéing skills of the students. She agreed. I commented that I assumed that at Year 6 the students would be able to papier-mâché independently but obviously no one had taught them this skill. At this point we were interrupted by an 'eaves dropper' Jake who stated that I was correct. In his opinion all his teachers had "assumed we could papier-mâché - but I have never been taught how" [Researcher Journal Wednesday 17 September 2008].

In light of that revelation, papier-mâché skills were taught specifically to students in both Year 6 and Year 2. In the extract below the Researcher talked to Charlie, in Year 6, about papier-mâché.

R:	So this one's better because?
Charlie:	Because it has no bumps in it.
R:	Right, good. So you're improving your papier-mâché skills. What's the trick for no bumps?
Charlie:	Small bits of paper and smoothing it as I go.

The extract above illustrated that, in the second unit when papier-mâché skills were taught, students' technique did improve. Other skills also improved with practice. The group featured in the extract below were required to cut three "dials" for their radio from polystyrene. Jay was given the task, with Teddy assisting and Mandy watching over.

Mandy:	Put it down.
Jay:	No, look. I just did it.
Mandy:	Over here.
Jay:	Look at this, so it's not, look at this. It's just easy. You just do this.
Mandy:	Well, it's not straight then, Jay.
Jay:	Well it's pretty straight. Straighter than the other one I did.
Teddy:	That's actually fairly straight.
Mandy:	Is this the one you did?
Teddy:	Yeah, that, I think that was, yeah, that was the one that wasn't straight, that you said it doesn't feel…
Jay:	Which I did like that.
Mandy:	I'm taking it back inside. I am going to take it [the radio body] back inside. Teddy, Teddy, remember, Teddy, remember we have to do it and it takes ages.
Jay:	Look at this. Look how straight that is. How does that look?
Teddy:	Shock, that's really straight.

The above extract demonstrated that with practice the students were able to improve their skill level, in this case, using a craft knife to shape radio dials from polystyrene as seen in Figure 5.7.

It can be seen that the dials were completed, and although Jay found this process challenging (Researcher observation), he did in fact complete the process to a reasonable standard.

Figure 5.7: Jay's autophotographs of dial construction

Design Alteration

In the microphone group there was a major change in the last week of the construction process. The scriptwriters decided the users of the microphone - the commentators in the "play" - should be sitting down at a new desk on the side of the stage instead of standing up as seen in Figure 5.8. This meant that the microphone stand needed to be a desk model as seen in Figure 5.9, rather than a standing one. In the extract below, Minnie, Alan and the Researcher discuss this change.

Minnie: Alan, Alan if we make this shorter then we won't have to make this [the microphone head] smaller.

Alan: Mmm, true. I'll think about that.

R: Does the microphone actually change though? Weren't they still the same size, just because it was a little leg?

Alan: Yeah, it'll be the same size. Just umm, you may need to make that smaller.

R:	Alan, I really like your attitude. Some people could have got very upset when they, when they realise that their whole design was not correct.
Alan:	I don't really care.
R:	That's good. Good attitude.
Alan:	It's not really a redesign. It's just a rebuild.
R:	Right, okay. That's good thinking
Alan:	Well building and designing but mainly building.
R:	So are you, umm, Alan, are you using the same ideas but smaller?
Alan:	Yeah, basically, except that's not going to pivot because it's too small. I need it, I need it…
R:	So why doesn't it need to pivot?
Alan:	Because it's, it's so small.

The extract illustrated Alan's understanding of the differences between designing and construction. Once he realised that the size of the microphone head would not change, he recognised that the only change was in the length of the shaft and legs, and that the legs could be set rather than have to fold up.

Figure 5.8: Alan's autophotograph of the full length microphone stand

Alan took these two photographs of his stand before he knew the stand was to be modified to a desk model. This Stimulated Recall interview extract indicated that he understood the need for props to be designed with consideration of functionality and fitness for purpose, in that it needed to fold away when not in use.

Alan: Then that's it folded up.

R: Why did you need to fold it up?

Alan: Well that was just, I, I, well it wasn't actually a major, side track and I just thought so then we could just plonk it down in a corner, corner somewhere so it wouldn't take up too much space.

R: Yeah, that's important in the backstage, isn't it?

Alan: Yeah, so it could just lie along one wall and then that's with all the legs on, standing up.

The next photograph, Figure 5.9, shows Alan's autophotograph of the shortened version of the stand just before painting, and below it what he said about it in his Stimulated Recall interview.

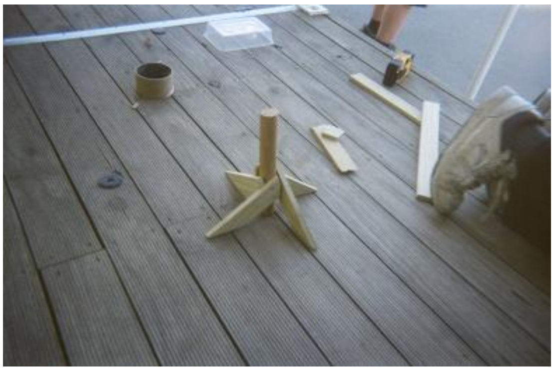


Figure 5.9: Alan's autophotograph of the shortened microphone stand

R: If you hadn't done the big one, would you have done this one as quickly or as well?

Alan: Umm, probably not as quickly but, probably just as well.

R:	Why do you say that?
Alan:	Umm, 'cos I wouldn't have done it as quickly because I wouldn't to know what to, wouldn't have known what to do but it would be the same quality because I would have worked out how to do it the same way.

In the interview Alan explained that he was able to make the new stand very quickly because of the skills and knowledge acquired in the making of the long stand. This illustrated that Alan was able to transfer knowledge and skills from his first construction through to the second version, which enabled him to construct it quickly.

New Skill Acquisition

There was also evidence that the Year 2 students developed construction skills, mainly papier-mâché and painting skills. In the extract below, Anne, Ellis and Adam explain their painting procedure to the Researcher.

R:	Anne, tell me about you're doing.
Anne:	Well, we're painting the other side of our fish, and so we can get it done and we've done the other side already.
R:	When you've done the blue, then what colours are you going to have?
Ellis:	Umm, we're doing blue all over it and then we, the decorations are going to be Anne's colours.
Anne:	Red.
R:	Okay, so why are you doing blue all over?
Ellis:	Because to get even colour and no paper.
R:	What's it called, doing one colour all over?
Anne:	A base.
Ellis:	A base.
Adam:	Base colour.

The above extract illustrated that the students in this group were able to complete a base coat before putting on the decoration on their fish. Another aspect of the construction process considered in Year 6 and not in Year 2 was the suitability of construction materials, which is discussed in the next section.

Suitability of Materials

The Year 6 students evidenced six instances of the consideration of materials in the construction process as seen in Table 5.6. The Researcher suggests that the main reason there were no instances in Year 2 was the fact that the Year 2 teacher decided on the construction materials and methods for the flying fish, therefore the Year 2 students were not required to consider this. It does not suggest that they are unable to consider materials in construction.

In Year 6, the students were required to select the best construction materials for their props. There was guidance available from teachers if required. In the first extract, Teddy and Mandy were requesting materials from their teacher who purchased what was required the following day.

Clara: You need spray paint. Okay cool, write that down on the list. I need that by the end of the day 'cause I'll go buy it tomorrow, definitely. Brown or black?

Teddy: Definitely brown.

Clara: And maybe we’ve got black paint so you could do some of that. And use some of the salmon colour. Start thinking about how you’re going to make that.

Teddy: The radio’s being finished in black.

Clara: Cool. We’ve got black paint.

Mandy: We need I need honeycomb wire. You know the wire, yeah, we need that the wire that we have in front.

Clara: How much?

Mandy: ‘bout that much [signals approximately 500mm].

This extract illustrated that in Year 6 these students determined the materials they required for construction. It also demonstrated the design freedom their teacher gave them. She made suggestions but left final decisions to the students.

Another aspect of material selection was consideration of the best methods to join the selected materials. In the next extract, Teddy, Jay, Mandy and teacher, Clara, discussed the best method for joining wooden framing and attaching plastic cardboard sheeting to the framing.

Jay: That's wobbly though.

Teddy: It's quite high because we also need something, one of those.

Clara: Brackets.

Teddy: Bracket to put on.

Clara: Yeap.

Teddy: Then hot glue then on. We could of tried ...

Clara: Just to give it a bit of a start. Because Wendy did say that PVA works best on wood.

Jay: Hot glue.

Teddy: I reckon hot glue because it dries fast.

Clara: It does dry fast, you're right.

Teddy: And it dries clear

Clara: No, you're right, yeah. PVA does dry clear as well, yeah.

Teddy: Yeah, but also it will be better with the cardboard.

Mandy: Well the hot glue will be helpful.

Clara: [laughs] It's a bit wobbly, isn't it? So if you put a bracket on it.

Mandy: Like that.

Clara: Alright, have you got more brackets?

Mandy: Yep.

Teddy: Yeah. We've got six.

Mandy:	One, two three four five. We've got five.
Clara:	Think about where you can place them so it's going to be most effective?
Mandy:	In the corners like that.
Clara:	So you're going to need one there, two, three, four.
Teddy:	We aren't going to have enough.
Mandy:	No because you've got these, this one's done and that one's done and then we'll have one left over for wherever we need to put it.
Clara:	Okay. So then it will be stuck hard to one, at least. Won't it? So maybe if you put them in the corners. So maybe put one.
Mandy:	Put them like that [demonstrates where they could go].
Teddy:	I just need to put a wee bit more hot glue.
Clara:	Okay. Get that bracket on there, I would. Hold that bracket. He needs to borrow that one. Good boy. Right. You will have to hold it Teddy.
Teddy:	It's going to be pretty hard.
Clara:	I'll hold the bracket. Ha, ha, Haa. [banging noise] Is that working?
Jay:	Yeah, it's working.
Clara:	Cool. Right, maybe if you hold it at the top, that's it. Watch your fingers.
Mandy:	Make sure it's even on the outer side.
Teddy:	It's really, the hot glue's not even hot.
Clara:	That's going to be enough glue there, I think.

And a little later, the Researcher approaches Mandy to inquire about what she was doing.

Mandy:	And we're gluing our bits of wood together.
Teddy:	That's really straight.
Mandy:	That is straight.

R: So why are you gluing it first?

Mandy: To make it stronger and so it holds in place while we put the nails in.

The above extract illustrates that the Year 6 students were able to carefully consider joining materials and methods as an integral part of their practice. Task allocation, discussed in the next section, was another aspect considered in the Year 6 practice.

Task Allocation

Table 5.6 indicates that there were six instances of task allocation captured in the data in Year 6 with none in Year 2. One suggestion for the lack of data in this sub-element in Year 2 was that the construction process was pre-determined by their teacher. In Year 6, because some of the designs were complex, with multiple components, task allocation was evident and is illustrated in the conversation below. Alan, of the microphone group, suggested that his group split into two, one constructing the stand and one the microphone head. This group later split into three when the students constructing the microphone head divided into construction of the actual head and the holder separately, evidenced in the element 'Management of Learning', sub-element 'Student facilitation of Construction'. "Oh You guys design a top. I'll do the bottom. We need, like the stand, the pole, the head". This extract, and the one referred to earlier, indicated that the Year 6 students could see the need for individual task allocation in their practice. In the next extract two boys are evaluating their contribution their group's props. This was a group of two boys Charlie and Xiao. Their task was to develop two guns for the German guards on stage as a part of the 1936 Olympic Games. The KLM and MP40 are the names of the two guns the boys developed.

Xiao: You didn't do all the work of the KLM. I did a lot of work with the MP40.

Charlie: I did all, most of the work with the MP40, and you did most of the work with the KLM.

Xiao: Yeah.

Charlie: It's half, half.

Illustrated in this extract is the importance the boys placed on equal contribution. Researcher observation noted that these boys were particularly engaged and successful at this task. Xiao was often seen by the Researcher off-task and avoiding work in the previous round. His classroom teacher told the Researcher that he was frequently off task. It is interesting to note in the above extract, that both boys wanted to be credited with their contribution to the group. This suggested they were motivated and engaged in this activity. As the students worked through their product development, an important aspect of learning was the understanding the students obtained of the process of technological practice. This is discussed in the following section.

Understanding Technology Process (including links between construction and attributes)

Students in Year 6 demonstrated their undertstanding of technological process in six instances while in Year 2 there were 22 as seen in Table 5.6. This sub-element included the students' ability to make links between their outcome and the required attributes, and the importance of working collaboratively.

Links to Attributes

The students in Year 6 were able to consider their final construction in light of the desired attributes determined earlier in the unit. This was illustrated by Minnie who voiced a concern that her groups' microphone was not durable enough: "We think it might break on stage because it broke before while I was trying to get it up." This extract illustrated that Minnie understood durability as an attribute. The following extract comes from a conversation between the Researcher and Charlie. The Researcher asked Charlie how his 'gun' met the co-constructed attributes.

Charlie: It's ergonomically designed.

R: Ergonomically designed. Why is the gun ergonomically designed?

Charlie: Umm, like it fits into the hands.

This extract illustrated Charlie's understanding of ergonomics and that he is able to explain how his designed outcome is ergonomically designed.

The Year 2 students were also able to evaluate their designs against the co-constructed attributes. This was completed as a specific activity at this level. In the extract below, the Year 2 teacher asks the students what they would change if they repeated the process.

Fleur: Things I would change if we could do the flying fish again.

Rex: I would change umm, probably not that many things. I would change probably that messy (unint.)… like all the time.

Debby: I would change the fins because they would need to be about that big (indicates how big with her hands).

Rex: Much bigger.

Debby: Just a little bit bigger.

Fleur: Right, Issy. What would you change?

Issy: What I would change is the paint.

Rex: Big voice Issy, big voice

Issy: What I would change is the (unint.)…

Fleur: Change the colour, the pink to light purple. Anything else?

Issy: I would change the colour of the pink.

Fleur: Why?

Issy: Because umm, it doesn't look good with the blue.

This extract is interesting because it illustrated Issy's focus on colour. Regularly through the Mock-up and Construction stages, when asked about what she was doing or how she felt about what she as doing, colour and pattern featured in Issy's answers. The group's final construction can be seen in Figure 5.10.

Also illustrated in the above extract, was evidence of product evaluation which was the focus of the following sub-element.

Figure 5.10: Researcher photograph of Issy, Rex and Debby's fish

Working Collaboratively

Working collaboratively to design and construct a single outcome was a challenge to all the students at various stages. This was illustrated in the following extract when the Researcher asked Rex what was difficult about technology.

Rex:	I found hard to do is working with other people.
R:	Why?
Rex:	Because they're, people have different ideas that they didn't listen to my ideas.

Rex's comment offers considerable insight into technology practice, in that it is a collaborative effort and individual ideas are sometimes not heard.

Product Evaluation

Ultimately, in the eyes of the students, the success of this unit was determined by the quality of the props they developed. In Year 6 two extracts illustrate this product evaluation, and in Year 2 there were 16. In Year 6, time at the end of the construction phase was very tight because the production was looming and props needed to be completed. The Year 6 students were continually reminded about the co-constructed attributes and undertook a brief evaluation exercise of their final props just before completion. This might account for the relatively low number of instances of product evaluation evidenced in the data, as seen in Tables 5.6. To facilitate ongoing evaluation the Researcher, in the role of teacher, set an exercise up with the Year 6 students. The evaluation process specifically used co-constructed attributes. The Researcher then modelled her expectations using one group's prop - the Olympic torch. In the next abstract, the Researcher talked to Jake about how his prop met the desired attributes. Jake's prop was three Olympic medals, gold, silver and bronze, attached to a small pillow.

Jake:	We were talking about my pillow and it's ergonomically designed but and it's, not a pillow that you sleep on.
R:	So what does that do? By hot glue gunning, if there's such a word, the medals on to the umm cushion?
Jake:	So they won't fall off.
R:	So which of those criteria?
Jake:	Umm, strong, durable and safe because they won't fall off.

The above extract illustrates explicit facilitation by a "teacher" of product evaluation against pre-determined attributes. It also illustrated that this student understood and was able to discuss how his prop met the required attributes.

Students in Year 2 undertook a specific exercise to facilitate the evaluation of their final products. The co-constructed attributes were used to facilitate this process. One main difference between the attributes in Year 6 and Year 2 was the language used. For example, instead of using 'era' and 'culture specific' as they did in Year 6, in Year 2 the attribute was 'look like the real thing'. In the following extract Anne, Ellis and Adam respond to the question 'What do they like about their prop?'

Anne: Well, they're colourful and, they're colourful and umm, and good.

Adam: They're colourful. They've got wings.

Anne: Well, it's nice and colourful and bright.

Adam: Anne, it's my turn.

Anne: I painted that colour.

Adam: Anne, Rex has a little dot of orange on the eyeball.

Anne: So it looks cool.

Adam: Yeah, and it's got marks.

Anne: Are we also had to paint the wings all white so they were nice and bright. And we also had to paint the wings all white so they would stand out.

The above extract illustrated that the Year 2 students were able to use the pre-established attributes to evaluate their design. It is interesting to note that appearance was a focus of their consideration, despite there being a number of other attributes such as looking realistic, being safe to use and being able to be seen by the audience.

Product evaluation did not only occur at or near the end of the construction phase. Ongoing evaluation during the construction process was also evident in the extract below. Rex, Debby and Issy are trying to decide which shape wings and fins to have.

R: Right, I've got Issy and Debby and Rex here and we're talking about some fins. So tell me what you're trying to do. Issy, you tell me.

Rex: We're trying to…

R: Issy. No, no.

Issy: We're trying to decide what shape will be because we can't agree.

R: Okay. Debby. Tell me what you think.

Debby: Well, me and Issy want this shape fin and Rex wants that shape fin.

Rex: No, this shape.

R: Okay, right, and Rex, you tell me what you're thinking.

Rex: Well, I want like a sharp, like sharp ends.

The above extract illustrated that during the construction process these Year 2 students were thinking about what they liked and wanted on their final outcome. However, it does not evidence on what criteria these decisions were being made. Further questioning by the Researcher may have assisted in finding this out.

It is also relevant to note that some extracts featured in the Learning Strategy sub-element, are also examples of product evaluation in Year 2. This illustrated that there was overlap between sub-elements and many extracts were applicable in more than one sub-element. The extracts selected in each section offer the best examples that have not already been selected elsewhere, to avoid repetition wherever possible.

The main differences between Year 2 and Year 6 in this element of Technology Knowledge and Skills come in the sub-elements of Suitability of Materials and Task allocation, both of which occurred in Year 6 and did not in Year 2. Possible reasons for this are mentioned in both sub-elements. Emerging construction ideas is also an area of difference with considerably more instances recorded in Year 6 and Year 2. One suggestion for this was that the Year 6 students had the freedom to decide on construction skills, techniques, materials and methods, whereas in Year 2 the classroom teacher determined this. The greater number of instances of Understanding Technology Process and Product Evaluation in Year 2 than Year 6, is the other main area of difference in this element. The Researcher suggests that this difference does not necessarily mean a difference in knowledge or skill but is explained by the fact that the Year 2 students undertook formal activities in these areas and in Year 6 they were completed on an informal basis that may not have been captured in the data gathering process.

This section discussed the knowledge and skills obtained by the students as they constructed their technological outcomes and the differences between the two levels. The following section compares Stage 4 with the previous three stages.

5.3.6 Comparison Between Stages

The final element Technological Knowledge and Skills related to the construction of the students' outcomes, and was therefore considerably different from the three previous stages. Tables 4.2, 4.3, 5.1 and 5.2 very clearly indicate that at each stage the Technological Knowledge and Skills relate to the learning focus in that stage, as one would expect. This section compares the data across the Construction stage with first, second and third Stages: Character and Function, Planning and Mock-up. The section is organised into the four elements: Funds of Knowledge, Making Links and Connections, Management of Learning and Technological Knowledge and Skills. While the differences between years are reported after each element, this section will report the differences between the elements.

In this stage the sub-elements in the Funds of Knowledge element remain the same: Participatory Enculturation and Passive Observation. However, Tables 4.2 and 4.3, and 5.1 and 5.2 indicate that Participatory Enculturation and Passive Observation are either not used or used infrequently in Year 2 in the construction stage, which is similar to the Planning Stage - Stage 2. In Year 6 there was an increase in the use of Participatory Enculturation while Passive Observation increased from Stage 3 but decreased compared to Stage 2. According to the total number of instances across all stages, this stage would rank third after Stage 1 with 23, Stage 2 with 17, Stage 4 with 15 and Stage 3 with nine.

Making Links and Connections saw no new sub-elements introduced in Stage 4. Knowledge from other disciplines returned but at a lower level than Stages 1 and 2. It was missing from Stage 3 as can be seen in Tables 4.2 and 4.3, and 5.1 and 5.2. Making links to newly learned technological knowledge and skills were more prominent at this stage than in other stages in the unit. This could be explained by the fact that this was a time when students implement knowledge gained in previous sections, and there was more learning preceding this stage than any of the others. Making Temporal Connections was not evident in this stage. Perhaps as students implemented more knowledge from the current unit, the reliance on knowledge gained from the previous unit diminished.

Tables 4.2 and 4.3, and 5.1 and 5.2 also indicate Management of Learning continued to be the most prolific element in each stage. Stage 4 saw the introduction of Specific Teacher Assistance with Construction and prompts related specifically to Task Management as the students moved into the final construction phase. Teacher Behaviour Management returned but incorporated assistance with collaboration, which was a specific feature in Stage 3. Teachers continued to facilitate learning with Specific Learning Strategies and Higher Order Questioning clustered together. There were no instances of Transmission at this stage, which did feature in the three previous stages. Student Facilitation of Construction also featured at this stage for the first time, however, there was no section specifically related to peer discussion as this was incorporated into this sub-element.

Technological Knowledge and Skills obtained by the students evolved as the unit developed, so obviously they had a different focus in Stage Four than they did in the earlier stages, as the students constructed and evaluated their props to meet previously identified criteria. This was particularly obvious in the sub-element of the understanding of the evolving nature of technological process, as the aspect learned about related to the stage of the practice the students were involved in. For example, in Stage 2 technology process focused on Planning for Practice, while in Stage 4 the focus was on linking attributes to product construction. Two sub-elements begun in Stage 3, task allocation and materials identification and selection - Suitability of Materials, also continued into Stage 4. New sub-elements to emerge in Stage 4 were construction skills and product evaluation. One significant link between Stages 1 and 2 was the implementation of the co-constructed attributes required for stage props. There was evidence at this stage that the attributes of props learned in Stage 1 and listed in Stage 2, influenced the students' constructions and were used to evaluate their outcomes.

5.4 Chapter Conclusion

This section concludes the second of two results chapters in which the Researcher reported findings from data gathered during the implementation of a technology unit in an urban primary school in both Years 2 and 6. This chapter presented results for the third and fourth stages of the props technology unit in which the students mocked-up (Stage 3) and constructed (Stage 4) the actual props for their class items in the school production. These stages were the more practical stages of the unit.

In the latter two stages, the same sub-elements in Funds of Knowledge were revealed as in the first two stages. No new sub-elements were identified. During Stage 3 neither the Year 2 nor 6 students deployed Funds of Knowledge through Passive Observation, however, they did deploy knowledge gained through Participatory Enculturation to assist them in the construction process, more so in Year 2 than Year 6. During Stage 4, this was reversed with more incidences of Participatory Enculturation in Year 6 than Year 2.

In both Stages 3 and 4 students did not make temporal connections to prior technology units however they did make links to new technology knowledge at both Stages 3 and 4. This seems logical because as the students progressed through their unit they began to utilise learning from the earlier stages of the current unit rather than relying on technology knowledge from previous units. Knowledge from other disciplines was deployed to assist the construction process in Year 6.

