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4. LEARNING IN TECHNOLOGY

INTRODUCTION

Technology Education never ceases to excite and amaze me as the possibilities for engaging students in authentic ways using 21st Century learning strategies are endless. Not only does it teach students to appraise technology and creatively and innovatively design technological solutions, it offers truly genuine reasons for engaging students in learning in every other curriculum area. What better reason to learn to write a report than to report to the local council why a playground should be redesigned or built, or to undertake a statistical analysis than having to find out which flavours are the most popular in healthy snack food? In this chapter I begin with a 'macro' approach investigating broad theories relevant to learning in technology education then discuss each with application to the technology classroom with implications for teachers and students considered through the identification and progression of learning.

The mixture of practical skills and knowledge and culturally situated learning makes technology unique in the school curriculum. Constructivism, cognitive apprenticeship, and sociocultural learning theory are particularly relevant to technology because they site learning with the learner and promote interaction with people and the environment. Cognitive apprenticeship theory acknowledges the role of a more experienced other, while sociocultural theory acknowledges the role that culturally situated tools (technologies including written language) play in learning. Understanding how students use tools and the expertise of others to construct knowledge and understanding about technology is a critical component to understanding the nature of technology education.

Conversation and dialogue have long been attributed successful to learning. This chapter also explores how dialogue can be used to further thinking and learning. 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). At present, we are hearing much about 21st Century Learning and Guided Inquiry. This chapter also explores these approaches and what the currently changing nature of education means for technology.

Focus in the latter part of the chapter shifts more specifically to teaching quality technology education and how to enhance students' learning by embracing current teaching methods and exploring new concepts and ideas. It also discusses how

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technology can be incorporated into programmes of learning to maximise and advance learning for students. Some elements required for successful planning and implementation of technology are discussed and illustrated. These include learning intentions, formative assessment and progression and their applications to technology education.

RELEVANT LEARNING THEORY TO TECHNOLOGY EDUCATION WITH ASSOCIATED IMPLICATIONS

Sociocultural learning theory

Sociocultural Learning Theory enables the exploration of tools and dialogue and their place in learning. "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). Identification of and using individual's funds of knowledge (González, Moll, & Amanti, 2005), cultural knowledges and ways of doing and knowing from home and community also contribute significantly to learning especially in technology education.

Child development in a sociocultural way of thinking is related to the ways of doing things within the communities in which they develop (Rogoff, 1990). Smith (1998, p. 21) and Rogoff (1990) suggest 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. This theory has a focus on the role adults and more capable peers play in learning, with an emphasis on peer group interactions and collaborative learning (Daniels, 1996a; Richardson, 1998). Child development occurs through everyday participation in society and reflects the relationship between the child and its community. To understand how individuals learn and develop through participation in the world, it is necessary to understand that meaning is more than a construction within an individual (Rogoff, 1998, cited in Fleer, et al., 2006, p. 31). Learning is related to cultural practices and circumstances of the communities in which they develop (Hedegaard, 2004 cited in Fleer, et al., 2006; Rogoff, 1990). Child development is related to cultural practices and circumstances of the communities in which they develop (Rogoff, 1990), and occurs as the learner interacts with the community in which they live (Fleer, et al., 2006; Rogoff, 1990). Smith (1998, p. 21) suggests that children gradually come to know and understand the world through participation in their own activities and in communication with others. Wertsch (1998) argues that virtually all human action is socioculturally placed, even when the individual is alone because the things they do and use are products of a social community.

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 a slow growing understanding of practices and actions that occur where and when people live and work together. Let us imagine it this way. Any change in a child's development appears twice or on two levels, first in the social plane (intermental)- copying without understanding and then psychological plane (intramental functioning)- doing with understanding (Murphy & Hall, 2008; Rogoff & Lave, 1999; Wertsch, 1981; Wertsch, Minick, & Arns, 1999). New knowledge and skills first appear between the child and another person on the social plane and then as they develop understanding, within the child on the psychological plane. The movement from the social plane to the psychological plane is called internalisation. (Daniels, 1996b; Vygotsky, 1978; Wertsch, 1981). An example of these two planes follows.

> Imagine a toddler participating in teeth brushing after eating or before bed. This cultural 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. This social behaviour is occurring at a social (intermental) level of functioning without understanding. When the child understands why she/he is cleaning her/his teeth the child is said to be operating at a psychological (intramental) level of functioning. Learning actually occurs only when the child moves from the first level of functioning to another (Fleer, 1995).

Sociocultural theory also considers the role of action and tools or artefacts in the construction of knowledge (Wertsch, 1998). Given that child cognitive development is dependent upon an individual child's responses to cultural and societal influences, with sociocultural theory it is