A range of strategies continued to be implemented to assist students' learning. Students developed a single prop per group of three students; therefore collaboration and co-operation were absolutely necessary at these two stages. The data suggested that both teachers assisted with collaboration skills. Managing Students' Behaviour featured in the Management of Learning element at both stages. It is interesting to note that in Stage 3 the students in both levels managed the behaviour of their peers and at both stages teachers facilitated collaborative and co-operative skills between students. Teachers also continued to introduce specific activities to facilitate students' understanding of key ideas. At both stages and at both levels this approach facilitated students' evaluation of either their mock-up or their final prop. At Stage 4 teachers were also involved in construction assistance through the facilitation of construction ideas and assisting with the physical skills. At the same stage, students also assisted each other with construction. Transmission of information featured in the Stage 3 but not in the Stage 4. This could be explained because by the time the students were constructing their props they had acquired information that was likely to be given to the class using a formal transmission process. All groups learned appropriate construction techniques with assistance from their peers and teachers, although this was done individually and in small groups through debate and discussion, as opposed to straight transmission of skills. Year 6 students were involved in selecting suitable materials for their final props, while in Year 2 this was determined by the classroom teacher.

Technological Knowledge and Skills, evidenced at Stages 3 and 4, reflected the collaborative and practical nature of the tasks undertaken. Data presented in Stage 3 of this unit, reported at the beginning of this chapter, indicated that students were able to construct three-dimensional models from two-dimensional plans. In Year 2 this process was carefully modelled to the students by the Researcher in her role as teacher. In Year 6, the students developed their mock-up designs without the process being modelled for them. Evidence presented suggested that students understood that the mock-up process preceded the construction process, and informed their design ideas. When questioned later, students were aware that the mock-up was not a final design and making a mock-up assisted their designs evaluations. In the final stage of the unit, Stage 4, the students constructed a single technological outcome per group. Both Year 2 and 6 students were able construct their designs having planned and modelled their ideas previously. A new sub-element introduced in this chapter, and present in both Stages 3 and 4, was Task Allocation. This involved the identification of the tasks to be undertaken and either allocating individuals to do different tasks or allocating a completion time for individual tasks.

Year 6 students also considered suitable materials for their constructions, whereas this was not required of the Year 2 students. Students in both Year 6 and Year 2 undertook product evaluation during both mock-up and construction stages. Evaluations of mock-up designs in Year 2 were mostly focused on two attributes, size and aesthetics, and were evident in the sub-element Understanding Purpose of Developing a Mock-up. The data suggested that the Year 6 students had a more sophisticated understanding of the purpose of a mock-up, with several groups developing more than one mock-up to compare or contrast design ideas. Students in Year 6 were also able to evaluate their designs using more complex, and a wider range of, attributes.

In Stages 3 and 4 students developed mock-ups and final props for their school production; this chapter - Chapter 5 - has reported these findings. In the final section of this chapter the findings from both Chapters 4 and 5 are synthesised into emerging themes.

5.5 Results Conclusion

This next section discusses key findings of both results chapters and identifies some emerging themes from these chapters. Through analysis of the data in this study, the Researcher could see a number of threads or streams, referred to subsequently as themes. Some of these themes came and went, some merged and separated, some were continuous, some started anew during the journey and continued, and others are only present for a short time. Elements and sub-sections made up the themes evident throughout the technological practice. Each element: Funds of Knowledge, Making Connections, Management of Learning, and Technological Skills and Knowledge contained a varying number of sub-elements. In the sections below the researcher summarises the results from Chapters 4 and 5 in terms of themes through and across the elements. The data suggested three major themes emerge from the data. As suggested, these themes were not distinct or discrete, but ebbed and flowed, merged and separated though the journey of technological practice.

Conversation in technology education in this study indicated that dialogue had three distinct purposes justifying the existence of three major themes: Deployment, Conduit and Knowledge; all of which have an interconnected relationship rather like a set of cogs. Imagine this set of three interdependent cogs, the first turning the second, which in-turn drives the third, as can be seen in Figure 5.11. Although the first and third cogs are not touching, the movement of the third is dependent on the first which deploys its influence through the second cog. The third cog is bigger than the second and the second cog is bigger than the first. This signifies cognitive growth in students as they deployed knowledge across fields of learning in a structured and planned manner such as within a purposely-planned unit of work in technology.

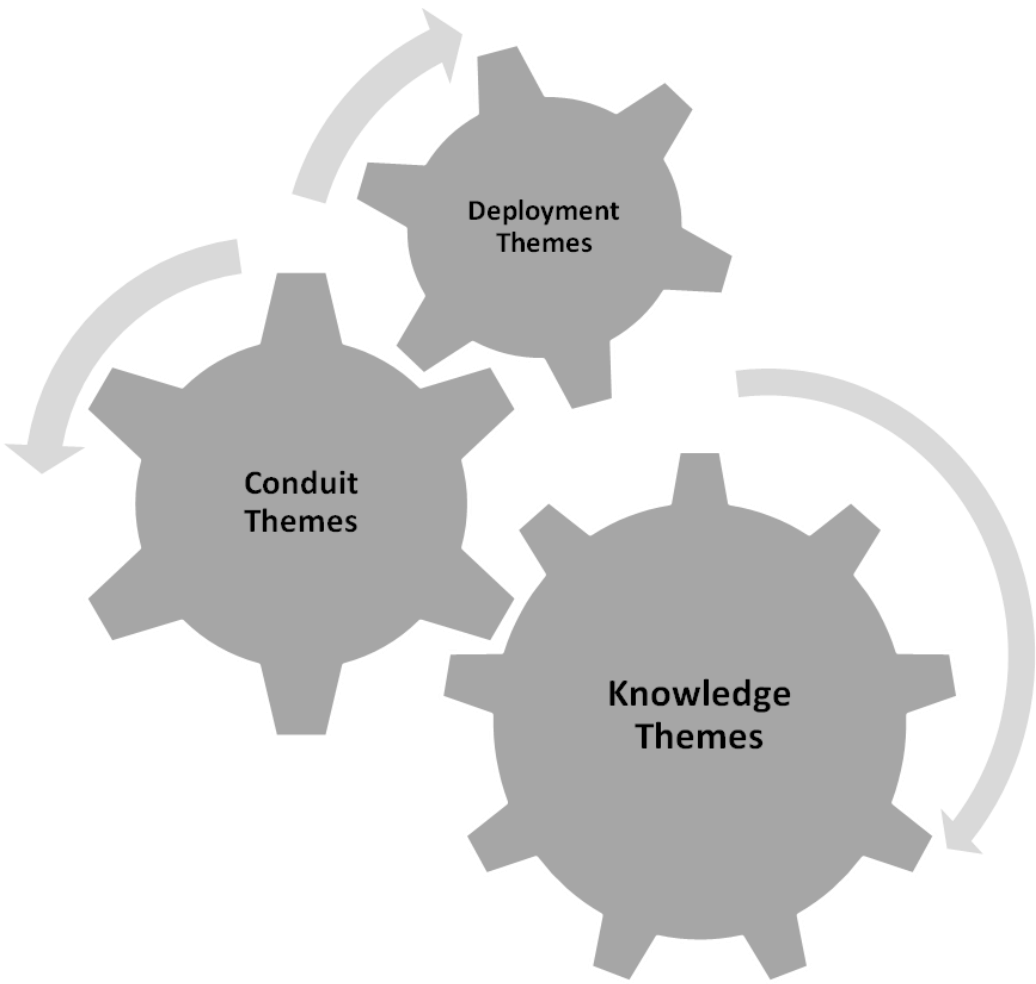


Figure 5.11: The Interconnected Nature of Emerging Major Themes

The first major theme contains conversations that show the deployment of students' existing and recently learned knowledge, either from their home, community and culture, or from knowledge learned at school: from technology - either earlier or from the current topic - and from other disciplines. This is termed the Deployment Theme. The main sources of Deployment Themes in this study mostly incorporated the first two elements: Funds of Knowledge and Making Connections. Knowledge and experiences need to be presented to students in a manner that facilitated purposeful deployment to enhance students' technological practice.

The second major theme, Conduit, centres on the implementation of learning strategies and techniques taught, and implemented by students and teachers to manage and facilitate technology practice, thus acting as a conduit for the deployment of knowledge and experiences into contextually relevant technological knowledge and skills. Conversations in Element 3, Management of Learning, was the main source of conversations in the Conduit Theme.

The third major theme, Knowledge, has a focus on technology knowledge and skills gained during students' technological practice. The Knowledge Theme appeared as a result of a merger of Deployment Themes and Conduit Themes into student knowledge and understanding of components, practice and nature of technology education. Element 4, Technology Knowledge and Skills was the main source of Knowledge Themes in this study but also there were links with other sub-elements such as Making Temporal Connections and New Technology Knowledge situated within the Deployment Theme. In the section below each major theme is discussed in detail, including the identification of minor themes.

5.5.1 Deployment Themes

The data suggested there were six Deployment themes, within the first two elements: Participatory Enculturation, Passive Observation, Knowledge from Other Disciplines, New Technology Knowledge, Making Temporal Connections, and Physical Prompts. Both main themes within Funds of Knowledge were continuous through all four stages of the unit and coincide with the elements Participatory Enculturation and Passive Observation. In Stages 1, 3 and 4 this theme was a single strand with general deployment of Funds of Knowledge. However, in places minor themes emerged. There were three aspects to Participatory Enculturation in Stage 2. The first was the influence of the occupations of the students' parents, including related activities and materials students may be exposed to at home. The second, the functional and physical design features of artefacts routinely engaged with in the home. The third was related to family values, and behaviours in terms of the social and co-operative skills and guidelines students are exposed to at home.

Passive Observation starts in Stage 1 as two minor themes: the first was that students were able to recognise the geographical and or historical location of an artefact through observation of said artefact *in situ*, usually in a movie, on TV, or in a book. The second was understanding the form and function of an artefact through the same means. Deployment Themes changed into two new minor themes in Stage 2: the first was recognition of artefacts suitable for props in their specific play, and the second, knowledge of the processes and procedures undertaken in the planning of a technological outcome. In Stages 3 and 4 the minor themes in Passive Observation reunite.

In Management of Learning, there were two minor themes, which occurred in three of the four stages, and two very minor themes, which occurred in only one or two stages. The two main themes were the elements Knowledge of Other Disciplines and New Technology Knowledge. Knowledge of Other Disciplines begins in Stage 1, continues in Stage 2, is not evident in Stage 3 but resurfaces in Stage 4, and simply referred to input of learning from other learning disciplines undertaken at school such as mathematics, sciences visual art and social studies. The other was New Technology Knowledge, which began in Stage 2 and continued through Stages 3 and 4. This knowledge was the technological knowledge specifically taught within the current context of study. In Stage 4 the attributes theme - students' deployment of knowledge about desirable attributes of studied technological outcomes, from Element 4, merged with the Technological

Knowledge and Skills theme, because understanding attributes was deployment of technology knowledge learned. Both elements, Knowledge of Other Disciplines and New Technology Knowledge, have student initiated and teacher initiated aspects of conversation.

The first minor theme in Element 2: Making Connections, was students Making Temporal Connections, making use of knowledge gained from previous technology units to assist their understanding in the current unit. This occurred in Stages and 1 and 2 only. The second was the making connections to Physical Prompts used by the teachers to assist students in the visualisation of key ideas. This occurred in Stage 1 only in this element, but reoccurs in the Managing Learning themes when teachers make explicit links to modelled outcomes in Stage 2.

5.5.2 Conduit Themes

The element Management of Learning was the main source of conversation in the Conduit Theme. Within this element the merging of themes was especially evident in Stages 3 and 4. Five Conduit Themes with seven minor themes were evident in the data. Transmission - the giving of direct information through transmission, travels through the first three stages and incorporates two types identified in Stage 1: the direct giving of important facts to students, usually by teachers but sometimes by students themselves; direct teacher instructions and organisation of learners. In Stage 2 the purpose of transmission appeared to change to the facilitation of consistency of message and time saving. The use of questioning to facilitate students' higher order thinking was a theme that was consistently present in all stages; however, in Stages 3 and 4 it merged with other strategies for assisting learning.

Another theme present through all four stages was Peer Discussion - discussion between peers, usually group members within each class. In Stages 1 and 2 it was discrete with two minor themes. The first had two components: students instructing each other and, conversation to facilitate collaborative working, which also continued through Stages 3 and 4 merging with managing students' behaviour. The second minor theme also had two components: In Stage 1, intercognitive conversations in which participants challenged and learned from each other as they discussed aspects and issues within their practice was evident, and in Stage 2, conversation to assist the clarification of understanding of key ideas was evident. Both these components demonstrated students' ability to assist and learn from each other.

Management of student behaviour was a theme present in all four stages and, as stated above, merged with the Peer Discussion theme in Stage 3. Two minor themes emerged in this theme: student management of each other's behaviour and teacher management of students' behaviour. Management of behaviour in the context of this study mainly consisted of keeping students on task. There were no major behavioural issues in either class.

A merger of another two elements forms the next theme, present in all four stages. The theme is focussed on specific and targeted assistance to students. It included the implementation of specific learning strategies such as PMI (Plus, Minus, Interesting), No Hands Up and Talking Partners in Stage 1. It also included the targeted strategies to assist students' technology learning, such as a planned task to teach specific technology skills. Teacher modelling of the planning and mocking-up process was an example of this. This theme was present in Stages 2 to 4 and merged with Higher Order Thinking at Stage 4.

Two further sub-elements merged into another theme in this element. These are Drawing Out Pre-determined Answers which involved teachers questioning, probing and prompting to ensure a particular answer was reached, from Stage 1 and Eliciting Specific Information from Stage 2, in which teachers aimed to move students to a particular point of view through questioning. These strategies were both common questioning strategies aimed at teachers ensuring their students knew specific information. Finally in this element, there were three minor themes each unique to a single stage. In Stage 1 an external expert was brought in to assist students' conceptual knowledge in their area of study. In Stage 2 teachers spent considerable time assisting students to work collaboratively, and in Stage 4 it was evident that the students' assisted each other through the facilitation of construction ideas and skills and with the management of their tasks.

5.5.3 Knowledge Themes

One theme ran through all four stages in Element 4 - Technological Knowledge and Skills - and was the management of technological practice, ensuring the designed outcomes were completed on time. In this context this was vital as the props were needed for the productions' dress rehearsals. This theme was made up of two elements: Planning for Practice in Stages 1 and 2 and Task Allocation, which was an aspect of Planning for Practice in Stages 3 and 4. Task allocation was also merged with working collaboratively in Stage 4.

A further three sub-elements also made up another theme - Knowledge of Materials. The first was focused on suitable construction and artefact materials. It was present in Stages 1, 2 and 4. In Stage 1 it was evident as materials knowledge and skills and was focussed on developing an understanding that materials play a role in the character and function of objects. In Stage 2 the focus moved to the identification of suitable materials for mocked-up models and final outcomes. In Stage 4 the focus remained on material suitability for final outcomes and the evaluation of material performance. Skill development was the second knowledge theme that ran through all stages except Stage 3. Like the materials theme, it was made up of three separate sub-elements. First was the identification of skills needed to construct their technological outcomes in Stage 1. The second was the ability of students to draw or plan their intended outcomes in Stage 2, and the third, the physical construction skills as the students built their designed outcomes in Stage 4. Although not evident in the data, construction skills were also required by the students in Stage 3, Mock-up, hence the vision of an 'underground' theme running beneath the surface of Stage 3. The third theme evident in Stages 1, 2 and 4 was the understanding and identification of attributes which, in Stage 2, was separated into physical and functional attributes, and in Stage 4 was merged with the Conduit Theme of making temporal connections to earlier technology learning.

Students' understanding of the planning process was one sub-element that was unique to Stage 2 but was part of a wider technology process theme along with students' understanding of a technology design process and their ability to articulate it in Stages 3 and 4 respectively. Three Knowledge Themes remained in Element 4; two consisted of two sub-elements and one consists of one. The first of these, 'Understanding the Purpose of a Mock-Up' demonstrated students' understanding of modelling and was also linked to the previously mentioned theme related to articulation of the technological process. The second was the students' understanding of construction techniques and processes. Together these themes demonstrate students' understanding of the complexity and decision making in developing mock-up and final technological outcomes. The second remaining theme linked students working collaboratively in Stage 3 and the allocation of specific and different tasks in Stage 4, and was linked to task allocation at Stage 3, mentioned above in conjunction with students planning for practice. So too was the last sub-element in which students demonstrated knowledge of product evaluation, as they demonstrated an understanding evaluating their designs using developed attributes to guide them.

Evidence that learning in technology occurred during the implementation of the unit was further backed up by the teachers in their final interview. In response to a question about students' learning during the study Clara and Fleur responded as follows:

Clara: Probably following a process, learning a process of how to and the importance of planning and the importance of the process and not just racing in, coming up with your design and thinking you know the best idea straight away. Actually doing the research and coming up with better ways of doing things and, learning to slow down.

Fleur: The success? Getting children to work in groups of different abilities. Like Clare [said], learning about the process because in the first unit [Round One], the children tend[ed] to rush and weren't so sure about the process but when we came down to the second unit [Round Two], the children were a lot more aware and they actually took a wee bit more time on each section of the process. So I think the outcome was actually probably better than the first, outcome

Clara: I'd agree. They realised the importance of each step?

Fleur: And they actually realised that you've got to do all that research of the flying fish or the importance of looking at the pictures and looking at the different aspects of each fish and then reflecting and then putting it into their own plans.

In summary, the results recorded in Chapters 4 and 5 suggest that conversations within technology education can be divided into elements and sub-elements. Within and across these elements and sub elements, are a number of interconnected themes of conversation. Themes have two levels:

1) major themes, of which there are three;

2) minor themes are multiple smaller themes within each major theme.

All themes started and stopped, merged and separated, and travelled in parallel throughout the technology practice. The next chapter, Chapter 6 will discuss these findings in detail using a synthesis of literature and findings in an attempt to answer the following research questions.

5.5.4 Main Research Question

What is the nature of conversation in Technology Education?

Sub Questions

1) What types of conversations enable students to participate in collaborative technological practice?

2) How do children's prior and concurrent experiences influence their technological practice?

3) What happens in the classroom to increase the likelihood of students deploying knowledge and skills from other areas into technology?

4) What insights into technology education can be gained through an analysis of student's conversations with their teachers and peers while participating in technology education?

Chapter 6. Discussion

6.1 Introduction

In this chapter results of this study are discussed in light of the relevant literature. The study's contexts, stages, elements and themes are outlined initially to give an overview of the terminology used in the chapter. Each of the remaining sections answer a research question beginning with discussion about the types of conversations students engage in when undertaking technology practice. Subsequent discussion answers the remaining questions and includes: insights into sources of knowledge deployed by students - Deployment theme; and insights into ways of maximising learning opportunities to enable or facilitate learning in technology - Conduit Theme. Finally, insights into students' actual technology learning - Knowledge Theme - are discussed. The following chapter, Chapter 7, discusses the implications of the findings for teachers and researchers, as well as providing concluding comments.

The study was undertaken in a New Zealand urban primary school with two classes of students, one from Year 2 and one from Year 6. Students undertook two technology units over the period of a year. The main data-gathering phase occurred during implementation of the second unit in which the context was "Props for Our School Production". In Year 2 the class item was a Taiwanese folk fishing tale, with each group designing and developing a flying fish to be placed beside a fishing boat on stage. The Year 6 students designed a range of props to support a short item written by two class members encapsulating the Olympic Games from 1896 to1936.

In the next section the unit stages, identified through analysis of the students' autophotographs are defined and summarised. This is followed by a description of the four elements of conversation, which indicate sources of conversations, or influences on conversations and were identified through closer analysis of the data. This section concludes with an overview of the three themes of conversation which indicate purpose.

6.1.1 Identified Stages

Four stages of practice emerged from investigation of the initial transcripts and detailed analysis of students' autophotographs of their "significant learning" undertaken in the study. These stages were: character and function, planning, mock-up and construction. The stages of practice identified relate to the framework of the unit of work taught in each classroom and are key components of the design process used by the students, situated within the New Zealand Curriculum (NZC) achievement objectives (Ministry of Education, 2007).

The overall purpose of the lessons in Stage 1 was to develop students' understanding of the character and function of props in stage productions. The early lessons had two areas of foci. The first was building students' understanding of the place and properties of props and the second was investigation into the function of the actual props to be developed within their situated context. Planning within technological practice is a broad term, which encompasses everything from very early ideas and sketching, to full detailed drawings. Compton and France (2007) suggest there are two aspects of planning in technology practice: planning for technological practice and planning for technological outcomes. Planning for technological practice occurs so that a specific technological outcome is developed within the required timeframe with the desired materials and resources available when needed. While undertaking planning of their practice students considered task identification, sequence and dependency – that is, which tasks depend on the completion of prior tasks? These typically involved strategies such as: lists of tasks completed or to be completed, identification of resources available to be used, timeline development, and critical paths such as Gantt charts. Strategies used depend on the level of achievement, age and stage of development of the students.

Planning a technological outcome involves students actively designing, and drawing in detail, their intended technological outcome. In this study, initially the students discussed their ideas with the members of their group and either their teacher or the Researcher. Then they sketched some early ideas, selected one from the group, or combined aspects of a number of ideas, and collaboratively drew in detail their outcomes. The third stage of practice identified was the mocking-up of the final designs. This occurred subsequent to the drawing of designs, and prior to the construction of the actual props. Developing a mock-up was identified as the next stage, because early analysis of the data indicated that the students identified their mocked-up designs to be a significant part of their process and learning. Following planning and mocking-up of their props, the students went on to construct their technological outcomes - the props. The students used the knowledge gained through their research, teacher planned activities about the character and function of props, planning and modelling to develop their props to meet co-constructed attributes, and in the case of Year 6 students, planned specifications. Outcome development and evaluation are critical outcomes of technology (Compton & France, 2007). Compton and France (2007) also suggest that students develop the ability to develop their outcomes in line with established attributes. In Year 5 and 6, students should be able to evaluate and select appropriate materials and components to inform the final construction of their outcome and evaluate the suitability of materials and components, in order to select those appropriate for use in the production of their outcome. Students should also be able to produce an outcome that addresses a brief.

Close inspection of the data across all four stages revealed four elements to conversation; further analysis of the data indicated that within and across the stages and elements, conversations had varying sources and purposes, which have been clustered and labelled ‘themes’. Both elements and themes are outlined below.

6.1.2 Elements of Learning

Initial data analysis identified four elements, which influenced students’ learning while undertaking technology practice. These elements have been termed Funds of Knowledge, Making Connections, Managing of Learning, and Technological Knowledge and Skills. In Funds of Knowledge the students made links to and use knowledge from their home and community (Gonzalez, et al., 2005) to assist their learning and that of their peers. For example Ellis referred to gutting fish with his grandfather when discussing the stuffing of fish with Anne, and Dougal drew on knowledge of materials obtained from his Dad who was a contractor.

Making Connections saw the students and teachers making links to prior learning in technology. This occurred when Clara referred to the stages undertaken before construction in the Space Station unit, and to other school based disciplines. This also occurred when Mandy and Teddy were measuring materials for their ‘radio’ deploying their skills in mathematics.

In the Managing of Learning element the students were engaged in learning episodes, which were planned to facilitate student learning, using a range of strategies which maximised learning. These strategies included strategies such as No Hands Up, Agree/Disagree and PCQ (Pros, Cons, Questions) and are outlined in Appendix 20. Finally the aim of undertaking learning in technology is to build technological literacy through the developed understanding of technology knowledge and skills.

The Technological Knowledge and Skills theme offers evidence of this learning, such as Rex’s understanding of the purpose of annotations and Alan’s ability to modify his microphone design following a change in requirements from the script writers. To assist the understanding of the interrelated nature of the emerging elements of conversation, one can imagine a braided river meandering across the plains. Elements and sub-elements, rather like the streams of the river, merge and separate, disappear and reappear, while essentially having three main themes.

6.1.3 Themes

Subsequent and closer analysis of the data revealed three major themes of conversation that are based on three distinct purposes: Deployment, Conduit and Knowledge; all of which have an interconnected relationship, rather like a set of cogs, as can be seen in Figure 5.11.

- The Deployment theme identifies knowledge and skills students deploy to facilitate to assist their understanding of, and learning in technology. They are sourced mainly from the elements of Funds of Knowledge and Making Links and Connections. This was illustrated by Alan who deployed his knowledge of an inches symbol (″) to assist his group to determine the size of radios from the 1930s.

- Conduit Themes describe conversations that assist the students in making connections from their deployed knowledge to their current learning in technology practice. Conduit themes were solely sourced from Management of Learning element and were illustrated through the inclusion of an external expert - the props manager, assisting the students' understanding that some props used in plays are specifically designed and made by theatre staff.

- Knowledge Themes describe the conversations in which students demonstrate technological knowledge and skills in relation to their current project. Knowledge themes emerged from a synthesis of the Deployment and Conduit themes and are sourced in the elements of Technological Knowledge and Skills, and Making Connections. This was clearly illustrated in the Year 2 Stimulated Recall interviews when the participants were able to clearly articulate the purpose of a mock-up.

6.2 Types of Conversations:

This section will address the research question: *What types of conversations enable students to participate in collaborative technological practice?* The data from this study suggested that classroom conversation during technological practice had three distinct reasons: 1) for cognitive growth, 2) for managing learning, 3) to transmit specific information. Sociocultural Learning theory indicates the importance and role of dialogue in cognitive development. A number of theorists suggest that dialogue assists students' understanding and cognitive development (Alexander, 2008; Fleer, et al., 2006; Mercer & Dawes, 2008; Shields & Edwards, 2005). Conflict also plays a significant role in cognitive growth and understanding for some students (Doise & Mugny, 1984; Resnick, et al., 1991).

The data from this study shows that significant insight can be gained into students' abilities and understanding in technology. For example, Alan's conversation with the Researcher about the suitability of items as props evaluated against pre-determined attributes in Section 4.3.5, indicates his understanding of how attributes can be used to evaluate technological outcomes. This section explores each conversation reason in turn.

6.2.1 Conversations involving Cognitive Growth

Findings from this study show that the students' knowledge and understanding of concept and procedures related to developing props for a stage show was assisted through conversation with their peers and their teachers. This was exemplified when the Researcher used open questions and discussion to assist Teddy, Mandy and Jay to determine the difference between antique and replica antique radios. It also occurred when Mandy contributed the idea of bracing the trellis timber to assist the construction of their radio. Teddy and Jay learned about the concept of bracing and all three learned about the functional nature of the bracing and the trellis wood.

These findings concur with Burr (1995), Clarke (2003) and Fleer (1995) in that language, more specifically oral language, plays a critical part in cognitive development. Conversations in which all participants are contributing to the discussion are termed interactions (Fleer, et al., 2006). Sociocultural Conflict Theory (Doise & Mugny, 1984) suggests that differing of opinions force students to coordinate their views with others'. Conflict was a significant aspect of several students' practice. In Section 5.2.4 it can be seen that Dougal and Alan's conflict about suitable designs for the microphone stand forced Dougal to consider his design critically and somewhat reluctantly agree that Alan's was the better. In Year 2 in his final interview Rex identified that working with others was difficult (Section 5.3.5). There were several occasions throughout the study when his group experienced conflict and an inability to work together. Two of these occasions are reported in Sections 4.5.1 and 4.5.2. However at the final focus group interview with the researcher Rex stated that working with Debbie and Issy had been good and that together they had achieved more than he could have by himself. “I like working with other people” and in response to the researcher question “If you were working by yourself, would your fish be as good as the one that you finally made?” All children answered “No” then Rex added “because then we can actually, work really, really hard. We wouldn’t just like work, be able to make it all by ourselves”.

During interactions participants may or may not be learning new information, skills or knowledge; they may in fact only be contributing what they already know and can do. Conversations, which involve cognitive growth, are conversations in which learning takes place for all participants and differ from other conversations in that the participants leave the conversation with new ideas and understanding. The literature suggests a variety of terms used for these conversations, including cumulative talk (Mercer & Dawes, 2008), dialogic teaching (Alexander, 2008) and interthinking (Mercer, 2006). The literature also suggests that these types of talk imply that the participants are growing in the same fields of learning or within the same context, or have convergent growth and so are labelled as Convergent Growth Conversations (CGC). The data in this study also suggests that participants may be learning new knowledge in different fields and purposes. This was evidenced in interviews between the Researcher and the teachers Clara and Fleur. They both indicated that through dialogue with the students they gained new knowledge about learning in technology, about successful pedagogical approaches and about what the student understands in technology. In these same conversations the students may be learning a new skills or understanding related to the context of the study. This was exemplified in Section 4.3.4 - Specific Learning Strategies, when Fleur talked about the benefits of asking students to ‘agree or disagree’ with statements. Students were engaged in deep thinking about props and Fleur learned the benefits of higher learning strategies. This type of conversation is characterised by divergent cognitive growth for all participants and is termed by the Researcher Divergent Growth Conversations (DGC). The

Researcher also suggests that all conversations involving cognitive growth be collectively called Intercognitive Conversation. The relationship between these conversations is represented in Figure 6.1. Figure 6.1 shows the interconnected nature of the three types of conversation which make up CGC as identified in the literature and subsequently clustered together by the Researcher. Although each is characterised slightly differently as outlined in Chapter 2, there is considerable overlap in terms of the overall purpose of such conversations. Sitting alongside the CGC, while still a subset of Intercognitive Conversations, are DGC.

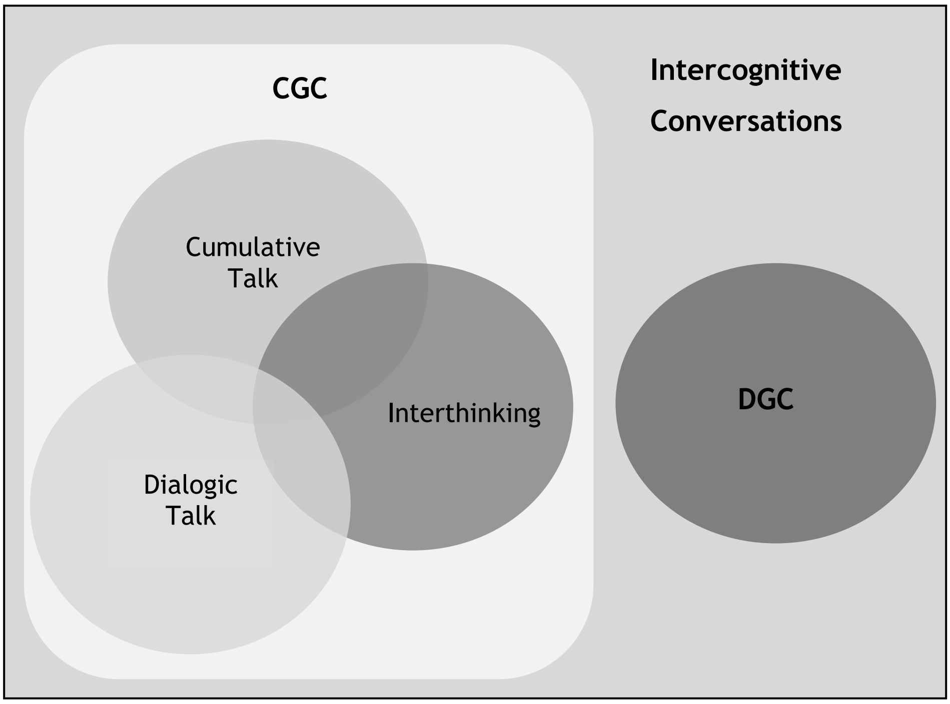


Figure 6.1: The relationship between Convergent and Divergent Growth Conversations within Intercognitive Conversations

In this study two types of Intercognitive Conversations occurred; the first, conversations between teachers and students, the second between students.

Teacher- student

This category included conversations instigated by teachers and also by students to teachers on occasions. Teachers planned and implemented strategies to engage students in higher level thinking on a number of occasions throughout the unit. Examples of higher-level questions occurred in Stage 1 of the unit in Year 6, when students were asked to identify and critique objects in relation to their suitability as props while searching on the internet. These conversations involved cognitive growth of the students who were in dialogue with the teacher as they developed their ideas about props.

During this time students also used conversation with teachers to assist clarification and processing of the information they came across. This was illustrated when Mandy, Teddy and Jay were trying to identify the number and size of dials and speakers on radios from the 1930s. Conversations involving cognitive growth also occurred in Stage 3 when students evaluated their mock-up to identify possible improvements before construction of their final product, and in the identification of techniques to be used, such as in joining. This was exemplified in Section 5.3.2 - Participatory Enculturation, when Mandy discussed with the researcher the best techniques for joining the trellis slats to make the frame of their radio prop.

It is suggested that dialogue assists students' understanding and cognitive development (Alexander, 2008; Mercer & Hodgkinson, 2008; Shields & Edwards, 2005). Jordon's findings (2004, cited by Fleer, et al., 2006) state that when students and teachers are equal partners in conversations, the areas of shared meaning are extended. This idea was illustrated in Figure 2.3. When conversations involve dialogue in which teachers are interested and open to learning from the students, as well as the other way around, then learning clearly occurs. The data from this study supports this, showing that teachers challenged students' thinking through the use of questioning designed to extend students' thinking beyond regurgitation and comprehension into areas of analysis and synthesis. Both students and teachers gained from the experience. This supports Mercer and Littleton's (2007) findings that teachers contribute to the way students think and that involvement in intercognitive dialogue enhances this process. Formative feedback is given to facilitate cognitive growth and raises achievement (Clarke, 2008). However, Mercer and Littleton's specific definition of dialogue as conversation that takes place during education activities does not go quite far enough to fully describe the teacher and students conversations in this section. Conversations assisted both parties' understanding, hence the introduction of the term Intercognitive Conversations. In this study, teachers facilitated students' thinking through the use of Bloom's higher level questions (1956) such as analyzing, evaluating and creating. Bloom suggested that questions involving the Analysis, Synthesis or Evaluation of information and knowledge assist students' cognitive development.

What was less obvious but equally important, was how the teachers developed cognitive understanding when in dialogue with their students. By listening to and discussing students' ideas and understanding, teachers discovered students' knowledge and skills. Clara and Fleur were able to utilise this knowledge to assess the students and identify their learning needs. These are examples of Divergent Growth Conversations as teachers were gaining insight into students' understanding of technology practice. Evidence that teachers developed an understanding of students' learning in technology occurred can be seen in the final interview between the Researcher and the participant teachers, as they were able to identify the shifts in students' understanding and knowledge of technology process between the first and second rounds. Figure 6.1 indicates the position of Divergent Growth Conversations within Intercognitive Conversations.

These findings support Mercer and Lyttleton's idea that conversation is a significant pedagogical tool for teachers. Daniels (1996b) and Lave and Wenger (1996) suggest that Joint Interactive Episodes (JIE) give rise to cognitive growth. The data from this study indicates that cognitive growth occurred for both students and teachers, although often in differing ways, hence the introduction of the concept of Divergent Growth Conversations. For example, when students were growing in their understanding about different props suitable for stage shows, and the methods of and reasons for constructing mocked-up designs, teachers on the other hand were learning about student understanding in technology and the students' concepts of technological processes and outcomes. This was exemplified in the final interview between the teachers and the Researcher, when the Researcher asked both Clara and Fleur about the most successful aspect of the Technology units taught, outlined in Section 5.2.7 - Understanding Technology Process. The study showed that students also learned through dialogue with each other. This is discussed in the next sub-section.

Student- student

When participants of the conversation are learning in, and about, a common context, the conversations are Convergent Growth Conversations. Students engaged in dialogue assisted each other, and while doing this they also advanced their own knowledge in, and about, technology. This was exemplified by Teddy, Mandy and Jay from Year 6, in Section 4.4.3 - Intercognitive Conversations, when they were undertaking a Google search on the nature of items from the late 1800s to 1930s. Together they discussed and discovered the nature of objects such as radios and microphones by offering possible directions and alternatives for their search. Convergent Growth Conversations also occurred in Stage 3 in Year 2, reported in Section 5.2.2 -Funds of Knowledge, when Anne and Ellis were discussing fishing and the relationship to stuffing a paper fish and the process of filleting a real fish after capture. Through discussing the process of gutting and filleting fish Anne and Ellis assisted each other to make sense of the process of stuffing the fish with paper to give it a three dimensional effect. The Year 6 students, Mandy, Teddy and Jay also used discussion to determine components required on their radio. This was done collaboratively in groups of three and is illustrated in Section 4.4.4 – Attributes - Physical Features. The students thus developed a clear idea of what they needed on their radio.

The data in this study concurs with the literature about critical components of technology practice. In the Year 6 example above, students were developing their understanding of how to do technology practice within a limited time frame by determining the tasks required of them and time frames available for each. Planning for Practice is an important component of technological practice, and involves the students in the identification of tasks and required time frames to ensure task completion on time. De Vries (2005), Jones and Moreland (2001) and Ryle (1984) all state that procedural knowledge is a vital component of technological literacy. Procedural knowledge is defined as the knowledge of procedure or “how to do things” (McCormick, 1997). Through using Convergent Growth Conversations while undertaking an activity, which facilitated students’ understanding of tasks to be completed within technological practice and the best sequence for the tasks, students progressed in their understanding of the process of developing a technological outcome. In Year 2 the students used dialogue to assist each other in the confirmation of what they were doing was an authentic activity. A number of theorists (Hennessy, 1993; Rogoff & Lave, 1999; Turnbull, 2002) have identified that situating students in authentic contexts assists learning.

A number of language and interaction theorists (Mercer & Dawes, 2008; Mercer & Littleton, 2007; Stith & Roth, 2008; Wertsch, et al., 1999) have suggested that conversations between students enhances learning for all involved. Data from the study also concurs with these findings, therefore by definition these conversations are Intercognitive Conversations.

6.2.2 Conversations for Management of Learning

The second main type and element of conversation found in this study was conversations for the management of learning. In this study observations indicated that a number of strategies, which facilitated learning, were implemented and can be seen in Appendix 18. These strategies required conversation at a number of levels. The first of which was an instructional level in which the teachers set the activity up with the students - these conversations are discussed in the next section, 'Conversations which Transmit Information'. Conversations discussed in this section are those that occurred among students, and between students and teachers, while the students were participating in the planned activities. Management of Behaviour was another type of conversation and is discussed in this section. As expected, much of this conversation was student-teacher conversation, however, surprisingly another conversation type that occurred during this study was students managing the learning of each other. These conversations are discussed in the student-to-student sub-section which follows next but one.

Teacher-student

Teacher-to-student conversations to manage learning included the implementation of specific strategies to engage students' higher level thinking (Appendix 18), modelling of required tasks, use of higher level questioning as students worked in their groups and specific strategies for managing behavior to ensure learning time for students was maximised.

The first strategy implemented to facilitate higher level learning was a strategy called “No Hands Up”. In Year 2 this was coupled with another strategy “Talking Partners” (Appendix 18: Strategies 1 and 2). These strategies required conversation at a number of levels, initially involving instruction and organisation of the learners when teachers set up the strategies with the students. The two strategies mentioned above were evidenced in Section 4.3.4 - Specific Learning Strategies and were implemented concurrently in Year 2. In Year 6 only “No hands up” was implemented. The intended purpose was that when teachers asked specifically designed questions, all students engaged in higher level thinking and discussion with their peers, rather than a more traditional model of putting up one’s hand if the answer was known. Teacher instructions included the expectation that all students would consider a response to each question and then, when combined with their ‘Talking Partner” discuss their ideas with that partner before sharing the thoughts of the pair with the rest of the class. Questions asked by the teachers were aimed at developing students’ higher level thinking. For example, Fleur asked the Year 2 students to consider and discuss whether a pencil sharpener would make a good prop and why. This was done using yet another strategy ‘Agree/Disagree’ in which the students were required to agree or disagree to a series of statements with justification (Appendix 18 Strategy 6).

At various times students worked independently throughout all four stages of the unit. During these times the classroom teachers and the Researcher in the role of teacher circulated among the groups asking higher level questions, to assist the students to make connections and understand aspects of learning, as can be seen in Section 4.3.4 - Higher Order Thinking. Teachers used questioning to assist students to consider wider and deeper concepts about the character and function of props and the process of designing and developing a technological outcome. At the same time teachers also gained an understanding of the students’ learning in technology. This was exemplified when the researcher talked to Alan about the last minute change in specifications for his microphone stand. He had learned that his previous learning was still applicable to the new microphone stand, and as a teacher the Researcher gained an understanding that Alan was able to transfer learning from one scenario to another.

Modelling (Section 4.4.3 - Assisted Learning Strategies) was another strategy used by Fleur in Year 2 to assist students' learning. The planning and making mock-up processes were modelled for the students. The actual models and the process modelled during the construction of the outcome plan and mock-up was subsequently referred to on a number of occasions by both the classroom teacher and the Researcher in the role of teacher.

The final strategy - 'Management of Student Behaviour' - by teachers occurred explicitly in Stages 1 and 2. It is interesting to note that as the students became more engaged in the practical aspects of the unit, the nature of behaviour management changed from being quite direct- commenting on specific behaviours to more indirect behaviour management such as teacher assistance with collaboration, independence, issues and problems (as noted in Sections 5.2.4 and 5.3.4 in Stages 3 and 4). An example from Stage 1, Section 4.3.4 - Positive Reinforcement, of explicit behaviour management occurred when Fleur gave specific praise to Adam for answering a question - an example of positive reinforcement. Less direct behaviour management occurred in Stage 3 (Section 5.2.4 - Assisted Learning) when Clara encouraged her students to take responsibility for their own work.

These findings are clearly supported in the literature in a number of ways. A number of theorists (Bellanca & Brandt, 2010; Clarke, 2003, 2008) suggest that questioning is an essential tool for teachers. Bourne's (1994) theory that learning is more effective when clearly structured and organised is also borne out in this study. Strategies implemented in the study aligned with the perspective that teachers make powerful contributions to the way students think and talk (Bakhtin, 1981; Mercer & Littleton, 2007). Modelling is suggested in the literature as an important aspect of scaffolding learning and was illustrated by Fleur and the

Researcher in Year 2 by modelling the planning and mock-up processes. (Clarke, 2003; Clarke, Hattie, & Timperley, 2003). Modelling also aligns with the literature related to learning theory in technology education, as it demonstrates to students that planning outcomes and developing mock-ups are an authentic component of technological practice (Hennessy & Murphy, 1999; Turnbull, 2002). These findings also concur with Collis and Dalton (1994) and Yates (2001) who suggest that managing students' behaviour is dependent on the development of a shared framework of expectations. In Stage 1, seen in Section 4.3.4, teachers explicitly managed behaviours. In Stage 2, seen in Section 4.4.3, the students started to manage their own behaviour (discussed below) and by Stage 3, seen in Section 5.2.4, students were working with very little evidence of explicit behaviour management and students, particularly in Year 6, were taught to take responsibility for their own learning. The study also showed that students were able to manage their own learning, also seen in Section 5.2.4 and Section 5.3.4 - Student Facilitation of Construction. This is discussed in the following sub-section.

Student-student

One surprising finding of the study was that students managed their own and peers' learning and behaviour. Student-to-student conversation to manage learning occurred in a number of ways. A number of strategies focussed on 'interstudent' conversation (student-to-student) to foster intercognitive conversation to enable students to assist their own and each others' learning. This was clearly illustrated in Section 4.3.4 - Student-to-student Instruction. Students were also observed managing their own and peers' behaviour and assisting each other with tasks, as illustrated in Section 5.3.4 when Minnie assisted Alan and Dougal to reach a consensus about dimensions of the microphone head.

Students appeared motivated with the task and were keen to stay on-task and meet teachers' expectations. This was particularly noticeable at Stage 2 when the students were planning and drawing their intended outcome. It continued in Stages 3 and 4 through students assisting each other with the practical aspects of technological development; for example, the self-management of learning in Year

6, when Mandy, Teddy and Jay were discussing which materials would be suitable for the construction of their radio, as seen in Section 4.4.3 - Clarification of Understanding. Peer monitoring of behaviour was exemplified in Year 2 when Rex told Debby and Issy what his Dad suggested when he and his brothers did not agree, as seen in Section 4.4.1 - Family and Co-operative Skills .

Again these findings are supported in the literature. In Sociocultural Conflict Theory, Doise and Mugny (1984) state that difference in understanding and opinions best spark cognitive development. In Year 6 Teddy, Mandy and Jay spent some time debating which materials would be best for the construction of their radio, again seen in Section 4.4.3 - Clarification of Understanding. Collis and Dalton (1994) suggest that when students know their boundaries and have a sense of shared ownership, management of behaviour is more effective. These students had very clear boundaries set in Stage 1 of the unit. In the subsequent stages, students were motivated to complete the tasks at hand, and therefore assisted each other in achieving their goals and managing behaviours was an aspect of this.

The above sub-section discussed a number of strategies implemented during the study to manage students' learning. Another aspect of classroom practice is the simple transmission of information which differs from this sub-section in that the conversation is not two way and recipients are not necessarily asked to respond to the information.

6.2.3 Conversations which Transmit Information

In the early stages of the unit the students were specifically told what props were by Julian, the props manager from a local theatre company. He played an important part in developing the students' concepts about props with the direct giving of information about props. Students were given the opportunity to ask questions, however, the purpose of the session was to show the students a number of props and for them to learn about the role and function of props in a stage show. Through using a stage manager for this aspect of the unit the teachers enhanced students understanding in terms of authenticity. Demonstrated to students was the fact that developing props for stage production was an authentic and necessary task. These tasks are outlined in Section 4.3.1. This aligns with Hennessy (1993) and Turnbull's (2002) understanding that students need to be aware that their activity is authentic to technology practice and to their own culture.

Direct transmission from teachers to students occurred in two main ways and was essentially adult-to-student. The first was through the introduction of an external expert, who told the students about the character and function of a variety of props, as outlined in Section 4.3.4 in Stage 1. The second was the giving of instructions when setting up activities, also mentioned in the Management of Learning. Conversation, which involved the introduction of the strategy, and the instruction and organisation of the learners during the introduction and implementation of these strategies, were given using transmission. Reasons for this method of delivery include ensuring all students receive consistent messages and instructions, including time management. This supports Bourne's (1994) theory that learning is more effective when clearly structured and organised. Transmission of information featured in the Stages 1 to 3 but not in the Stage 4. This could be explained because, by the time the students were constructing their props, they had acquired information that was likely to be given to the class using a formal transmission.

Transmitted learning in these classrooms occurred in a face-to-face mode, ensuring the presence of a number of Clark and Brennan's (1991) characteristics which impact conversation. These include: co presence, indicating all parties can be readily seen and heard; and visibility and audibility, in which speakers and listeners can be seen and heard. Other characteristics of classroom learning include co-temporality, in which the speakers and listeners experience the same space in time; simultaneity, when queries can be answered immediately, and finally sequentiality, in which the listeners receive the given instructions sequentially by the speaker. Although transmission may not be considered the most desirable use of conversations in terms of developing students' higher-level thinking, it does play a role in delivering information to students.

The second use of transmission came in the form of setting up activities, instructions and outlining teacher expectations in terms of work to be achieved within the lesson, and expected behaviours, illustrated in Section 4.3.4 - Instructions and Organisation of Learners. Typically these conversations occurred at the beginning of a lesson to ensure consistency of message and assist in time management. This allowed teachers to maximise time used in the classroom for actual learning activity, which Yates (2001) suggests should be a key aim.

This section has discussed the ways in which conversation-enabled learning was managed during the unit to maximise opportunities for students, through a series of carefully planned and implemented activities. This learning is encompassed in the Conduit Theme as it assists students' transfer and application of knowledge, skills and information from deployed sources to current technology learning. The next section discusses what knowledge from deployed sources, or knowledge students brought to their learning from outside the current unit.

6.3 Insights into Sources of Knowledge: Deployment Theme

This section will address the following research question: *How do children's prior and concurrent experiences influence their technological practice?* The findings in the study show that there are two main sources of this information, the first being from home and community, or Funds of Knowledge, and the second being knowledge learned at school in which students were able to make connections to prior learning in other disciplines, including earlier technology learning. These two make up the elements Funds of Knowledge and Making Connections respectively and are discussed in the sections below in turn. Together the Researcher has clustered them as methods of deploying existing and learned knowledge and skill to technology practice.

6.3.1 Funds of Knowledge - Influence of Children's Prior and Ongoing Experiences

While undertaking their technological practice the students brought to their learning, knowledge and skills they had learned from home and other cultural and community activities they were involved in, as illustrated in Section 5.3.2 by Mandy's knowledge of wood construction using bracing. It is interesting to note that this was not a structured requirement explicitly directed from the teachers, but rather occurred incidentally as students realised they had relevant knowledge and skills they could contribute to their group. The study showed that procurement of Funds of Knowledge occurred in two ways. The first was through Participatory Enculturation in which students obtained the knowledge and skills by participation, such as the example mentioned above. The second was Passive Observation in which knowledge was gained through a non-participatory observation, such as Dougal and Alex's knowledge of 1930s microphones learned through watching television and movies, as can be seen in Section 4.3.2. Each of these are discussed in the sub-sections below.

Participatory Enculturation involves being enculturated into an activity through engagement resulting in transferable knowledge. This knowledge and these skills are obtained through children being actively involved in family and community activities. Engagement includes active participation, where a child is involved in the activity, and peripheral participation where the child is on the periphery of the activity but able to engage in the activity through questions and conversation. Gaining knowledge through Participatory Enculturation also provided students with opportunities to know information their peers did not, and the ability to share practices unique to their family and culture. Knowledge gained from these experiences appeared to provide them status or 'mana' (high status for Māori) within their peer group. Participatory Enculturation knowledge was gained through five means: family activity, after-school activities, parents' occupation and interests, artefacts used at home, and family social and co-operative practices.

Evidence of Participatory Enculturation through engagement in a family activity occurred very early in the props unit. As a part of the project, the students were given a disposable camera so that they could record their process of developing a prop. Section 4.3.2 illustrates this, when the students' first task was to ask a friend to take their photograph so that the first photograph in each camera was that of its owner. Moke was concerned that her camera was broken as this was her first experience with a non-digital camera, but Duncan was able to reassure her as he had experienced how the photos are released. This conversation illustrates that knowledge gained through Participatory Enculturation gave Duncan the confidence and status to reassure his classmate that her camera was not broken. It demonstrates that use and knowledge of technological devices gained from home and community assist students' confidence in their use.

The data suggests that students brought learning from after-school activities to assist them in understanding the character and function of props. This was also illustrated in Section 4.3.2 - Particpatory Enculturation. After-school activities are defined as activities that students do independently of their family. Typically going to external teachers for lessons or tutoring, playing sport or undertaking hobbies by themselves. When researching props, much of the information the students came across was from the United Stated of America. The drawing on information gained through participation assisted in understanding and interpreting information relating to research in another area. It is a requirement in technology to interpret designs of others; this extract demonstrates Alan's ability to interpret a symbol for inches (") a measurement and symbol not used in his school environment but one that he used in his home environment.

The significance of the role of parents' occupations in what the students bring to their learning and that students use these Funds of Knowledge to position themselves as an expert and to gain respect or 'mana' from their peers became evident in the data. Understanding potential construction materials is a significant aspect to planning technological outcomes. This was exemplified when Dougal suggested using wood for the microphone head because his dad was a contractor and had plenty at home.

The students also deployed knowledge gained through interaction with artefacts in the home environment. The data demonstrates how students made use of artefacts they knew, understood and used at home and in their community to make sense of learning undertaken at school. Dougal again exemplified this, when he likened the slotting of the microphone head into its holder to a computer docking station and is illustrated in Section 4.4.1 - Design Features of Artefacts.

Funds of Knowledge deployed by students were not only artefacts and process knowledge and skills directly linked to home and community culture, but they also deployed their community and family social skills and knowledge. This is relevant to planning design ideas in technology education, because students were frequently required to design technological outcomes co-operatively and collaboratively. This was very explicitly exemplified in Section 4.4.1 - Family Social and Co-operative Skills, by Rex, who made suggestions about reaching agreement within his group by suggesting what his dad modelled at home with his siblings and him.

This study shows that students gained knowledge through Participatory Enculturation in a number of ways, including engagement with parents' work and recreational activities. González, Moll and Amanti (2005) state that by drawing on household knowledge, the students' experiences are legitimated thus authenticating the nature of classroom activity. Learning through Participatory Enculturation involves the students in interaction with the context of learning. This can involve dialogue with participants, active engagement with materials, activities and artefacts, and practices that are an integral part of living in a community. The literature suggests that learning through active engagement is effective. Turnbull (2002) found that learning embedded in an authentic context proved more effective than learning in contextual isolation. Hennessey (1993, p. 15) suggests learning is most successful when "embedded in authentic and meaningful activity, making deliberate use of physical and social context". Rogoff's (1990) theory on cognitive apprenticeship methods of learning, suggests that the enculturation of students to authentic practices through activity and social interaction, facilitates effective learning. Mercer and Hodgkinson (2008) suggested that communication can be either interactive verbal participation of both parties, or non interactive verbal participation of the teacher only. Conversation in Participatory Enculturation would be of the interactive nature. The data also supported Wertsch's (1998) Sociocultural perspective that a child's cognitive development depends on their response to societal and cultural influences from their home and community. The data also suggests that students learn through passive observation, which is discussed in the next sub-section.

Passive Observation

The second sub-element of Funds of Knowledge refers to learnt knowledge obtained through passive observation in which the students were non-participatory observers; for example through watching movies, television or reading books. In this method of gaining cultural knowledge and skills, the students did not interact directly with the knowledge source. The data suggests that students used knowledge gained in a passive observatory role and applied it to the learning that took place in their classroom. Students were able to do this in several ways. They were able to locate technology in historical and cultural contexts. There were two aspects of historical location identified in the data. Students understood the function and form of an artefact in a historical setting; for example, the knowledge two Year 6 boys had about microphones from the past came from watching television and movies, both activities commonly associated with their culture, as seen in Section 4.3.2 - Form and Function. Students also understood that objects gave a historical location to a setting, illustrated when Minnie was able to locate a historical setting from a picture of a wagon, in the same section. This demonstrated that in technology education the students used prior passive observation to assist their personal construct of an object from different eras.

Students also gained an understanding of the purpose and role of props through Passive Observation. In Years 2 and 6, students listened to Julian, the props manager from the local theatre. Julian explained the purpose and function of props. He illustrated his talk with a range of props his company had used in the past. He discussed how each was used *in situ*. Issy from Year 2 used the knowledge she gained from attending the theatre to assist her understanding of the definition of a technological outcome. Her input into the conversation indicated that she may have understood that the trunk used as a prop in a play she had seen, had multiple purposes also illustrated in 4.3.2.

Both the above examples occurred in Stage 1 of the unit when students were developing notions of props. However, the students also continued to deploy knowledge from passive observation to assist them in construction of their designs. This occurred when students were problem-solving possible solutions to design issues, thus facilitating the construction of their designs. They deployed information learned through the watching of movies and television. This was illustrated in Section 5.3.4 - Design Features when James was surprised that Olympic medals in the 1936 games did not have ribbons and that the medals were not hung around the athletes' necks. James's prior learning about Olympic medals was most likely to have come through passive observation of television and books on the 2008 Olympic Games held in Beijing. In this case the information gained initially proved to be incorrect, but further learning through engagement with the internet meant he was able to correct his initial understandings, and therefore alter the design features of his Olympic Medal.

When learning through Passive Observation, the students were only observers and unable to interact with the suppliers of the knowledge. These findings on Passive Observation are somewhat surprising, as much literature on learning and knowledge acquisition discusses the need for participation in authentic activity to engage learners (Rogoff, 1990; Turnbull, 2002; Wiggins, 1998). However, this study suggests that students retain information learned through passive observations and are able to use this in their technology learning. The data suggests that learning in technology education, obtained through passive means, is later deployed through active and authentic means. At the time of actual learning for these students, the context was not embedded in authentic meaningful activity; however, we can see that students deployed knowledge gained through these means to inform their practice, thus authenticating its deployment rather than the actual learning. Mercer & Littleton (2007) and Shields & Edwards' (2005) argue that teachers need to engage in quality dialogue with students and parents to help them make sense both cognitively and experientially of the world in which they live and work. By doing this, teachers may be able to facilitate deployment of knowledge and skills learning through Passive Observation. González, Moll and

Amanti (2005) suggest that teachers need to know and understand the communities and cultural practices of their students. By having an understanding of the activities their students are not only actively, but also passively engaged in, will assist teachers in maximising learning opportunities in the classroom by actively making explicit connections to these practices.

This study clearly supports Gonzalez, Moll and Amanti's (2005) theory that students draw on experiences, knowledge, and skills from their home and community to assist their learning in technology, as the data clearly demonstrates that students do this. This study takes Gonzalez, Moll and Amanti's Funds of Knowledge further through investigation and identification of students' method of gaining Funds of Knowledge. The data suggests that students do this through two means: 'Participatory Enculturation' and 'Passive Observation'. Students in this study also brought previous school-based learning to their learning in technology. This is discussed in the section below.

6.3.2 Making Links and Connections to School Learning

This section continues to answer the research question *How do children's prior and concurrent experiences influence their technological practice?* In addition, it is still associated with the Deployment theme of learning and focuses on school-based learning. Students made connections to prior school-based learning in several ways. These included making temporal connections to earlier technological learning, the utilisation of new learning from earlier in the current unit and transferring knowledge from other school-based disciplines, each discussed in the following sections.

Temporal Technology Knowledge

In Year 6, on several occasions in Round 2 of the study, students made connections to technology learning that occurred during Round 1. These connections were made through generic technological knowledge, as the contexts of the units within the study were very different. It is interesting to note that Students in Year 2 didn't make temporal connections and this is possibly explained in two ways. The first is that the Year 6 teacher was trained in the current curriculum and had taught technology previously. Jones and Moreland

(2001) suggest teacher knowledge is critical. Clara, in Year 6, referred to knowledge and skills learned in the previous unit and so did her students. However Fleur, the Year 2 teacher, had trained with the draft curriculum only and had not previously taught technology. She didn't make temporal connections to the previous unit, nor did her students. The other possible explanation is related to Jones' (2009) Characteristics of Progression. For example, in Year 6 Shelia was able to compare a link in processes between the first and second units. Jones states that in the middle primary students (Years 4-6) are able to undertake product analysis and generation through direct observations and comparison. In Year 2, students tend to generate less complex ideas through simple shaping and assembling, with a limited range of tools and materials. As the unit progressed, students were also able to utilise learning from prior planned activities within the unit, as discussed in the next sub-section.

Utilising New Technology Knowledge

Although the focus of this study has the students undertaking their own technological practice, in Stage 1 they were also asked to consider how and why people use technology, in this case actors' use of props on stage; the context of the unit. This knowledge was later utilised as the students were also engaged in their own technological practice as they designed and developed props of their own - 'knowing how'. The data suggests that Year 6 students utilised knowledge from Stage 1 in Stage 2. They then continued to build on learning as they progressed through their practice. This was illustrated when in Stage 2, Sophie remembered that at the local theatre props needed to be durable to last for at least three shows, and in Stage 4 when she recognised that the medals needed to be culturally and historically authentic. "I did the medals and I was working on painting them which would come under the specific era and culture".

In Year 2, students made explicit connections to learning in Stage 1 in Stages 3 and 4, but not in Stage 2. With the assistance of their teacher, and the Researcher in the role of teacher, they were able to develop desirable attributes of props which they referred to in the evaluation process. They were also able to make links between their planning, mocked-up design and the final outcome with assistance from their teacher or the Researcher. This was illustrated by Rex, who was able to identify that one success of his design was its size, as it was easily seen by the audience. 'Big enough for the audience to see' was one of the attributes of props identified by the class in Stage 1.

The Technological Knowledge and Skills element of the Analysis Framework, presented in Chapter 3 of this study, includes aspects of both Ryle's (1984) 'Knowing That' and "Knowing Why' technology categories and Jones & Moreland's (2001) domains of knowledge: 'Societal, Conceptual and Procedural. The students in both year levels deployed knowledge gained in the early lessons of the unit, later in the unit when they were designing, modelling, and constructing their outcomes. As well as deploying technological knowledge, students also deployed knowledge from other disciplines; this is discussed in the following sub-section.

Knowledge from Other disciplines

In Stages 1 and 2, students from both Years 2 and 6 used knowledge from other disciplines. In Year 6 students regularly deployed mathematics when considering the dimensions of intended props, and in Year 2 students were able to describe fish as oval. These findings are interesting when we consider the knowledge used in other disciplines, such as mathematics, was not explicitly mentioned by the teachers to the students. Another important aspect of the unit was knowledge of the dramatic arts and the role that props play in a dramatic production.

In Stage 3 there was no evidence in either year level, and in Stage 4 evidence that only Year 6 students deployed knowledge from other disciplines. The Researcher believes that in Stages 3 and 4, where no data suggesting discipline knowledge transfer actually occurred, that in actual fact it may have been present or was even likely. However, it was not captured because data focus was on conversation and provided as oral evidence, although the actual outcomes the students developed do, for example, show evidence of the skills of papier-mâché and painting from the visual arts as can be seen in Figures 5.10 and 6.2.

Figure 6.2: Minnie's autophotograph of the papier-mâchéd microphone head.

Compton and France (2006) recognised the interdisciplinary nature of technology. This is well illustrated in this study. In order to authenticate the activity for their students, teachers recognised that the students needed knowledge of dramatic productions by understanding the role and function of props. The learning became, to use Murdoch and Hornsby's (2003) phrase, "worthwhile exploration" because the students learned that making props was an important part of dramatic production and they had a vested interested in developing high quality props.

Jones and Moreland (2000) suggest that many teachers use a thematic approach to teaching technology, with unifying ideas carried from other academic disciplines on the understanding that students would be able to transfer this knowledge without difficulty. Their study revealed that, in fact, students had difficulty with knowledge transfer unless explicitly taught by teachers. The findings in this study, particularly in Year 6 are contrary to this, because in fact students did automatically deploy knowledge from other disciplines with little direction from their teachers. However, this Researcher suggests that instances of deployment of knowledge from other disciplines could have been increased, particularly in Year 2, if specific knowledge transfer was taught.

In conclusion, the study indicates that students drew on knowledge from a range of home, cultural and schools experiences to assist their learing. Those captured in this study occurred with little or no formal transfer from teachers, but rather occcurred when students saw opportunities to contribute to the development of their props. There were times during the study when teachers did design learning activities to assist students deployment of existing and new learning. This Researcher has identified learning in this area as a Conduit Theme of Learning. This is discussed in the next section.

6.4 Insights into Maximising Learning Opportunities to Enable Learning Development: Conduit Theme

This section answers the research question: *What happens in the classroom to increase the likelihood of students deploying knowledge and skills from other areas into technology?* Learning encompassed in the Conduit Theme assisted students' transfer and application of knowledge, skills and information from deployed sources to the current technology learning. Classroom teachers use a range of strategies to do this. The purpose of developing and implementing strategies is to increase the effectiveness of learning (McGee & Fraser, 2008). This section illustrates the strategies introduced in Section 6.2 and is divided into two sub-sections: Transmission and Assisted Learning Strategies.

6.4.1 Transmission

As stated in Section 6.2, two types of transmission were evidenced in the data for this study. The first was the direct giving of contextually related facts, and the second was the giving of instructions and directions for up-coming activities. In the early stages of the unit, the students were specifically told what props were by Julian from a local theatre company. He played an important role in developing the students' concepts about props with the direct giving of information about props. Students were given the opportunity to ask questions, however, the purpose of the session was to show the students a variety of props and for them to learn about props' role and function in a stage show. Through using a props manager for this aspect of the unit, the teachers assisted the students to enhance their knowledge about props. The data suggests that the students did develop sound understandings of props through transmission of information. Yates (2001) suggests that consistency of information is an important ingredient in a successful classroom and should be a key aim. Students in the study were also exposed to notions of authenticity as it was illustrated that developing props for stage production was an authentic task for a theatre company. This aligns with Hennessy's (1993) and Turnbull's (2002) understanding that students need to be aware that their activity is culturally authentic.

The second use of transmission came in the form of setting up activities, instructions, and outlining teacher expectations in terms of work to be achieved within the lesson, and expected behaviour. Typically these conversations occurred at the beginning of a lesson, ensured consistency of message, and assisted in time management. This allowed teachers to maximise time used in the classroom for actual learning activity. McGee and Fraser (2008) also stress the importance of giving clear concise instructions within the classroom. Other strategies were also implemented in the classroom to assist students learning and these are discussed in the following sub-section.

6.4.2 Assisted Learning Strategies

Strategies implemented in the study had the explicit aim of extending students' thinking about the character and function of props and the collaborative construction of props. These included strategies to implement higher order thinking, strategies to foster classroom dialogue and the use of prompts and other teaching aids.

Higher Order Thinking

The students participated in several activities which facilitated peer discussion about their understanding and learning in relation to props. In Year 6 these strategies included an activity in which the students were given a number of pictures of potential props - as can be seen in Figure 6.20 - which they critiqued using their co-constructed attributes for good props. It can be seen from Alan's quote next to Figure 6.3, that this did, in fact, assist his technological practice. The second was PCQ (Appendix 18: Strategy 5) and occurred in Stage 2. In the activity, the students identified the pros and cons of their initial design ideas and then identified questions they wanted answered. Following this activity, students were given the opportunity to obtain stakeholder feedback about their designs, and make subsequent changes to their designs based on their evaluation and received feedback.

"It helped us think about what we needed to do to make our props." - Alan in his Stimulated Recall Interview.

Figure 6.3: Alan's autophotograph of the props pictures they studied

In Year 2, the students used the strategy Icon Prompt (Appendix 20 Strategy 4) to evaluate their final prop. This strategy facilitated their design evaluation through the use of icons to give focus to specific evaluation components. For example, a happy face ☺, to identify the positive elements of their design, a sad face ☹, to identify elements which needed improving. Also included were a question mark to prompt students to ask further questions about their designs, and a heart for the identification of their emotions about their process and final outcome. Finn illustrates the effectiveness of this strategy in relation to process, in his response to the heart icon in which he stated that his greatest challenge was not working by himself. In relation to the final outcome, in her response to the happy face icon, Anne stated that she like her outcome because it met all the required attributes. Another strategy used to engage students at both levels in higher level thinking was the actual design-based nature of technology, in which these students were required to design and develop their intended outcomes. To do this the students, particularly in Year 6, were involved in problem-solving as a number of challenges presented themselves along the way. This was clearly illustrated by

Minnie and Dougal as they tried to establish the best way of supporting the microphone head at an angle so it could then be attached to the stand.

Earl and Timperley (2008) suggest that structured activities can result in a real change in learning. Evidence of learning, presented in the data from this study, suggests this to be the case. The success of the final props was clearly evident at the final production. Learning in the 21st Century (Bellanca & Brandt, 2010) suggests that in today's world students need to be actively involved in the analysis, evaluation and syntheses of information rather than just the regurgitation of a series of facts. They suggest that problem-based learning is an essential component of education required for preparing students for life in the 21st Century. This is particularly relevant in this technology study as students were required to develop technological outcomes to meet specific needs. This process itself requires evaluation and synthesis of ideas and information from prior and current learning, and is well illustrated in the data from this study. During construction of the final outcome students worked at Bloom's (1956) level of Synthesis. Bloom defines synthesis as the pulling together of elements or parts to form a whole. When creating their outcomes the students were required to consider the definition and purpose of props, the era and cultural setting of the stage production, their earlier design ideas and decisions. It is interesting to note that on a number of occasions when things got difficult, the students drew on their Funds of Knowledge. This was demonstrated when Mandy's group were attempting to joined timber slats at 90 degree angles, and when Rex attempted to assist Debby and Issy to work co-operatively. Dialogue was an essential component of this sub-section and is explored further in the next sub-section.

Dialogue: Peer Discussion and Teacher-to-student Discussion

In Year 2, teaching strategies 'Talking Partners' and 'No Hands Up' were implemented to facilitate conversation. In Year 6 'No Hands Up' was implemented. These strategies were particularly successful in Year 2, as there was one very dominant child in the class - Ellis - and another who was painfully shy - Issy. In the final interview, and in an informal conversation with Fleur following the unit, the Researcher was told that Fleur has continued to use these strategies, and she indicated that 'Issy was a different student who had begun to contribute to whole class conversation', something she had not done in the past. Also in their final interview, in response to the question "What most impacted on the students' learning?" Fleur responded "Their thinking, and the questioning, their questioning techniques and the evaluations as well, and like I'm still using your no hands up". Clara responded "probably the vocabulary of technology. I think that was really important for them, I think at a high level, to understand a real, what is a technologist [is] and how, the language that they use and that they were being technologists and that their understanding of technology and what it was about changed and the importance of that became quite obvious. Yeah, their understanding of the technology they had done in the past and compared to what they're doing now, as well as what Fleur said." Both responses indicate the central position that dialogue took in the students' learning.

These strategies, 'Talking Partners' and' No Hands Up', were also combined with another strategy 'Agree/Disagree' (Appendix 18: Strategy 6) in Year 2. In this strategy the students responded to a statement to which they needed to either agree or disagree, and then justify their response. The Agree/Disagree statements were developed to ensure students were working at Bloom's (1956) Analysis level. For example, the statement "props should be small" focused the students' thinking on logical fallacies of the argument and to recognise particulars of a valid statement (Bloom, 1956). In actual fact, this statement received a well justified response in both the 'agree' and 'disagree' categories.

Students in both Year 2 and 6 also grouped in threes for the unit. Each group was required to develop one prop. To do this they needed to communicate with each other and reach a consensus. This had its challenges and a number of groups struggled with this at times. Reaching a consensus was not always easy therefore classroom dialogue between students within each group, and between students and teachers were actively planned and implemented. Sociocultural Conflict Theory (Doise & Mugny, 1984), theories about the value of classroom dialogue (Alexander, 2008; Clarke, 2003; Fleer, 1995; Mercer & Dawes, 2008; Mercer & Hodgkinson, 2008; Mercer & Littleton, 2007; Shields & Edwards, 2005) and the use of Blooms (1956) higher level activities go a long way to explaining the eventual success of the projects in both classrooms, and the technological knowledge and skills gained by the students along the way. Doise and Mugny suggest that with a focus on language as a tool, conflict is an essential component of cognitive development. All groups experience a differing of opinions at times. All overcame this and eventually produced successful outcomes. The intermediate and final outcomes (Compton & France, 2007), and the responses about learning in technology obtained through the Stimulated Interview process, are clear evidence that the participants in this study gained significant knowledge about technological process and practice. Teachers also used physical aids to prompt and assist students' learning. These are discussed in the sub-section below.

Physical Prompts as Teaching Aids

The final Assisted Learning Strategy discussed in this section was the use of physical prompts as teaching aids used by the teachers to assist learning. These included the video of the Movie 'Hook', and a stage play that had visited the school earlier in the year, actual props from a theatre and subsequent pictures of props, video clips and photographs of real flying fish and the process of catching flying fish, and finally pictures and images of objects from the late 1800 to early 1900s. All these prompts were used in Stage 1 of the unit and were part of an introduction to stage props for the students. Again this relates to Bourne's (1994) claim that learning involves students making sense of their everyday world. These findings support the idea that students are much more able to make sense of new materials if it is clearly organised and managed. The findings also support notions of authenticity (W. Fox-Turnbull, 2003; Hennessy, 1993). These students saw and experienced authentic use of stage props and learned about the context of their intended outcomes - The Olympic Games 1890 to 1930 and Catching Flying Fish.

In conclusion, this section has discussed how teachers plan for and maximise students learning opportunities in the classroom using a variety of strategies, and answered the research question 'What happens in the classroom to increase the likelihood of students deploying knowledge and skills from other areas into technology?' The next section focuses on the last research question about the actual technological skills and knowledge learned by the students during the study.

6.5 Insights into Children's Technology Learning: Knowledge Theme

This section will address the following research question: *What insights into technology education can be gained through an analysis of student's conversations with their teachers and peers while participating in technology education?* As mentioned above, the data shows considerable insight into students' technological knowledge and skills. This section explores the components of technological knowledge and skills that were evidenced in the data. The data suggests that there were three aspects in which insight was gained into technological knowledge and skills acquired by the students. These include knowledge and understanding of attributes, the contribution of materials to the physical and functional features of props, and knowledge of technological practice including acquisition of technical knowledge through the gaining of physical skills during construction. Each of these are discussed in turn in the sub-sections below.

6.5.1 Attributes

During the study, insights were gained into students' understanding and use of attributes. Attributes are defined as the desirable characteristics of a technological outcome or system. Identifying attributes is a common precursor to specification development and they are not standardised measures. They are broad descriptors that can be described as relative to each outcome (Compton & France, 2007). In Stage 1 of this study, the students listened to an expert speaker and investigated a range of props through a series of planned activities, then as a class co-constructed desirable attributes for the props for their class. These were called 'characteristics of props' and can be seen for both classes in Chapter 4, Sub-section 4.3.6. Evidence that the students understood what attributes were was partially evidenced through the co-constructed attributes identified by the students in both classes. Students were also able to articulate what attributes were, as evidenced by

Alan when he told the researcher that attributes were things that made good props. In subsequent stages, the students evidenced their understanding of attributes by incorporating those they had identified as a class into their designs and final outcomes. This was exemplified in Year 2 by Rex when evaluating his final outcome, when he suggested that his groups' fish might have been bigger. This related to the Year 2 attribute "big enough for the audience to see".

These findings concur with de Vries' (2005) suggestion that one component of technological literacy involves the exploration of the physical and functional features of technological artefacts. Ryle (1984) suggests that technological literacy also includes "Knowing that" and Jones and Moreland (2001) discuss the importance of conceptual knowledge. The data in this study suggests that students understood and engaged with the concept of desirable attributes for their outcomes and how they, once identified, assisted the students by informing designed outcomes. Students also gained an understanding of the importance materials play in developing outcomes. This is explored in the sub-section below.

6.5.2 Materials

Further insights were gained about the students' abilities to understand and work with construction materials. Data from the study suggests that learning about materials involved two aspects related to materials. The first was the identification and function of a range of materials. Students in both Years 2 and 6 undertook learning in this aspect. The second was selection of and evaluation of the suitability of those materials for their designed props. This was only relevant to Year 6 as they were required to determine the most suitable materials for the construction of their props. In Year 2 the classroom teacher determined that papier-mâché would be used.

In Stage 1, the students the students undertook a number of activities which assisted their understanding of materials. The first was the visit from Julian with a range of props. Some of the props brought from the theatre were actual artefacts, and therefore made of materials related to the original intended purpose and function; such as the metal coal bucket and a hemp rope. Other props were imitation objects made of materials to prevent decomposition, or harm, for example, a plastic banana and knife. A third set of props were handmade objects of exaggerated or altered size or character, for example a very large hammer puppet made from fabric and a giant papier-mâché lollipop. The students also viewed videos of two stage productions one of which they had experienced earlier in the year and one from a movie. Following this, the Year 6 students undertook research about objects from the 1890 to 1936 Olympic era, and critiqued a range of objects for suitability as props. One of the tasks they were given was to determine the materials these objects were made of. This was exemplified when the Year 6 class was sharing the findings of the activity, in which students had to critique a range of objects in terms of their suitability as props. Several students mentioned materials as an aspect that made the props suitable and, Clara, the class teacher commented "Materials are really important aren't they? They keep coming up". In Year 2, evidence that they were developing an understanding of the role of materials was exemplified by Adam and Jayne, who were able to recall construction materials of props from the stage show they has seen previously.

In Stage 2, as a part of planning their intended outcome, the Year 6 students were required to identify the construction materials of actual objects and what their props would be constructed of. Obviously the first influenced the second, as looking authentic was a required attribute. Another aspect related to materials, joining, occurred in Stage 4 as the students needed to determine the best way of joining different materials in a way that would ensure durability - another required attribute. The first aspect was exemplified by Alan, Dougal and Minnie as they discussed the pros and cons of using wood and papier-mâché for their microphone head. The second aspect was exemplified by Mandy as she determined that metal bracing would be the best method of joining slats of trellis timber at 90 degree angles.

McCormick (2009) suggests that little research has been conducted in primary schools on students' understandings in relation to technology practice and materials. However, Jones (2009) does discuss material selection and suggests that as students moved from Year 4 to 8 they were more able to consider a wider range of materials for their designs. This study shows that students at Year 6 were able to consider a number of different materials for their designs. Technological conceptual and procedural knowledge (Jones & Moreland, 2001; McCormick, 1997) and technical knowledge (Jones & Moreland, 2001) include knowledge and understanding of materials. In their chapter about planning for capability and progression, Doherty, Huxtable, Murray and Gillett (2002) suggest three major concepts in design and technology, one of which is "skills used in design and technology" in which working with materials and equipment is listed as one aspect. Stein, Ginns and McRobbie (2002, p. 198) identify knowledge of technology contexts as an example of Knowledge at Work, of which they identify materials as one. The New Zealand *Technology in the New Zealand Curriculum* document (Ministry of Education, 1995) named 'Materials' as one of seven technological areas. In 2007 with the implementation of *The New Zealand Curriculum* (Ministry of Education, 2007), 'Materials' was removed as a technological area and added as a transformation. Compton and France (2006) identified 'Materials' as one of three transformations undertaken during technology practice, along with Energy and Information. They stated that during technology practice, either materials, energy and / or information are transformed through manipulation, control, storage or transportation. Compton (V. Compton, 2010) identified that materiality is a key aspect of technological knowledge.

The literature suggests there is some recognition that knowledge of materials plays a role in students' understanding and practice in technology. This study suggests that understanding the role, function, properties and characteristics of materials is a significant aspect to learning in technology, and highlights a gap in research in the way students identify and select materials for modelling or final outcomes. Understanding of, and participating in, technology practice is another significant aspect in learning in technology and is discussed in the following sub-section.

6.5.3 Technological Practice Knowledge

This section will address the following research question: *How can analysis of teachers' and students' conversation give insight into children's technology practice?* Understanding what technology practice is and how to undertake it constitutes technological practice knowledge. The study also offers insight into knowledge of technological practice. The data suggests that there were four components to students' understanding of technology practice. These include knowledge of planning for practice, including task allocation; product construction; and product evaluation. Each is discussed in turn below.

Planning for Practice and Task Allocation

In this study, the Year 6 students used discussion to determine a list of tasks they needed to do, and a possible sequence for the tasks to ensure the props were completed on time. This was done collaboratively in groups of three. The data suggests the students developed a clear idea of what they needed to do and the time frame required for each task. For this technological practice in both year levels, the final completion date was not negotiable as the props needed to be completed for the final dress rehearsal for the school productions. In Year 2 most of the students' practice was undertaken during a "technology week" about five weeks before the production so timeframes were only briefly mentioned by Fleur.

The data suggests this activity progressed their understanding of the process of developing a technological outcome. Through dialogue with each other, the Year 6 students were able to determine a list of tasks and a suitable timeline. It was best exemplified when Marcel commented to his teacher, about how strange it was that it took three weeks to develop an outcome which would only be used for five minutes. The data also suggested that in Stage 4, the Year 6 students were able to independently undertake task allocation - allocating different tasks to different people. There could be several reasons for this. Prior to the Mock-up stage, students were able to undertake tasks together or the same tasks separately. As they continued with their practice, timeframes became tight and deadlines critical, therefore the opportunity for task allocation presented itself, as students were able to work on separate components of the same outcome to ensure efficient use of time. Charlie and Xiao, who each took responsibility for different guns, exemplified this. Another possibility for explaining task allocation was difficulty in working collaboratively. This occurred in Alan, Minnie and Dougal's group when Alan took responsibility for the microphone stand, and Minnie and Dougal the microphone head and its the attachment. This occurred as Alan did not work well with the other two and had difficulty accepting their ideas.

Planning for Practice is an important component of technological practice within *The New Zealand Curriculum*. The findings from this study concur with this. Planning for Practice involves the students in the recognition of tasks and required time frames to ensure task completion on time, and is a part of the technology curriculum strand Technological Practice (Ministry of Education, 2007). De Vries (2005), McCormick (1997) and Jones and Moreland (Jones & Moreland, 2001), and Ryle (Ryle, 1984) state that procedural knowledge is a vital component of technological literacy. Procedural knowledge consists of knowledge of specific contextually bound procedures and generic procedural knowledge - knowledge of procedures undertaken across a range of technologies (Jones & Moreland, 2001). The students successfully planned and undertook their practice with all outcomes completed in time for the dress rehearsals. This was an example of developing generic procedural knowledge. Specific procedural knowledge also overlaps with knowledge of construction, as being able to undertake physical construction skills will entail knowledge of how specific skills and processes are undertaken. These are discussed in the next sub-section.

Knowledge of Construction

The data from the study showed that construction ideas occurred in the areas of skill acquisition and development, and design alteration. In Stage 4, the students in both year groups constructed the outcomes they has previously planned and mocked-up. One insight gained in the study occurred in the construction phase in the area of skill acquisition and development, and related to context specific procedural knowledge of papier-mâché, and teachers making assumptions about prior learning. In an incidental conversation with the Year 6 teacher, Clara, the Researcher mentioned the improved nature of the students' papier-mâché skills in

Round 2 of the study compared with Round 1. The Researcher also commented that she had assumed that by Year 6 the students would have previously been taught how to papier-mâché, but Round 1 proved this not to be the case. James, one of the class members, overheard the conversation and agreed with the Researcher stating that no one had taught them to papier-mâché and that teachers seemed to assume they could do it.

Assumptions are defined by Paul and Elder (2012) as something that is taken for granted or presupposed and can be unjustified if there is no good reason to support the assumption. Teachers often make assumptions in the classroom and if, as in this case, they are unjustified, students and teachers can find themselves in a position where furtherer scaffolding and teaching are needed. In her unpublished Master's dissertation Edward-Leis (2010) recommends that teachers avoid making assumptions about students' ability to engage effectively either with discovery-based learning activities or with their peers without the relevant scaffolded instruction. The findings in this study support this. Making assumptions about students' abilities to papier-mâché meant than an important opportunity to improve student's technical knowledge and the quality of their technological outcomes was lost.

The second insight came in the area of design alteration and was exemplified by Alan in Year 6. The design alteration mentioned in this sub-section differs to design alteration due to product evaluation. This design alteration came about because of a last minute change in externally provided specifications. Despite the fact that Alan spent most of his technology time, over two weeks, designing, mocking-up and constructing a stand for a 'standing microphone', during the last week the script writers decided that the microphone needed to be a 'desk microphone'. Alan was able to make the necessary changes to his outcome and he made use of previously learned construction techniques, knowledge and skills to quickly construct the new stand, with no further written planning and modelling.

Alan's ability to change aspects of his design while maintaining and modifying others supports Jones' (2009) understanding of progression in technology. Alan was able to undertake product analysis and solve seemingly complex technology tasks, which would put him working at a senior primary level, according to the Characteristics of Progression in Learning Technology by Jones and Moreland (2003, cited in Jones, 2009). Jones also suggests that students in the lower primary school can join and assemble materials in a limited way. In Year 2 the students used only papier-mâché in the construction of their props because their teacher indicated in the planning process that this was all they could manage. In the middle primary school, Jones states that students are able to construct and modify using simple tools with reference to planning and agreed criteria. The data from the study concurs with this. One area where the findings from this study differ from Jones and Moreland's Characteristics of Progression is in the area of using mock-up and the ability to modify designs accordingly, which he indicated begins in middle primary, but the evidence presented in this study indicates that students in Year 2 or from lower primary are able to do this also.

The study indicated that in Stage 4 the students also learned a number of physical skills. In Year 2 these were centred on the papier-mâché and painting processes. In Year 6 skills learned by the students depended on their design and construction materials and techniques. These skills were exemplified through the quality of the final outcomes and included developing techniques to join wooden slats at 90 degree angles, joining plastic, wood and fabric, constructing pivoting joints, papier-mâché, painting a range of surfaces, and a variety of others.

Physical skills developed and deployed in the development of technological outcomes are referred to in the literature as technical knowledge (Jones, 2009; Moreland & Jones, 2001; Moreland, et al., 2001). Jones (2009) suggests that skill accuracy and precision develops along with sophistication in tool selection and use, as students progress through primary school. The data from this study supports these findings. In Year 6, the students were able to select their own construction methods and developed their outcomes to a higher standard than the Year 2 students, whose construction techniques were similar across the class and were more scaffolded and teacher-directed than in Year 6. Another critical aspect of technological knowledge clearly evidenced in the study, is product evaluation, which is discussed in the next section.

6.5.4 Product Evaluation

The study also allowed insight into students' ability to evaluate their outcome according to predetermined attributes. Students in both Years 2 and 6 were able to evaluate their outcome. This was exemplified with Dougal's suggestion that changing his design would affect the authentic nature of the final outcome, because he was aware of the need for his outcome to be realistic and this was one of the desirable attributes identified by the Year 6 class. It is interesting to note that, in Year 6, the students were able to evaluate against a range of attributes. However, in Year 2 the students commented on only aesthetics and size when they evaluated their flying fish.

Jones (2009) suggests that technology is more than the sum of its parts and that the progress is not linear. As students develop, so do their cognitive capacities and their ability to process increasingly more complex ideas. The findings about product evaluation in this study support this notion. In Year 2 students were able to evaluate designs using two simple attributes - whether it looked good and whether it was big enough for the audience to see, even though other attributes were identified and displayed in the classroom for the students to see and consider. However, in Year 6 a wider range of attributes were used to inform students' evaluations of their outcomes, with a more sophisticated rationale.

6.6 Chapter Conclusion

This chapter answers the research questions by taking the key findings identified in the results chapters, Chapters 4 and 5, and discussing them in relation to current literature. Each research sub-question was answered in turn with the ultimate goal of answering the key research question: *What is the nature of conversation in Technology Education?* The study introduces two major new concepts in relation to the nature of conversation and what they reveal within technology education in the primary classroom. These new concepts are the themes of conversation that make up conversation in technology in the primary school; and an expanded notion of Funds of Knowledge (Gonzalez, et al., 2005). Two significant differences between the data and current literature emerged. The first relates to knowledge transfer and the second to lower primary school students' ability to engage with and use modelling and mock up designs to inform their final designs. Also identified, is a gap in the literature related to students' decision making and understanding of materials and the impact these have on construction techniques.

Three themes of conversation were identified in the study. The first of which is the Deployment Discussion, in which students drew on learning from previous experiences. The second theme, the Conduit Theme, explored how teachers and students maximised learning opportunities though the implementation of specific strategies and techniques, culminating in the third theme: the Knowledge Theme in which students evidenced and used their new technological skills, knowledge and understanding.

Types of conversation and the role of conversation in technological practice were also discussed in this chapter. The study concurs with the literature (Alexander, 2008; Mercer & Dawes, 2008; Mercer & Littleton, 2007; Shields & Edwards, 2005) about the significant impact on conversation has on students' learning. However, it expands on the above authors' notions of dialogic conversation or exploratory talk with the introduction of Intercognitive Conversations, which include not only conversations in which participants undertake cognitive development in the same areas, termed in this chapter Convergent Growth Conversations, but also cognitive development may occur in different fields termed in this chapter as Divergent Growth Conversations.

This study's findings supports the view that students use their Funds of Knowledge (Gonzalez, et al., 2005), knowledge gained from their home and community and knowledge gained from other school-based activity, to assist and inform their technology practice. This chapter introduced an expanded understanding of González, Moll and Amanti's work on Funds of Knowledge, through the identification of two methods of acquiring home, cultural and community based knowledge, which were then deployed by students. These were Participatory Enculturation and Passive Observation.

The chapter discussed the findings which showed that students deployed both Funds of Knowledge and other school-based knowledge without explicit teaching for knowledge transfer, which contradicts earlier research by Moreland and Jones (2000) that knowledge transfer did not occur unless specifically taught by teachers. Another area of contradiction discussed was students' abilities to undertake technological practice, and this study identifies that in Year 2, in lower primary school, students are able to develop mock-up designs to critique and alter subsequent designs. This counters Jones (2009) Characters of Progression which suggest that students begin to use mock-ups in middle primary.

The following chapter, Chapter 7, concludes findings from this study through discussing the implications for teachers and teaching, the implications for students and the implications for researchers in the field of technology education, including insight into methodology and research processes.

Chapter 7. Implications and Conclusions

7.1 Introduction

Chapter 7 concludes findings from this study through a discussion of the implications for teachers and teaching, and the implications for researchers in the field of technology education for a number of key findings. The chapter is divided into two sections: Implications for Teaching and Teachers, and Implications for Researchers.

Due to the qualitative nature of this study, participant samples were small and it is therefore difficult to be able to make generalisations about the nature of students' conversations in any context other than in this study. However some readers will be able to see the relevance of the findings by making links to their experiences and practices.

There are two significant aspects of the study discussed in relation to implications for teachers. The first is 'The Nature of Conversation"; in other words what types of conversation best engage students in order to maximise their learning in technology. The second is 'What Students Learn in Technology and How Learning Appears to Occur'. This includes what close investigation of conversation reveals about students' learning in technology.

In the Nature of Conversation aspect there are two key findings. The first is that three themes contribute to the nature of conversation in technology education: identified knowledge and skills students bring to learning in technology (Deployment); how 'brought' knowledge is used in learning in technology (Conduit); and the third, evidence that technological learning occurs (Knowledge). The second key finding in the Nature of Conversations is an expanded notion of classroom talk, from current thinking that conversations involving cognitive growth usually refer to growth in a single direction or aspect, to the idea that all participants (students or teacher) undertake cognitive growth but either in the same or different directions.

In the second aspect about students' learning, 'What Students Learn in Technology and How Learning Appears to Occur', there are four key findings:

a) That this study offers an expanded notion of Funds of Knowledge to encompass methods of gaining knowledge, including the identification and introduction of two sub-categories of Funds of Knowledge - Participatory Enculturation and Passive Observation - in which students obtained social, cultural and community knowledge to contribute to their learning in technology.

b) That the results from this study challenge current understanding of if and how students transfer knowledge and skills from other curriculum-based disciplines into technology.

c) That this study has furthered the understanding of the nature of progression in technology, especially in relation to product evaluation against attributes, and insight into the ability of students in lower primary schools to make and use mock-ups to inform decision making.

d) That data from the study suggests a gap in the literature in relation to students' investigation, selection and use of materials within their technological practice.

Discussion in this chapter also includes dialogue on the implications for researchers in the use of Stimulated Recall using autophotography as a research method in technology.

7.2 Implications for Teachers and Teaching

This section discusses the implications of the significant findings of the study for teachers and their students. The section is divided into two parts: Nature of

Conversation and What and How Students Learn Technology. Figure 7.1 gives an overview of the Aspects identified as key findings in this study in the Implications for Teachers and Teaching section.

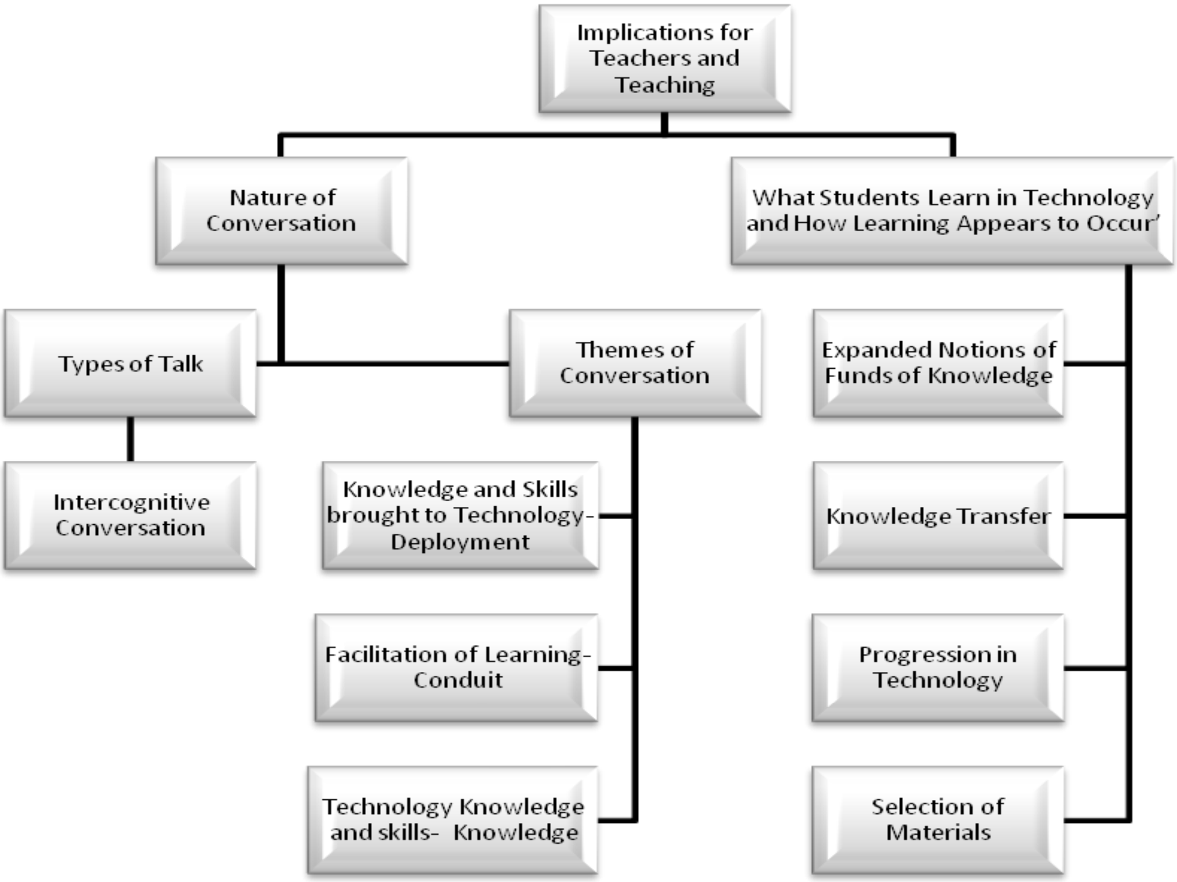


Figure 7.1: An overview of Key Findings of Implications for Teachers and Teaching

7.2.1 The Nature of Conversation

Elements of conversation identified in the study indicated that student's conversations have a significant impact on their practice in technology. There were three major themes to students' conversation in the study. These themes impact on teaching and learning in technology. In the first theme - Deployment, students deployed knowledge and skills from other means, including their home, community and other school-based learning to assist and contribute to their learning in technology. Some knowledge they already possessed and brought to their practice without specific prompting from teachers. At times teachers explicitly drew on knowledge they knew the students had. An implication of this for teachers is that students come to their technology projects with significant knowledge from their home, cultural and school communities. This knowledge comes in a range of forms and types, and includes not only direct content knowledge but also process knowledge and knowledge about ways to behave, for example, strategies for working collaboratively. Understanding this breadth of knowledge will enable teachers to prompt students' deployment of existing knowledge and skills through questioning and direct statements.

The second theme is conversation used to facilitate and transfer learning and understanding to their technology practice - the Conduit Theme. It is important for students (and therefore their teachers), that as much learning from their home or community, or from knowledge already gained at school, contributes to technology practice. Conduit conversations assist students in recognising the relevance of prior learning. An implication for teachers is that students need to be given ample opportunities to explore, talk about, and use pre-existing knowledge. Conversations in the Conduit theme do this by acting as a pathway between the first theme, knowledge with the potential for deployment within technology practice, and the third theme, technological knowledge and skills. Conversations in the Conduit Theme include the implementation of teaching and learning strategies used to assist students' learning. By explicitly drawing students' attention to potential sources of knowledge, teachers assist deployment of this knowledge to learning in technology. Learning can be facilitated through the careful implementation of planned and focused activities which enable students' engagement in the synthesis, analysis and evaluation (Bloom, 1956) of new materials. This study demonstrates that students' technological knowledge, skills and outcomes are enhanced through these planned learning activities and strategies.

Evidence of students' learning in technological knowledge is the third theme - the 'Knowledge Theme'. As the students worked through their technological practice they evidence learning of generic technology knowledge and skills, such as understanding the characteristics of technology, developing a brief and drawing and constructing technological outcomes. The nature of conversation during students' technological practice altered as the students worked through different stages of their practice. In the early stages the students were engaged in finding out about props in general, and then more specifically 'their' props. Subsequently, conversation changed to incorporate design and construction skills. Throughout, students were involved in conversations with their peers and also with their teachers, at times collaboratively and at times one-to-one. An awareness of conversation themes has an important implication for teachers as it will enable them to structure learning episodes to ensure exploration of sources of deployment opportunities namely, Funds of Knowledge and School-Based Learning. It will also assist them in recognising the value of conversation, particularly dialogue in both formative and summative assessment of technology education.

Types of Conversation

Several types of conversation are used in the classroom to enhance learning in technology. Teachers need to be aware of this to ensure quality learning occurs. The quality of teaching of technology is critical because it continues to be challenged on a number of fronts in New Zealand primary schools. These include ever decreasing time spent in Initial Teacher Education (ITE) programmes learning about technology, an increased emphasis on literacy and numeracy programmes in primary schools, and decreased time for teaching 'topic' based disciplines such as technology (Forret, et al., 2011). Therefore the implication for teachers is that all opportunities for teaching technology need to be maximised, and teaching needs to be of high quality and explicit in order to develop key technological concepts, knowledge, processes and skills within a limited time frame. Quality conversations about learning in technology can enhance this process. The study supports Doise and Mugny's (1984) stance on conflict. In situations where conflict arises, and because students are developing one outcome per group, they have to find a single solution, which means either acceptance of other's ideas or reaching a compromise. Therefore, teachers need to assist students' to understand that, although their own ideas are not always accepted, their contribution may be still important because conflicting ideas and opinions force all members of the group to question and justify their decision making, thus making stronger connections to key concepts and knowledge.

Intercognitive Conversation occurs when all participants of the conversation learn through dialogue with others. Another implication of teaching occurs through the analysis of conversations between teachers and students, or between students themselves. When engaging students in conversations, which facilitate synthesis, analysis and evaluation of materials and information, teachers are able to gain valuable insight into students' development of technological knowledge and concepts. This is important because, in order to teach technology effectively, teachers need to have a good understanding of what students learn in technology and how that learning occurs (Jones & Moreland, 2001). Also important is that by understanding the sources of deployed knowledge, teachers are in a better position to assist student deployment of this knowledge. Therefore classrooms where conversations about learning are commonplace, provide a constructive environment for cognitive development. Through conversation with their students and through listening to conversations among students, teachers are also able to gain insights into particular students' cognitive understanding in technology. Teachers need to do this because they need to know where a student is at in their understanding in order to give them quality feedback about their learning, and to identify the students' next learning steps (Black & Wiliam, 1998; Clarke, 2008).

The study also shows that through dialogue with each other, students were able to take their knowledge and skill development further than they would have been able to do individually. This was exemplified by Rex's comment about the quality of his outcome being better than he could have completed by himself. Students learned that by working in groups they were able to achieve more than they believed they could have done individually. The implications are that, in order to increase the effectiveness of learning, students need to learn how to question and challenge their own and others' thinking without attacking or experiencing feelings of being attacked. Students need to learn how to discuss and debate ideas, let go of some ideas, be open to the opinions of others and to alter opinions as new information comes to light (Alexander, 2008). Teachers need to teach and model to students how to talk to each other in a manner that facilitates learning for all parties.

The study found Funds of Knowledge affected what students brought to their learning in technology. Student acquisition of knowledge, and then deployment of that knowledge into their technology project context, was a significant aspect of their learning. The analysis of the conversations in the classrooms indicated that students gained their knowledge for later transfer from either their participation in activities with their families, interactions with artefacts or through social structures at home. They also gained knowledge, later transferred to assist their technological practice, from more passive activities such as watching TV or reading books. Students who brought knowledge from their home and culture to their technological practice were able to contribute to, not only their group's technological outcome, but their own and peers' technological context knowledge. By understanding the value of their own cultural practices, students put themselves in a better position to assist their group, which in turn assists the development of their self esteem, a major contributing factor in students' learning (Clarke, et al., 2003). Students learned they all have valuable contributions to make, and at times knowledge they take for granted because it is an integral part of their home and community culture, may not be known to their peers and subsequently contribute significantly to the groups' technology practice. Funds of Knowledge have considerable impact on learning as they assist students' understanding of the historical and cultural location of artefacts and of practices of significant adults in work, recreational and in social settings.

These findings have implications for teachers because they demonstrate that students learn from each other. Through conversations in which all participants contribute, support and challenge each other, all can learn. Teachers need to understand that students bring knowledge gained at home and in their community to technology education, and use it to assist them in understanding and contributing when developing technological outcomes in a collaborative manner.

7.2.2 What Students Learn in Technology and How Learning Appears to Occur'

Another significant implication for teachers and teaching, was the insight gained through the analysis of conversation in this study related to how students learned in technology. The study challenged current learning theory on the acquisition of knowledge in four main aspects: Knowledge Transfer, Materials, Product Evaluation and Student Motivation and Learning.

Knowledge Transfer

Students use knowledge from a range of sources to assist and contribute to their technological practice. As well as their Funds of Knowledge, knowledge of skills, processes and practices learned at home and in their community, students use temporal knowledge learned in previous technology activity to assist their understanding of technology process and some techniques, for example, papier maché. They also use knowledge learned from other disciplines and, as a unit progresses, they deploy knowledge learned earlier within the current unit, which contributes to their technological practice. This understanding has implications for teachers and students. Awareness of these sources of learning may further assist students' access to and use of a range of knowledge. This study demonstrates that students transfer specific aspects of knowledge without specific prompting to do so; perhaps an awareness of sources of knowledge will assist students in scaffolding their thinking to search these aspects of their knowledge.

With an understanding the significance of culturally based knowledge, teachers are also in a better position to plan units of work within authentically situated contexts. This has the potential to motivate students by enhancing opportunities for them to implement cultural practices and knowledge from their homes and communities, to assist their own and others' learning. However, in order to be able to do this, teachers must first have knowledge of their students' cultural backgrounds and practices.

Another aspect of knowledge transfer that has significant implications for teachers is students' knowledge transfer from other school-based learning. This study found that in Year 6 the students implemented ideas they had gained from other school subjects without specific instruction to do so. This counters research by Moreland and Jones (2000) and the Researcher's own experience that students need to be specially taught in order for knowledge transfer to take place. One possible explanation is that the students in this study were highly motivated to develop quality outcomes, because they were open to scrutiny from all those attending the school productions. Increased motivation to complete quality outcomes meant that students searched for ways of doing things well, and therefore drew on knowledge and skills they had on hand as well as undertaking research where necessary. Teachers need to be cognisant of the impact an authentic context has on students' motivation to achieve in technology.

The students in this study were motivated, and therefore not only achieved high quality technological outcomes, but also gained considerable understanding of the nature of technology and technological practice as was evidenced in their Stimulated Recall Interviews. Students also gained considerable knowledge and information from their peers. The 'givers' of the information gained 'mana' or status as they were able to contribute in ways their peers were not. The 'receivers' of information had access to information they may have otherwise not had, or taken considerable time and energy obtaining. For students this also facilitated further insight into their peers' culture and ability to contribute. The major implication for teachers and their students is that, by working collaboratively and embracing learning from a range of cultures and disciplines, students are able to extend their capabilities, knowledge and skills.

Materials

The Year 6 students in this study independently determined that materials selection would have a major impact on their technological outcome and whether or how it met the pre-determined attributes. Students considered materials on two levels in this study. The first was construction materials of the original objects, for example radios in the 1930s were made of wood. The second, materials most suitable for a stage props depicting an object, again to ensure it met co-constructed attributes, such as being realistic, durable, safe to use, and easy move on and off stage. Students also considered materials best suited for making mock-ups.

The implications for teachers include teaching students that the selection of materials will impact how final outcomes meet identified attributes. Therefore, teachers need to provide opportunities for the exploration and testing of a range of materials. They also need to assist students' understanding of how and why materials impact on design and the functional and physical nature of the outcomes. Teachers also need to understand that students need to know materials selected for intermediate outcomes will impact on final designs. For example, materials selected for mocking-up will impact on the usefulness of the mock-up in terms of the students' ability to evaluate and critique design features.

Product Evaluation

Students were able to undertake product evaluation at a number of stages in the design and construction process. This was particularly surprising at Year 2. The students were able to create a mock-up of their intended design and were able to suggest modifications to improve their design when they evaluated their ideas against the attributes which were co-constructed with the class and their teacher. These were continuously displayed in the classroom for the duration of this process. Implications of this for teachers are that children in junior primary schools do benefit from developing mocked-up designs, and are able to alter their design according to one or two simple attributes, especially when co-constructed with the class, and the students have a clear understanding of the attributes and why they are important. Students in Year 6 were able to use a wider range of more complex attributes to evaluate their designs. These students were also able to seek feedback from external stakeholders and alter designs accordingly. Therefore, teachers at this level should facilitate the co-construction of a range of attributes, following implementation of critical investigation of existing products and stakeholder and client needs. Subsequently students can be engaged in quite sophisticated activities to facilitate design evaluation and modification.

Student Motivation and Learning

From the outset of the practical outcome development, which followed the development of students' understandings of the character and function of props and the specific artefacts (flying fish, radios, and microphones), the students worked within a framework with clearly identified desirable attributes for their props. The eventual success of the outcomes indicated that the students used these to continually evaluate their outcomes at each stage of development: planning, mocking-up and construction. The implications of this for teachers are that, when students are involved in the process of determining attributes of a successful outcome, they are more aware of the ongoing quality of their outcome and they use the attributes to evaluate their outcomes on an ongoing basis.

In this study students were fully engaged in the product development process and motivated to do a good job. After 'production night' several students, particularly from Year 6, commented to the Researcher that they thought their props 'were better than any of the other classes'. A number of parents also commented on the props developed. The high interest and motivation to develop quality technology outcomes supports the notion that authentic learning is motivational for students in technology (Hennessy & Murphy, 1999; Hill & Smith, 1998; Rogoff, 1990).

Students learn in technology by accessing existing knowledge from both home and school and blending it with newly learned knowledge which they apply to develop a technological outcome. Newly learned knowledge includes developing notions of the character and function of their intended outcome and understanding technological practices and processes. Application of this knowledge enabled the development of successful props for their school production. To maximise learning opportunities, teachers assisted students' learning through engagement in activities using a range of strategies. This understanding links to the three major conversation themes identified in this study, which can be seen in Figure 5.11.

The implications for teachers include the understanding of the role of metacognition in undertaking technological practice. Metacognition is the identification and understanding of thinking (Fisher, 2009). By being aware of their thinking, and understanding the sources of their knowledge, students are in a better position to use and or reconfigure what they know and understand when new information comes to light. Being cognisant of this assists teachers in their planning and delivery of technology, and encourages them to facilitate students' awareness of their own thinking. Another implication that is particularly important is that, by undertaking units of work that are culturally situated and in which the students are motivated to complete high quality outcomes, assists students' learning in technology.

7.3 Implications for Researchers

The study highlighted a number of critical aspects of technology education that have implications for researchers in this field. These include:

a) quality classroom talk enhances successful participation in outcome development;

b) how and why students deploy knowledge and skills from beyond the technology classroom or even school to inform their technological practice;

c) junior primary school students' ability to use mocking-up to inform technological process;

d) the impacts materials have on the physical and functional features of technological outcomes.

The study shows that talk in the primary technology classroom is related to three themes. The first is talk about knowledge and skills students bring to their learning, in which Funds of Knowledge are shown to have two significant types, each of which could be investigated further. The second type of talk assisted in the facilitation of learning through planned strategies and techniques used to maximise students' learning, and finally, the third type, talk that evidenced technology learning had occurred.

The study also identifies a discrepancy between the data and literature about young primary school students' capabilities for modelling through developing a mock-up. This opens up an opportunity for researchers to further investigate young students' abilities in modelling and understanding the purposes for undertaking the modelling.

Findings from the study also contradict some earlier findings about knowledge transfer and students ability to transfer knowledge from other disciplines to technology without explicit prompting. This is another potential area of further research. There is also potential for further research into how and why primary school students make decisions about the materials they use for modelling and developed outcomes. Each of these are discussed below in two sections: Further Studies and the Analysis Process.

Further Studies

The participants in the study worked collaboratively to design and construct their intended outcomes. In order to develop a single outcome as a group of three, collaboration and co-operation were essential. This study highlights the difficulties students had when working collaboratively (for example two students in each of two groups had particular difficulty, Alan and Dougal in Year 6, and Issy and Debby in Year 2). When working collaboratively students were forced to use dialogue with their peers in order to reach compromise when different ideas were put forward. The Researcher believes there is potential for further study into students' ability to work collaboratively on a single project, while implementing a number of talking strategies to assist in the collaborative process and protecting the self esteem of all members. This would be particularly relevant to senior secondary schools where students rarely engage in collaborative technology practice despite it being common place in industry based technology practice.

In this study, to develop their selected props, students needed a range of knowledge and skills to assist the development and construction processes. The study showed that students deployed skills and knowledge from other sources without specific prompting and it identified two new sources of Funds of Knowledge. The first being Participatory Enculturation, in which students bring knowledge they have gained through active engagement in activities such as building tree houses with a father, or fishing with a grandfather, and Passive Observation, in which knowledge gained comes through non-interactive observation, such as watching movies and television. As these sources are newly identified, there is further potential in this area to investigate these sources of Funds of Knowledge, to establish further insight into each and to determine the effectiveness of each, and whether these are the only two sources of Funds of Knowledge, or are there others not identified through this research.

The findings of this study contradict earlier findings that students fail to transfer knowledge from other disciplines unless this was specifically taught. This too, was the Researcher's previous experience. For example, students in Year 6 automatically drew on their mathematical knowledge when determining the dimensions for their designs and at both levels the students deployed painting skills already learned. Therefore, this study opens the door for further research into knowledge transfer, in particular in relation to levels of student motivation, because in this study, students were highly motivated to be successful and their technological outcomes were high stakes, as they were required for their class items in the school production. An example of a research question might be: Are levels of knowledge transfer higher when students are highly motivated for success?

This study found that students in early primary school were able to develop mock-up designs to evaluate and modify their design ideas using a limited number of attributes to guide them. In the Year 2 Stimulated Recall interviews some students were able to articulate what a Mock-up was and why it was made. This contradicts earlier findings, and therefore opens opportunities for further research into how young primary school students' evaluate their technological outcomes using intermediate outcomes and attributes.

The study also found that students in Year 6 evaluated their outcomes using a greater number, and more complex attributes than students in Year 2. In Year 6, students considered all their identified attributes: easily recognisable, durable, safe, era specific and ergonomically designed. In Year 2 only two of the five attributes were considered by the students in their product evaluations: able to be seen and colourful. One implication for researchers is that this field needs further investigation given the qualitative nature of this research and the small number of participants. The Researcher feels it would be interesting to investigate this matter to determine whether it is a typical difference or just in this study. Investigation could also be completed in related areas, such as the number and complexity of attributes able to be used by students at various levels of primary school.

In Year 6, the students understood the influences materials had on the quality and function of their final product. For example, Mandy understood that wood would make a good frame for their radio but that it needed to be joined carefully. The radio group also realised that plastic coreflute could cover the frame and be painted to assist their design's authentic appearance. In Year 2, the students in the study were not given an option of selecting suitable materials for their final outcome. Their teacher determined that the flying fish would be made from papier-mâché. This poses the question about the age and stage at which students are able to select appropriate materials for their outcomes to benefit the quality of outcomes and increase its likelihood of success, thus offering an implication for a researcher with the potential of a new field of investigation.

The above section gave some indication of potential implications for research in the field of technology education. The next section highlights a number of implications around the research methods used in the study.

7.3.1 The Analysis Process

Data gathering methods used in the study include participant observations of students working in technology, recorded and transcribed audio classroom conversations, and stimulated recall interviews using autophotographs and students' work samples.

The researcher specifically selected audio recordings of the students working rather than video recording for two main reasons: the first to simplify the data, and the second to ensure a focus on the spoken word. The researcher suggests that, given the study was about the nature of conversation, this strategy worked well because it enabled the capture of natural conversation without the children becoming self-conscious. However, in subsequent studies the Researcher suggests the use of individual microphones on each of the participants would be more successful than the group microphones used in this study. One regret the Researcher did have was that when the class was undertaking whole class discussion with their classroom teachers some voices were not recorded due to the placement of the two microphones. Again individual microphones on each participant child would allow a clearer capture of data.

The study indicates that clear insight into the student learning and understanding of technology is enhanced through the telling of stories. This was exemplified in Year 2 when Anne and Ellis were telling the stories of their fishing experiences, thus giving the Researcher in the role as teacher insight into the students' understanding of the process of gutting, and conversely, stuffing fish. In Year 6, it was exemplified by Mary, who told the story of her Dad building a tree hut at home, thus giving the classroom teacher insight into her use of bracing to join slats of timber at 90 degree angles. Implications for the researcher here include the possibility of developing further understandings of the place and role of story-telling in technology education, and if and how teachers and students are advantaged by this story telling.

Insight Gained from Stimulated Recall Interviews with Autophotographs

Stimulated Recall Interviews using the students' autophotographs was one of the methods used for gathering data. Through analysis of the transcripts and photographs taken by the students the Researcher determined the four stages of the unit identified as significant. These were Character and Function, Planning, Mock-up and Construction. The stimulated recall interviews assisted the Researcher in gaining insight into what technological knowledge the students had at the conclusion of the unit. In Round One of the study, the Researcher taught students to use a camera and to take photographs of the work in technology. This was done on digital cameras. In Round Two all students were given a disposable camera for a number of reasons: so the photographs could not be deleted; to identify who took each photograph (the first photograph on each camera was a self portrait); to provide a reasonably unbreakable camera; and to enable every student to own the camera and associated photographs. The students were interviewed as soon as the photographs were developed at the unit conclusion.

A number of insights were gained during this process and the Researcher would make several recommendations for those using Stimulated Recall with autophotographs. Although using the disposable cameras enabled ownership of the cameras and provided a durable camera, the Researcher would recommend the use of digital cameras in future studies for two main reasons. The first is on-going access to photographs taken by the students. Students, teachers and researchers would be able to monitor and record photographs taken in an on-going manner. Accidental photographs, photographs taken by “friends” and mistakes could be deleted. The second is that the Stimulated Recall interviews could be undertaken more promptly at the conclusion of the study as photographs would not need to be printed, rather shown to the students on a computer. In addition to these two main reasons, digital photographs can also be filed and back-ups made on an on-going basis. In conclusion, the Researcher believes Stimulated Recall using autophotographs was a successful tool in assisting researchers to understand students’ learning in technology education. However, she would recommend the use of digital cameras for this process, bearing in mind that the students and researcher would have to be diligent about recording photographs taken, especially if students were unable to each have a digital camera. In secondary schools, and to a lesser degree, primary schools, students are more and more likely to have cell phones with a digital camera which could be used. Steps would need to be taken to ensure the safety and integrity of the photographs.

7.4 Summary

This section concludes the study with a brief overview of the significant aspects of the study. This was a qualitative study within a socio-cultural paradigm undertaken in a New Zealand urban primary school with six participant students in each of Years 2 and 6. The overall purpose of the study is to gain insight into the nature of conversation in the primary classroom while students were engaged in technology education. The aims of the study are to gain an enhanced understanding of the influences on students when developing technological solutions, to understand the nature of conversation most beneficial to students, how and when these conversations are best undertaken to effectively enhance students' learning and to illustrate the value and influence of focussed conversations between teacher and student to give teachers clear insight into students' learning and achievement in technology.

In the study, literature in a number of areas is investigated and includes: knowledge and skills in technology education; Sociocultural theory in general and in education, ways of working in technology; Funds of Knowledge, and the nature and role of language and conversation in learning.

Analysis of the data identified four main stages within a unit of work that are significant to the students. These stages - Character and Function, Planning, Mock-up and Construction - are based loosely on the main purpose of the activities the students are undertaking at the time and were subsequently used to frame the presentation of the study results in Chapters 4 and 5. Across all stages, four elements of conversation emerge according to their main purpose or reason for the conversation. The first purpose is Funds of Knowledge. In these conversations students bring to their technology practice knowledge and skills learned from their home and community. Newly identified in this study are two sub-elements: Participatory Enculturation and Passive Observation. The second element identified is Making Links and Connections in which students make specific links to prior school-based learning, from other disciplines, previous technology units and earlier in the current unit where applicable. The third element Management of Learning involves conversations undertaken for the purpose of managing and maximising students' learning. These conversations are initiated by and involved individual students, groups of students and teachers in varying combinations. In this element numerous sub-elements emerge, the most significant of which is the use of conversations in which all participants undertake cognitive development and conversations which involved higher order thinking. Other aspects of the element include behaviour management and transmission of direct instructions and information. The fourth and final element is Technological Knowledge and Skills in which students' learning in technology is evidenced. Again, several sub-elements emerge, the most significant of which includes students understanding of technological process and practice, the role and function of materials in the development of a technological outcome and the impact specified attributes has on students' designed outcomes.

Further analysis of the data, stages and elements led to the identification of three interconnected themes of conversation that are significant to students when undertaking technology practice. The first theme is the Deployment Theme and includes all knowledge and skills the students contribute to a conversation at any one time. The third theme is the Knowledge theme which evidenced students' technology knowledge and skills. The second element facilitates a linking of deployed knowledge to current technology knowledge, hence its name, the Conduit theme. Themes are interconnected rather like a set of cogs as seen in Figure 5.11.

In Chapter 6 these findings were discussed in relation to and through synthesis with relevant literature; consequently seven key findings from the study emerged. These are summarised below. That:

1) three themes contribute to the nature of conversation in technology education, Deployment - identified knowledge and skills students bring to learning in technology; Conduit - how brought knowledge is facilitated into learning in technology, and Knowledge - evidence of that technology learning;

2) classroom talk in which all participants undertake cognitive growth is termed Intercognitive Growth Conversation. It comes in two types: learning in either the same direction - Convergent Growth Conversations - or different directions - Divergent Growth Conversations;

3) Funds of Knowledge has two sub-categories which describe how students obtain their knowledge: Participatory Observation or Passive Observation;

4) students can spontaneously transfer prior knowledge from other sources into technology;

5) students in lower primary school are able to make and use mock-ups to inform decision-making in relation to product evaluation against attributes;

6) there is a gap in the literature in relation to students' investigation, selection and use of materials within their technological practice; and finally

7) Stimulated Recall using autophotography is an effective method of investigating technology.

The study concludes with a number of implications in two main categories: Implications for Teachers and Teaching, and Implications for Researchers. Implications for teachers are discussed through two aspects, the first of which is the Nature of Conversation in Technology and the second, 'What Students Learn in Technology and How Learning Appears to Occur'. In this section the Researcher offers several implications summarised in Figure 7.1. They include, but are not limited to, the importance of understanding students' Funds of Knowledge and the role of conversation in the facilitation of learning in technology. Implications for research identified in the study came under two categories. The first, potential for further investigations including further research into the sub-elements of Funds of Knowledge, students working collaboratively, and students' learning in technology, particularly in the fields of progression, knowledge transfer and the role of material selection in technological practice.

The second, a critique of one method used in the study - Stimulated Recall using autophotography, using digital which is recommended rather than film cameras.

This study makes a significant contribution to the field of student learning in technology education by enhancing understandings of the nature of conversation in technology and the impacts quality conversations have on students' learning in technology. Considerable insight was also gained into the nature of knowledge and skills students bring to their learning in technology, and how teachers and students can maximise learning opportunities in technology education.

7.5 Concluding Comments

The findings of this study have challenged my understanding of what it is to be a good teacher. When teaching in the senior primary school, I always felt that a quiet classroom was required for quality learning to occur. This study has enabled me to see the value of classroom talk. It has shown me that when classroom dialogue is well structured and specifically taught to students, they are able to enhance their own and others' learning. I have realised that teachers play a crucial role in teaching students how to talk to each other. Debate and argument when coupled with an open disposition to learning and change can enhance learning. These findings have the potential to transform learning in technology, particularly at secondary school when students frequently do projects on their own. The study has emphasised to me the importance of students working collaboratively on a single project. This puts students in the situation of having to listen to and work with others. In order to develop a single technological outcome, they are forced to talk and listen to each others' ideas, make compromises and sometimes accept ideas other than their own. Therefore, this study has highlighted the need for teachers to teach students the value of offering ideas, and to understand that even when their ideas are not accepted by the group for further development, their contribution at the very least forces participants to consider a range of options, thus validating all input into the process. The notion that all participants in a conversation can learn, excites me. A study highlight occurred when in his final interview, Rex, Year 2, who was troubled with two girls in his group constantly arguing, told me that their group's fish was better than he could have completed alone. He stated that working with the girls enabled this to happen.

I am also excited by the idea of conversations in which teachers learn from their students, not only about contextually bound matters (Convergent Growth Conversations) but also about how, what and why students are learning in technology (Divergent Growth Conversations). The study has offered me insight into teacher metacognition around students' learning in technology as a part of everyday teacher practice, and how this has the potential to enhance students' learning.

The pathway from my initial conversation with Reuben to the writing of these concluding comments has been huge journey over a period of eight years. Through listening to students' stories about what they know, what they can do and how they learned it, has offered special insight into what students bring to technology and how this knowledge can be maximised for the benefit of, not only the individual, but others also. The identification of four elements of conversation has offered me insight into the roots of conversation; why the students are able to say what they are saying and how they knew such things. The three themes assisted me in the interpretation of conversations by both students and teachers, and in the future I hope they will assist teachers in the planning and delivery of meaningful programmes of work in technology by offering clarity about the conversations they facilitate in the classroom.

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Appendices

Appendix 1: Initial Letter to Principals

Technology Education Centre
School of Sciences and Physical Education
College of Education
University of Canterbury
PB 4800
Christchurch

XXX February 2008

XXXXXXXXX
XXXXXXXX School

XXXXXXX Christchurch

Dear Mrs/ Mr XX

I am a senior lecturer and head of centre for technology education at the University of Canterbury, College of Education and hold current full teacher registration. I teach technology education to the primary B Tch Ln and Grad Dip students. At present I am undertaking a study of children's learning in technology education as a part of my PhD through the University of Waikato.

I am hoping that you might consider becoming my host school, to enable me to undertake this project. I would like to work with two classes of children and their teachers, one at Year 2 and Year 6, preferably in non composite classes. The project would involve the planning and delivery of two units of work in technology education in each classroom, the first in Semester One and the second in Semester Two. During each unit I would like to focus closely on three children in each class, undertaking semi formal and informal interviews, videoed observations and taking samples of their work.

The aims of the study are to gain an enhanced understanding of the learning that influences children when developing technological solutions and to illustrate the value and influence of focussed conversations between teacher and child in the hope of gaining clear insight into children's learning and achievement in technology.

The study will also include professional development in the new technology education curriculum statement for the teachers involved and any other teachers who are interested. As a teacher educator I have and will be involved in MOE professional development in technology and I will willingly share with the teachers involved new understandings and ways of working in technology. Although as the researcher I will not be involved in the actual delivery of the units I will support and guide the teachers through the unit planning process and I will also provide all resources and consumables used during the planning and delivery of the technology. I imagine the unit to be based loosely on one of the technology exemplars, but this of course will be up to the teachers involved.

Please be assured that all data and information gathered by me during the study will remain confidential to myself and my thesis supervisors. Parental consent and child assent will be sort for all children in each class. All data and information gathered will be kept securely at the University of Canterbury and care will be taken to ensure school and teacher anonymity is maintained throughout all stages of the project including the final reporting process.

Please fill in the form below indicating whether you are able to assist me with this project or not and return to me as soon as possible.

Thank you very much for considering this project.

Yours sincerely

Wendy Fox-Turnbull
Senior Lecturer
College of Education
University of Canterbury
Phone 03 3458124

To Wendy Fox-Turnbull
Technology Education Centre
School of Sciences and Physical Education
College of Education
University of Canterbury
PB 4800
Ilam
Christchurch

Thank you for considering working with our school on this technology education project.

- ❑ Unfortunately we are unable to assist you at this time
- ❑ We are able to assist you with this project.

The two teachers involved will be:
Yr 2 :___________________________
Yr 6:___________________________
Regards:
Signed ___________________________
Principal's Name: ___________________________
School: ___________________________
Date: ___________________________

Appendix 2: Letter of Confirmation to Accepting Principal

Technology Education Centre
School of Sciences and Physical Education
College of Education
University of Canterbury
PB 4800
Ilam
Christchurch

XXX February 2008

XXXXXXXXX
XXXXXXXX School
XXXXXXX Christchurch

Dear Mrs X
Thank you for allowing me to work with your staff for my research project. The project will involve the planning and delivery of two units of work in technology education in each classroom, the first in Semester One and the second in Semester Two. I will now make contact with the classroom teachers to discuss planning and delivery of the units of work.

I look forward to working with staff to ensure the aims of the study are met. As stated in my pervious letter the aims of the study are to gain an enhanced understanding of the learning that influences children when developing technological solutions and to illustrate the value and influence of focussed conversations between teacher and child to give teachers clear insight into children's learning and achievement in technology.

I will also contact you regarding the professional development in the new technology education curriculum statement for the teachers involved and I am happy for any others who are interested to be involved.

Please be assured that all data and information gathered by me during the study will remain confidential to myself and my thesis supervisors. Parental consent and child assent will be sort for all children in each class. All data and information gathered will be kept securely at the University of Canterbury and care will be taken to ensure school and teacher anonymity is maintained throughout all stages of the project.

Thank you very much for allowing for me to complete this project in your school. I look forward to working with you and your staff.

Yours sincerely

Wendy Fox-Turnbull
Senior Lecturer
College of Education
University of Canterbury

Phone 03 3458124
027 4319058

Appendix 3: Letter to Teachers at School

7 March 2008

XXXX School
XXX Place
Christchurch 8014

Dear Teacher

I am a senior lecturer and head of centre for technology education at the University Of Canterbury College Of Education. I teach technology education in the Bachelor of Teaching and Learning and Graduate Diploma of Teaching and Learning programmes. At present I am undertaking a study of children's learning in technology education as a part of my PhD through the University of Waikato.

I am hoping that you and your class might consider becoming one of my two host classes to enable me to undertake this project investigating technology education in primary classrooms. I would like to work with two classes of children one at Year 2 and Year 6.

The project would involve the planning and delivery of two units of work in technology education in your classroom, the first in Term Two and the second in Term Three 2008. During the second unit (Part Two) I would like to focus more closely on six children. These children will be involved in semi-formal and informal interviews, observations and audio recording of their conversations with their peers and you about their learning and autophotography (children taking photographs of their own work). These photographs will form part of the data generated form the project. All children will be able to keep their photographs however I plan to retain a copy of those taken by some children. Samples of work and the unit plans will also form a part of the research data.

Should you consent I look forward to working with you to ensure the aims of the study are met. These aims of the study are: to gain an enhanced understanding of the types of conversations that enhance children's learning in technology; to illustrate the value and influence of focused conversations between teachers and students; and to understand what influences children when developing technological solutions.

I will support you in planning the units within the framework of the new technology education curriculum statement. I will also provide all resources and consumables used during the planning and delivery of the units.

Please be assured that all data and information gathered by me during the study will remain confidential to me and my thesis supervisors. Parental and child consent will be sort for all children in each class. All participants will be free to leave at anytime throughout the study. Data and information gathered will be kept securely at the University of Canterbury and care will be taken to ensure that school and teacher anonymity is maintained throughout all stages of the project and its reporting.

The data gathering during the study will be that of recorded conversations between participants, their peers, their teachers and the researcher. The participants will also be provided with a disposable camera so they are able to record their own technological practice. These photographs will be the motivation for further conversations with the researcher in the form of semi-structured interviews. Some work samples will also be collected. I therefore request your consent to record and observe conversations you will have with the participants about their learning in technology. Transcripts of these conversations will also be as data.

If at any time there is an issue with the project please feel free to contact me using the details provided in this letter. In the event of an issue not being resolved at this stage you are welcome to contact my chief supervisor: Dr Kathrin Otrel-Case, Senior Lecturer, Centre for Science and Technology Education Research, The University of Waikato, Private Bag 3105 Hamilton New Zealand, Ph: 64 7 838 4639, Fax: 64 7 838 4272.

Thank you very much for considering allowing me to undertake this project with you and in your class. You and any of the research participants are free to remove any data gathered or to withdraw from the research at any time. Please fill out the form below to ensure that I have the necessary details and return it to me in the prepaid envelop supplied.

Yours sincerely

Wendy Fox-Turnbull

Senior Lecturer

College of Education

University of Canterbury

Private Bag 4800

Christchurch

Phone: 3458124, Mobile:027 4319058

Appendix 4: Class Information and Teacher Consent Form

Technology Education Centre
School of Sciences and Physical Education
College of Education
University of Canterbury
PB 4800
Ilam
Christchurch

Thank you for considering working with my class on this technology education project.

- ❑ Unfortunately I am unable to assist you at this time
- ❑ I am able to assist you with this project.

Name: ____________________

Classroom number: ___________________

Year level: ___________________

Number in class: ___________________

Boys: ______ Girls: ______

Ethnic makeup of class: NZ Maori: ______

European: ______

Asian: ______

Pacific Island: ______

Other (please state):_____________________

School Phone Number: ___________________

Room Extension Number: ___________________

School Fax: ___________________

Home phone number (optional):_________________

I consent to allowing my conversations with the participants about their learning in technology to be recorded and used as research data, to my unit plans and some samples of the children's work also being used as research data. I understand that the children or you will be able to keep the photographs they take in Part Two and that the researcher will retain a copy of photographs from selected children. I also understand that I am able to withdraw any data provided at anytime.

Signed: ____________________________ Date: ____________________

Appendix 5: Acknowledgement Letter to Teachers

Technology Education Centre
School of Sciences and Physical Education
College of Education
University of Canterbury
PB 4800
Ilam
Christchurch

XXX February 2008

XXXXXXXXX
XXXXXXXX School
XXXXXXX Christchurch

Dear XXXX
I am a senior lecturer and head of centre for technology education at the University of Canterbury College of Education. I teach technology education to the primary B Tch Ln and Grad Dip students. At present I am undertaking a study of children's learning in technology education as a part of my PhD through the University of Waikato.

Thank you for allowing me to work with you and your class for my research project. The project will involve the planning and delivery of two units of work in technology education in each classroom, the first in Semester One and the second in Semester Two. I will also send a letter home to all parents and caregivers of the class to request consent to undertake the study.

I look forward to working with you to ensure the aims of the study are met. The aims of the study are to gain an enhanced understanding of the learning that influences children when developing technological solutions and to illustrate the value and influence of focussed conversations between teacher and child to give teachers clear insight into children's learning and achievement in technology.

I will also provide you with professional development in the new technology education curriculum statement and I am happy for any others who are interested to be involved also. As a teacher educator I have and will be involved in MOE professional development in technology and I will willingly share with the teachers involved new understandings and ways of working in technology. I will support and guide you through the unit planning process and that I will also provide all resources and consumables used during the planning and delivery of the units.

Please be assured that all data and information gathered by me during the study will remain confidential to myself and my thesis supervisors. Parental consent and child assent will be sort for all children in each class. All data and information gathered will be kept securely at the University of Canterbury and care will be taken to ensure that school and teacher anonymity is maintained throughout all stages of the project and its reporting

Thank you very much for allowing for me to complete this project in and with your class. Please fill out the form below to ensure that I have the necessary details to complete the project and return to me in the prepaid envelop supplied.

Yours sincerely

Wendy Fox-Turnbull
Senior Lecturer
College of Education
University of Canterbury
Phone 03 3458124
027 4319058

✂ --

Name: ______________________________________

Classroom number: ___________________________

Year level:___________________________________

Number in class: ___________________________

Boys:_____________ Girls:___________________

Ethnic makeup of class:_______________________

School Phone Number:_________________________

Room Extension Number:_______________________

School Fax:__________________________________

Home phone number (optional):_________________

Appendix 6: Initial Letter to Students

Wendy Fox-Turnbull
Senior Lecturer
Technology Education and Professional Studies
College of Education
University of Canterbury
PB4800
Christchurch

5 May 2008

Room Four
XXXXX School
XXXXPlace
XXXXXX

Dear
My name is Mrs Wendy Fox-Turnbull. My job is to help teachers learn more about teaching you technology. I would like to learn more about how you learn in technology. To do this I will be studying what the children in your class do and say when studying technology during this year at school.

I would like to look at and listen to you while you are learning technology. Sometimes I would also like to talk to you about what you are learning and thinking. I will also teach you how to photograph your own work in technology.

To help keep you safe when I write about what I have found out, the people reading the report will not know who you are or which school you go to. You can change your mind about being studied at any time; you just need to tell me, your parents, or your teacher.

If at any time there is a problem with the project you can tell me using the details provided in this letter or through your teacher. In the event of an issue not being resolved at this stage your parents or teacher are welcome to contact my chief supervisor: Dr Kathrin Otrel-Cass, Senior Lecturer, Centre for Science and Technology Education Research, The University of Waikato, Private Bag 3105 Hamilton New Zealand, Ph: 07 838 4512, Fax: 07 838 4272.

If you are happy for me to study you learning in technology please write your name on the form below. Thank you very much.

Yours sincerely

Mrs. Wendy Fox-Turnbull

Part One Child Consent Form

I am happy for Mrs Wendy Fox-Turnbull to talk to me and look at me while I learn technology.

Name: ______________________________ Date: ______________________

Appendix 7: Initial Letter of Consent to Parents

Technology Education Centre
School of Sciences and Physical Education
College of Education
University of Canterbury
PB 4800
Ilam
Christchurch

XXX February 2008

Parents of Room XX
XXXXXX School

Dear Parents
I am a senior lecturer and head of centre for technology education at the University Of Canterbury College Of Education and I hold current full teacher registration. I teach technology education to the primary teacher trainee students. At present I am undertaking a study of children's learning in technology education as a part of my PhD through the University of Waikato.

The aim of the study is to gain an enhanced understanding of the learning that influences children when working in technology. The project will involve me observing and interviewing students in MrsXXX/Mr XXX 's class while they undertake two studies in technology education, one in Semester One and one in Semester Two this year. This will involve me videoing the children while they are working, talking to them about their learning and analysing samples of their work. Three children in the class will be identified to be studied very closely. I will undertake one to one interviews with these children. If your child is one of these children I will contact you subsequently.

Please be assured that all recordings and other information gathered by me during the study will remain confidential to me and my PhD supervisors and that all information gathered will be kept securely at the University of Canterbury. The identity of the school, teachers and children will not be evident in any reported findings.

Thank you very much for considering to allow me to complete this project with your child(ren). If you are happy for your child to participate in the study please fill out the form on the following page and return to school as soon as possible.

Please tick the separate box indicating whether you are happy for your child to be selected for the in-depth section of the study, which will involve one-to-one interviews and very thorough observation, including video and audio recording of your child while they work on their technology.

Yours sincerely

Wendy Fox-Turnbull
Senior Lecturer
College of Education
University of Canterbury
Phone 03 3458124
027 4319058

Appendix 8: Letter to Selected Children Round 2

Technology Education Centre
College of Education
University of Canterbury
Christchurch

XXX February 2008

Dear (child's name)

My name is Mrs Wendy Fox-Turnbull. I teach teachers to teach you technology. To learn more about how you learn in technology I would like to study what you do and say when studying technology during this year at school.

To do this I would like to record what you say and do when learning in technology. I would like to listen to you as you talk to your teacher and I would like to talk to you about what you are doing and what you are thinking.

When I write about what I have found out, the people reading the report will not know who you are or which school you go to. Everything you say to me will be a secret.

If you are happy for me to study you learning in technology please write your name on the form below. Thank you very much.

Yours sincerely

Mrs Wendy Fox-Turnbull

- -

I am happy for you to study me while I learn technology and talk to me about my learning.

Name:______________________________ Date:_____________________

Appendix 9: Letter to Non-Selected Children Round 2

Technology Education Centre
College of Education
University of Canterbury
Christchurch

XXX February 2008

Dear (child's name)

My name is Mrs Wendy Fox-Turnbull. I teach teachers to teach you technology. To learn more about how you learn in technology I will be studying what children in this class do and say when studying technology during this year at school.

To do this I would like to look at and listen to you while you are learning technology. Sometimes I would also like to talk to you about what you are learning and thinking.

When I write about what I have found out, the people reading the report will not know who you are or which school you go to. Everything you say to me will be a secret.

If you are happy for me to study you learning in technology please write your name on the form below. Thank you very much.

Yours sincerely

Mrs Wendy Fox-Turnbull

- -

I am happy for you to study me while I learn technology.

Name:______________________________ Date:______________________

Appendix 10: Letter with Amendments to Ethics Proposal

Technology Education Centre
School of Sciences and Physical Education
College of Education
University of Canterbury
PB 4800
Ilam
Christchurch

16 January 2008

Associate Professor Richard K Coll
Centre for Science & Technology Research
Science & Engineering
University of Waikato
Private Bag 3105
Hamilton

Dear Associate Professor Coll

Thank you for the feedback regarding my ethics proposal for my PhD. Please find attached the revised version. I have made the following changes as requested:

1. completed section 4j
2. replaced the word ‘Semester’ with ‘Term’ in letters to participants
3. included more details about what participants are consenting to. For example that all children will receive a disposable camera in Part Two and that I will retain a copy of photographs taken by selected children.
4. provided full contact details of myself and my supervisor
5. carefully proof read and corrected all typographical errors in the letters.

Yours sincerely

Wendy Fox-Turnbull

Appendix 11: Amendments to Ethics Approval

Application for Appendum to Ethics Approval

Human Research Ethics Committee

1 Title of Project

Technological Solutions: More than Meets the Eye

Children's Stories: Insight into learning in technology through analysis of children's conversations about their technological outcomes and decision making

2 Researcher and Contact Details

Wendy Fox-Turnbull

School of Sciences and Physical Education

College of Education

University of Canterbury

PB 4800

Christchurch

Program of study (if applicable)

PhD

Department/Centre/Unit

STER

Contact Address

7 St Clair Close

Harewood

Christchurch 8051

Other personnel

Dr Kathryn Otrel-Cass (Chief Supervisor)

Professor Alister Jones (Second Supervisor)

3 Research Adjustment

This application is requested in addition to ethical consent for this project which was granted on March 2008

After speaking with Dr Kathryn Otrel-Cass I have realised the need to interview the teachers involved in the project at four times during the study, before and during the teaching of the two technology units. To this end I will need to request formal permission from the two teachers to interview them at these times. The proposed letter and interview schedule are attached as Appendix 1 and 2 respectively.

4 Place in which the research will be conducted

St Albans Primary School Christchurch

5 Has this application in whole of part previously been declined approval by another ethics committee?

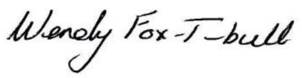
No

6 Is any of this work being used in a thesis to be submitted for a degree at the University of Waikato? Please specify.

Yes, PhD

Applicant Request for Approval of Ethics Application

Signed by the Applicant



Date 22 April 2008

Signed by the Supervisor

Date

Signed by the Chairperson/Director ________________________

Date ________________________

The ethics application is approved/requires further work

Signed on behalf of the Committee ________________________

(Chairperson of the Committee

Date ________________________

Appendix 12: Letter of Introduction Teachers

Please note that the teachers will be sent separate letters and consent forms.

Wendy Fox-Turnbull
Senior Lecturer
Technology Education and Professional Studies
College of Education
University of Canterbury
PB4800
Christchurch

22 April 2008

CXX XXXs /FXX XXX
XXXX School

17 XXXXXPlace

XXXX

Dear CXX / FXX

Thank you very much for agreeing to be a part of my study and for allowing me to work with you and the children in your class. As you know the project involves the planning and delivery of two units of work in technology education in your classroom. At our meeting on 7 April we determined that the first (Part One) would be in Term Two with a broad topic of “spheres” and the second (Part Two) in Term Three 2008 based round the school’s junior and senior productions. At this meeting we also arranged two further meetings prior to the beginning of Part One which I would like to confirm for 7 and 14 May at 3.15 p.m. at XXXXX School.

In my initial contact with you, you consented to me observing in your classroom during the delivery of the technology units, informally and formally interviewing your students, gathering samples of work and photographs of the children’s work using autophotography. After meeting with my thesis supervisor and further considering my research questions I would also like to interview you using a semi-structured interview format at four times during the study, one prior to Part One and one during Part One with this pattern repeated in Part Two

The interviews would last no longer than 15 minutes and will be recorded for accuracy purposes. If you consent to these interviews I would like to conduct the first of these on 7 May immediately prior to our meeting. For the initial interview I would like to talk to you together and would like to discuss your understandings of technology education and classroom conversation. If you agree to allowing these interviews to take place please fill in the form below and return to me on 7 May.

Yours sincerely

Wendy Fox-Turnbull

Phone: 3458124, Mobile:027 4319058

Name: CXX XXX /FXX XXX

XXXX School

I consent to my being interviewed as a part of this study. I understand that there will be four interviews of no longer than 15 minutes. The interviews will be of a semi-structured format and will be recorded for accuracy purposes. I understand that confidentiality and anonymity will be maintained throughout the study. I also understand that interview transcripts will be completed and given to me to check interpretation, accuracy and understanding and that I am able to withdraw any data at anytime.

Signed: ______________________________ Date: __________________

Appendix 13: Semi-structured Interview Schedules

One: Semi-formal interview of teachers together before Rounds One and Two *(Meeting Objectives 1-4)*

1.1 *What experiences had you had to date teaching technology education?*

1.2 *What is your understanding of technology education?*

1.3 *What is your understanding of technological practice?*

1.4 *What is your understanding of classroom conversation?*

1.5 *When you have a conversation with a child or children about his/her/their learning what you do consider as the main reasons for having the conversation?*

1.6 *When you have a conversation with a child or children tell me about the strategies you find valuable to maximise the purpose of the conversation?*

Two: Semi Structure Interviews with Children Prior to Observation and Recorded Learning in Technology

2.1 Tell me about what you know about learning in technology

2.2 How do you know this?

2.3 Tell me what you remember about the technology you have learnt at school so far

2.4 When doing technology at school what things help you the most?

2.5 When doing technology at school what are things that your teacher does

2.6 That is most useful to your learning?

2.7 What is the best thing about technology? Why?

2.8 What do you look forward to most when do technology?

Three: Semi Structure Interviews with Children During participation in Units One and Two

3.1 Tell me about your design?

3.2 Why have you designed it this way? (Year 2 and 4)

3.3 How does this meet the things that were explained in the technology brief? (Year 6 only)

3.4 If you could start again what changes would you make?

3.5 What has helped you decide which changes you could make?

Four: First Interviews with Year 2 Children Prior to Round Two Teaching

Room Four, Monday 18 August 2008

4.1 Introduction of myself, establish a relaxed atmosphere

4.2 Tell me about yourself

4.3 Tell me about your favourite toy.

4.4 Last term at school you learned about futuristic cars. What was the best thing about designing and making futuristic cars?

4.5 What is the hardest thing about designing and making futuristic cars?

4.6 When you were learning about futuristic cars what helped you learn?

4.7 What do you think that is technology, why?

4.8 Did talking to your teacher help?

4.9 How did talking to your friends help?

4.10 When doing technology, who else do you think it might be good to talk to? Why is that?

4.11 In technology this term you are going to be learning about how to design and make props (extra things in stage) for the school production. You are going to be working with two other children in a group. What do you think you will need to think about when you are working with your friends on this project?

4.12 Why is that?

Five: First Interviews with Year 6 Children Prior to Round Two Teaching

Room 16, Week of 25 August

5.1 Introduction of myself, establish a relaxed atmosphere

5.2 Tell me about yourself.

5.3 Tell me about your favourite electronic game.

5.4 Last term at school you learned about space stations. What was the most surprising thing you learned about designing and making space stations?

5.5 What is the hardest thing about designing and making your space station?

5.6 When designing your space station you first wrote a design brief. What is a design brief and how did it help you when making you space station?

5.7 When you were learning about space stations what helped you learn?

5.8 What do you think is technology, why?

5.9 Did talking to your teacher help?

5.10 How did talking to your group members help?

5.10 When doing technology, who else do you think it might be good to talk to? Why is that?

5.11 In technology this term you are going to be learning about how to design and make props (extra things in stage) for your class item in the school production. You are going to be working with two other children in a group. What do you think you will need to think about when you are working with your friends on this project?

5.12 Why is that?

Six: Children After Participation in Rounds One and Two

6.1 Tell me about your learning technology this year

6.2 How do you know this?

6.3 When doing technology at school this year what things help you the most?

6.4 When doing technology at school this what are the things that your teacher did that helped you learn the most?

6.5 When you were working in technology what things made you change your mind and do something different?

Seven: Children with their photos of their Technological Practice

Year Two Children Individually

Here are your photos.

7.1 Tell be about each photo and why you took it?

Other informal questions asked as chn identify points in their photos

7.2 Having looked at the photos and knowing that we have done technology two units this year 7.3 what do you think technology is?

7.4 Why do you think that?

7.5 What are the steps you go through when doing technology?

7.6 What helped you do technology?

Year Two Children altogether

7.7 What is the best things about doing technology?

7.8 What helped you the most when doing technology?

7.9 How did working in a group help you do technology?

Year Six Children Individually

Here are your photos.

7.10 Tell be about what you are doing in each photo and why you took it?

Other informal questions asked as chn identify points in their photos

7.11 Having looked at the photos and knowing that we have done technology two units this year what do you think technology is?

7.12 Why do you think that?

7.13 What are the steps you go through when doing technological practice?

7.14 What part did writing a brief play in your technological practice?

7.15 How did talking to other people help you learn?

7.16 Who were they and why did it help you?

7.17 What else helped you do technology?

Year Six Children altogether

7.18 What is the best things about doing technology?

7.19 How did working in a group help you do technology?

7.20 Why was that?

Eight: Semi- Structured Interview Schedule with Teachers 11 Weeks after Technology Study Completion

Tuesday 2 December 2008

8.1 What was the most successful aspect of the technology units taught as a part of this study?

8.2 What most impacted on the students' learning at the time of the study?

8.3 What learning has endured since the conclusion of the units?

8.4 Describe your students' attitude towards technology education before the study? After the study?

8.5 Why do you think this is?

8.6 Discuss the effectiveness of teaching strategies used during the last unit

Talking partners

No Hands up

Card Shuffle

Icon Prompt

KWHL

PCQ (Pros Cons Queries) Rm 16

8.7 Describe the differences you noted in the children's abilities and attitudes to towards technology between the first and second units.

8.8 Tell me about the conversations you had with children during the units?

8.9 What were the most effective conversations?

8.10 How do you know this?

8.11 What insight did you gain from talking to the children?

8.12 What makes you think this?

8.13 In your opinion what benefit did the children gain from having conversations with you?

8.14 In your opinion what benefit did the children gain from having conversations with their peers?

Appendix 14: Technology Education Park School: Fleur XXX, Clara XXX and Wendy Fox-Turnbull

Terms 2 and 3 Planners

	Week 4 26-30 May					Week 5 2-6 June					Week 6 9-13 June					Week 7 16-20 June					Week 8 23-27 June					Week 9 30 June-4 July				
	M	T	W	T	F	M	T	W	T	F	M	T	W	T	F	M	T	W	T	F	M	T	W	T	F	M	T	W	T	F
9-10.30																														
11-12.30																														
1.30-3.00																														

	Week 5 18-22 August					Week 6 25-29 August					Week 7 1-5 September					Week 8 8-12 September					Week 9 15-19 September					Week 10 22-26 September				
	M	T	W	T	F	M	T	W	T	F	M	T	W	T	F	M	T	W	T	F	M	T	W	T	F	M	T	W	T	F
9-10.30																														
11-12.30																														
1.30-3.00																														

Room 4 Interview One 18 August

Room 16 Interview One Week 25 August

Room 4 Interview Two Week of 1 September

Room 16 Interview Two Week of 22 September

Room 2: Year 2 **Room 16 : Year 6**

Appendix 14b: Required resources and approximate costs for the study

Items	Unit Costs	Totals
Administration and correspondence costs		$ 20.00
Library inter-loan costs	50 @ $5.00	$ 250.00
Recording services NVivo software data analysis package Digital camera and associated software		Provided by UC
Professional Development for NVivo		$ 350.00
Interview transcribing services	@ $20-$25/hr	$ 350.00
Digital Dictaphones	Borrowed from UC	$ 000.00
Costs of implementing the unit. Consumable resources Non-consumable resources		$ 500.00 $ 100.00
Researcher travel 40 return trips	62c per km 12 k round trip	$ 774.00
Researcher incidental costs		$ 50.00
Meetings with Supervisors in Hamilton Travel Accommodation	10 return flights @$350 30 nights accomm. @$123.00	$ 3500.00 $ 3990.00

Appendix 15: Props Technology Unit Plan

Technology Unit Planner Estimated Time:

Topic: Prop Design Level 2/3 Year: 2008

Stimulus/ Situation:
Mrs Warren has asked the classes to present a 5 minute production based on the Olympic Games.

Technological Need or Opportunity:
In order to enhance our production we have been asked to design and create props to help in the retelling of our story.

Resources

Materials/Equipment:
DVD of Hook
Data projector
Existing Props (Court Theatre)
Card
Paper
Papier Mache glue
Newsprint
Scissors/Craft knives
Paint and other decorative materials
Hot glue guns and glue sticks

Information, Web Sites, Books / Community Resources, visits or visitors:
DVD of Hook
Court Theatre – Actors and prop department
Theatre Education Database website

Strands and Achievement Objectives:

Technological Practice — Nature of Technology — Technological Knowledge

PP	BD	OD&E	CoT	CoTO	TM	TP	TS
✓	✓	✓	✓			✓	

Tick coverage and highlight assessment. Learning in all three strands must be evident in most units.

Technological Area Learning Focus: (justify)
Information and communication: Props enhance the ability to communicate ideas about culture and era different from you won.

Big Understanding:
We learn from the celebration of difference

Key Transformations: Information
Communicating message to the audience through the use of props (era and or culture)

Unit Summary:
1. Watch Hook to recognize props used in the stage production. Think – Pair – Share.
2. Talking to an actor to find out how and why they use props and what makes a good prop. Range of props.
3. Investigate existing props, materials and structure. Fitness for purpose.
4. Props from different eras and cultures, what makes a prop specific.
5. How do props give a message – old/greedy etc.
6. Recognise and discuss stakeholders.
7. Interview stakeholders to determine their needs.
8. Identify the tasks required and the timeline.
9. Selection and Initial planning of designs.
10. In groups of three choose best design.
11. Write initial brief.
12. Plan in detail.
13. Feedback from stakeholders.
14. Teach specific skills.
15. Modify design if/where necessary.
16. Create a mock-up.
17. Final brief – annotate initial brief.
18. Create final design.
19. Evaluate final designs.

Health and Safety Considerations:

Safe use of the hot glue guns - supervise use

Safe use of scissors and knives

Safe passing of knives

Follow school procedure for any visits (Complete a Risk Management Report)
Check First Aid kit

Vocabulary: (new to children)
Props Durable
Stage Era
Stakeholders Culture
Conceptual statement
Brief
Resources
Ergonomic
Feedback
Annotate
Recognisable

Planner v 07 by Wendy Fox-Turnbull and Paul Snape UCCE 2007 adapted from planner by Fiona Haynes, Paul Rodley, Dave Sim and Wendy Turnbull 1997

Technology Learning Intentions ***The students are learning to…***	**Learning Experiences** ***The students will…….***	**Strand & AO links**	**Technological Learning Evidence**	**Technology Success Criteria for Assessment at 2-3 Key Stages** *What are we looking for in the evidence?*
Identify the technological outcome in use	1. watch Hook to recognize props used in the stage production. Think-Pair - Share.	Tech Prac PP	Write list of props and definition.	
Interview an expert to identify the characteristics that make a TO fit for purpose.	2. talk to an actor to find out how and why they use props and what makes a good prop. Range of props.	Nat of T.C.T	Use a graphic organizer to list 5 features of a good prop.	
Investigate existing TO's to identify suitable materials and features.	3. investigate existing props, materials and structure. Fitness for purpose.	Tech Know TP	Annotations of photographs of existing props.	
Research TO from different eras and cultures identifying specific links.	4. research how props portray different eras and cultures and what makes a prop specific for an era or culture.	Nat Tech CT	Draw objects from a specific culture or era	
Investigate how a specific TO can communicate a message – old/greedy etc.	5. investigate how props portray a message by considering key features that give specific messages – old/greedy etc.	Nat Tech CTO	Collage of images that communicate a culture/era.	*Define what a prop is and it's effectiveness for stage production - Easily recognisable - Durable - Era/culture specific - Safe - Ergonomically designed
Define what a stakeholder is and their influence on outcome development.	6. discuss and define stakeholders and interview stakeholders to determine their needs.	Tech Know TP	List stakeholders and their key concerns	
Identify tasks to achieve a specific technological practice.	7. identify the tasks required and complete a realistic timeline.	Tech Know TP	Timeline	**Task definition: Identify and sequence and a realistic timeframe given.
Brainstorm a range of options	8. Brainstorm props needed to communicate the messages about era or culture and storyline;	Tech Know ODE	Brainstorm of options	
Select and justify one option and sketch their ideas.	9. Select one prop to develop, justify selection and undertake initial planning of designs for the identified prop.	Tech Know ODE	Sketches	

Technology Learning Intentions ***The students are learning to…***	**Learning Experiences** ***The students will…….***	**Strand & AO links**	**Technological Learning Evidence**	**Technology Success Criteria for Assessment at 2-3 Key Stages** *What are we looking for in the evidence?*
Present ideas for TO's	10. In groups of three present design idea to group and choose best design	Tech Know ODE	Oral presentations	
Re-write conceptual statement and identify the specifications needed for the prop.	11. Write initial brief for the given prop including 5/6 specifications.	Tech Know BD	Brief	
In groups plan TO in detail taking into consideration specifications and stakeholders.	12. Plan their prop in detail.	Tech Know ODE?BD	Detailed plan	
Present ideas to stakeholders and note feedback	13. Feedback from stakeholders.	Tech Know PP	Notes	
Practice specific skill development to assist in TO development.	14. Teach specific skills (papier maché, joining, painting).	Tech Know ODE	Outcome development	Can the students papier maché correctly - Layers - Smooth finish - Small pieces of paper - Appropriate amount of glue
Evaluate and react to feedback making prop more effective.	15. Modify design if /where necessary.	Tech Know ODE	Changes made to prop	
Create a mock up for identified TO	16. Create a mock-up of selected prop.	Tech Know ODE/BD	Create a mock up	The props meet the specifications mentioned above
Add to initial brief to develop final brief	17. Final brief – annotate initial brief.	Tech Know ODE	Final brief	
Create their final design	18. Create final props and test to use on stage.	Tech Know ODE	Final design	
Undertaker outcome evaluation	19. Evaluate final props against attributes	ODE	Final Design and Attributes	

Appendix 16: Framework Tables

Funds of Knowledge

Elements / Types	Character and Function	Planning	Mock-Up	Construction
1 Student-to-student				
Interactive				
Cumulative				
Intercognitive				
Non-Interactive				
Authoritative				
Disputational				
2 Teacher-to-student				
Interactive				
Authoritative				
Modelling				
Intergrowth				
b) Non-Interactive				
Revisitational				
Authoritative				
Encouragement				

Technological Knowledge and Skills

Elements / Types	Character and Function	Planning	Mock-Up	Construction
1 Student-to-student				
Interactive				
Cumulative				
Intercognitive				
Non-Interactive				
Authoritative				
Disputational				
2 Teacher-to-student				
Interactive				
Authoritative				
Modelling				
Intergrowth				
Non-Interactive				
Revisitational				
Authoritative				
Encouragement				

Management of Learning

Elements / Types	Character and Function	Planning	Mock-Up	Construction
1 Student-to-student				
Interactive				
Cumulative				
Intercognitive				
Non- Interactive				
Authoritative				
Disputational				
2 Teacher-to-student				
Interactive				
Authoritative				
Modelling				
Intergrowth				
Non- Interactive				
Revisitational				
Authoritative				
Encouragement				

Appendix 17: Initial Codes from Recorded Conversations

Categories and Associated Coding

Conversation Category	Code
Behaviour comment teacher	Bh
Challenging child thinking	ChCgTh
Child answer to doing question	WhDo
Child asking question of child	ChChQ
Child clarifying idea with teacher	ChTCl
Child clarifying idea with child	ChChCl
Child correcting child behaviour	ChChBh
Child engagement in a specific higher thinking activity /strategy	ChHTSg
Child evidences knowledge of brief development	ChBD*
Technological Modelling	Chm
Child evidences knowledge of Planning for Practice	ChPP*
Child evidences outcome evaluation	ChOE
Child evidences use of prior experience	ChPiE
Child evidences understanding of specific technology concepts	ChTC*
Child explaining ideas to teacher	ChTI
Child explaining outcome development	ChExOD
Child making links to experts	ChEtL
Child making links to prior research	ChRL
Child reading questions or instructions	ChRQIn
Child self aware of status	ChSA
Child showing evidence of Tech Practice	ChTP
Child working collaboratively or cooperatively	Ch+Co
Child not working collaboratively or cooperatively	Ch-Co
Explicit knowledge stated by child	ChKn
Functional properties	Ch FP*
Group Conflict	GC
Links to Nature of Technology	ChNT
Links to Technological Outcome criteria	ChTO
Material properties	ChMP
Misunderstanding	MS
Planning for Practice teacher instruction	TInPP
Positive explicit comments by teacher about child's work	TCh+Cm
Private evaluation of child’s ideas or work	TChPrEv

Problem Solving	ChPlS
Resource Management	RsMt
Safety Comment	Sf
Sharing design ideas with teacher	ChTShDeI
Sharing design ideas with each peer	ChCh ShDeI
Teacher asking what the child is doing	TCh WhDo
Teacher directing what activity the chn will do	TChDi
Teacher endearment	TChEn
Teacher aiding collaboration	TAiCo
Teacher aiding confidence	TAiCn
Teacher aiding Outcome Development	TAiOD
Teacher explicit about child's achievement	TChEpAc
Teacher evidences deeper listening	TDL
Teacher Indicates to child she is open to new ideas	TChNI
Teacher Instruction	TIn
Teacher Modelling	TM
Teacher probing child	TChPb
Teacher prompting child	TChPm
Technological Products	TP
Teacher recapping child ideas	TRcI
Teacher starter question	TStQ
Teacher stating fact	TFt
Teacher teaching specific skills	TSk
Undertaking Brief Development	BD

* not yet used

Key for Conversation Analysis

Code Abbreviation	Meaning	Code Abbreviation	Meaning
Ac	Achievement	Ms	Misunderstanding
Ai	Aiding	NI	New Ideas
BD	Brief Development	NT	Nature of Technology
Bh	Behaviour	OD	Outcome Development
Cf	Conflict	OE	Outcome Evaluation
Ch	Child	Pb	Probing
Cg	Challenge	Pi	Prior
Cl	Clarification	Pl	Problem
Cm	Comment	Pm	Prompting
Cn	Confidence	PP	Planning for Practice
Co	Cooperation /collaboration	Pr	Private
De	Design	Q	Questions
Di	Directions	R	Research
DL	Deep Listening	RsMt	Resource Management
Do	Doing	Rc	Recapping
E	Experience	Sf	Safety Comment
En	Endearment	Sg	Strategy
Ev	Evaluation	Sh	Share
Ep	Explicit	Sk	Skills
Et	Expert	So	Solving
Ex	Explaining	St	Starter
FP	Functional properties	T	Teacher
Ft	Facts	TO	Technical Outcomes
Gp	Group	TP	Technological Products
HT	Higher Thinking	+	Positive
I	Ideas	-	Negative
In	Instructions		
Kn	Knowledge		
L	Links		
M	Modelling		
MP	Material properties		

Appendix 18: Analysis of Broad Categories of Autophotographs

Participant	Learning about props	Planning for Practice	Sketching and planning	Mocking up ideas	Construction	Final Prop	Understanding and evaluating tech practice	Off Task
Ja	*2*		*1*	*1*	*21*	*1*	*0*	*1*
Do	*4*		*1*	*3*	*4*	*1*	*0*	*5*
Te	*0*	*1*	*2*	*0*	*2*	*0*	*0*	*2*
Mi	*5*	*1*	*5*	*8*	*6*	*2*	*0*	*0*
Al	*3*	*1*	*2*	*2*	*16*	*0*	*0*	*0*
Ma	*1*	*1*	*1*	*2*	*10*	*2*	*0*	*0*
De	**4**	**0**	**3**	**2**	**4**	**2**	**0**	**0**
Re	**4**	**2**	**2**	**7**	**4**	**5**	**0**	**2**
Is	**2**	**0**	**5**	**7**	**4**	**3**	**0**	**1**
An	**8**	**0**	**1**	**7**	**5**	**2**	**1**	**0**
El	**2**	**0**	**3**	**5**	**6**	**3**	**0**	**1**
Ad	**10**	**0**	**2**	**4**	**1**	**0**	**0**	**0**
Totals	42	6	28	48	83	21	1	12

Key: numbers represent number of autophotographs for each child. Italics -*Year 6*; Bold -Year 2

Appendix 19: Categories, and Themes for Conversation Analysis

Categories and Associated Coding

Broad Themes	Conversation Category	Code
Management of classroom programme, behaviour and resources 1M	Behaviour comment teacher	BhCm
	Child correcting child behaviour	Ch
	Child working collaboratively or cooperatively	CCC
	Group Conflict and Child not working collaboratively or cooperatively	GpCon
	Teacher aiding collaboration	TaiCo
	Teacher aiding confidence	TAC
	Child answer to doing question	ADQ
	Child self aware of status	CSA
	Safety Comment	Sfty
	Resource Management	RM
	Teacher asking what the child is doing	TQD
Management of Learning 2ML	Teacher Instruction	TI
	Child reading questions or instructions	CRQ
	Teacher directing what activity the chn will do	TD
	Planning for Practice teacher instruction	PPTI
	Teacher starter question	TSQ
	Teacher recapping child ideas	TRc
	Teacher explicit about child's achievement and Positive explicit comments by teacher about child's work	T+C
	Teacher prompting child	TPC
	Private evaluation of child's ideas or work	PEC
Thinking Challenged 3TC	Child engagement in a specific higher thinking activity /strategy	CHL
	Challenging child thinking	CgTh
	Teacher probing child	TPbC
	Child explaining ideas to teacher	CExT
	Problem Solving	PS
	Child asking question of child	CQC
	Child clarifying idea with teacher	CClT
	Child clarifying idea with child	CClC
	Teacher evidences deeper listening	TDL
	Teacher Indicates to child she is open to new ideas	TOI
Using Prior Learning 4PL	Child making links to experts	CLX
	Child making links to prior research	CLR
	Child evidences use of prior experience	CEdPL
Technological Practice: concepts, skills and knowledge 5TP	Child evidences knowledge of brief development	CEdK
	Child evidences Technological Modelling	CEdTM
	Child evidences knowledge of Planning for Practice	CEdPP
	Undertaking Brief Development	UBD
	Links to Technological Outcome criteria	LTO
	Child evidences outcome evaluation	CEdOE

	Explicit knowledge stated by child	EpC
	Teacher aiding Outcome Development	TAiOD
	Child evidences understanding of specific technology concepts	CEd
	Child showing evidence of Tech Practice	CEdTP
	Sharing design ideas with teacher	Sh De T
	Child explaining outcome development	C EpOD
	Sharing design ideas with each peer	C EpC
Technological Outcomes 6TO	Technological Products	TP
	Material properties	MP
	Functional properties	FP
	Links to Nature of Technology	LNT
Direct Teaching 7DT	Teacher stating fact	TStFt
	Teacher teaching specific skills	TtSk
	Teacher Modelling	TM

Key

Code Abbreviation	Meaning	Code Abbreviation	Meaning
Ac	Achievement	NI	New Ideas
Ai	Aiding	NT	Nature of Technology
BD	Brief Development	OD	Outcome Development
Bh	Behaviour	OE	Outcome Evaluation
Cf	Conflict	Pb	Probing
Ch	Child	Pi	Prior
Cg	Challenge	Pl	Problem
Cl	Clarification	Pm	Prompting
Cm	Comment	PP	Planning for Practice
Cn	Confidence	Pr	Private
Co	Cooperation /collaboration	Q	Questions
De	Design	R	Research
Di	Directions	RsMt	Resource Management
DL	Deep Listening	Rc	Recapping
Do	Doing	Sf	Safety Comment
E	Experience	Sg	Strategy
Ed	Evidences	Sh	Share
En	Endearment	Sk	Skills
Ev	Evaluation	So	Solving
Ep	Explicit	St	Starter
Et	Expert	T	Teacher
Ex	Explaining	t	teaching
FP	Functional properties	TO	Technical Outcomes
Ft	Facts	TC	Technology Concepts
Gp	Group	TP	Technological Products
HT	Higher Thinking	U	Undertaking
I	Ideas		
In	Instructions		
Kn	Knowledge	+	Positive
L	Links	-	Negative
M	Modelling		
Ms	Misunderstanding		
MP	Material properties		

Appendix 20: Strategies Implemented to Facilitate Learning

Strategy 1: No Hands Up

1. Typically in the primary classroom teachers begin a session with a quick recall of prior learning with a question and answer session with the same few students responding to the questions.

2. Teachers usually have a correct answer in mind and continue until the correct answer is obtained. Clarke found that even when an open question is asked the students stop thinking as soon as the first hands go up.

3. Many students experience this so often that they eventually stop even thinking about the answer because of the constant interruption and the development of the belief that they are less able than their peers.

4. In 'No Hands Up' students move towards a solution for the problems mentioned above. All students are asked questions as before, but they are told that anyone may be called on to answer the question.

5. To avoid the 'I don't know' answer, teachers are best to avoid recall questions and aim to ask open questions or questions about students' opinions or feelings, which avoid the right or wrong scenario (Clarke, 2005b).

Strategy 2: Talking Partners

Organisation and training of talking partners is essential regardless of age.

1. With all types of questions an effective way for students to respond is to ask the students to talk to a talking partner for 30 seconds to one minute.

2. The answers are then gathered from pairs using 'no hands up' with one pair being the spokesperson each time, with the emphasis being on a pair response rather than an individual response.

3. This strategy allows students to think, to articulate and therefore extend their learning and enable shy less confident students to have a voice and confident students have to learn to listen.

4. Talking partner can be modified into “Snowballing” when one pair joins another to form fours and take turn explaining their ideas to each other. Fours can then become eights and so on (Clarke, 2005a).

Strategy 3: Silent Card Shuffle* Apply (Application)

A co-operative strategy for learning that involves sequencing, classifying, matching, mapping or positioning. Produce a set of 10-30 cards containing relevant words or numbers on the topic to be addressed. Some cards can be duplicated and all cards used to add extra challenge to the activity (I.T.C. Publications, 2005).

1. Students are given a set of cards to sequence or classify and are told to silently organise the cards.
2. Children justify and define layout, modifications may be made.
3. Circulate, observe and discuss other groups but must not touch or rearrange other groups’ cards. Each group may leave an explainer behind
4. Return and refine at their home group based on what they have observed and discussed.
5. Teacher debriefing. The value in this strategy is not getting the answers “right” but rather the discussion that occurs during the process (I.T.C. Publications, 2005).

Strategy 4: Icon Prompt Analyse (Analysis)

Icon Prompt is used to engage students in debatable topics and allows them to see issues from a variety of perspectives. A different icon is used for each perspective. The children are given an icon and need to take that particular point of view in any debate undertaken.

☺	Who stands to gain or benefit? Who is happy about the current situation?
☹	Who stands to lose? Who is unhappy with the present situation?
$	What are the money aspects of the issue? Who will pay? How much will it cost?
?	What are the unasked/unanswered questions? Are there any other issues linked to this topic/ situation?

- How does this affect me? How does this link to what I already know? (I.T.C. Publications, 2005)

Strategy 5: PCQ

Pros	Cons	Questions
List all the benefits, strengths, plusses, advantages of an idea from as many points of view as possible.	List all the negative aspects, contra ideas, disadvantages, weaknesses of an idea from as many points of view as possible.	Offers an opportunity to ask questions, curiosity, probing and 'what ifs'. 'I wonder…' 'What if…' or 'It would be interesting to know…'

Strategy 6: Agree/ Disagree

Teachers make a statement about the context or topic of study. Students determine whether they agree or disagree with the statement and then justify why they say that (I.T.C. Publications, 2005).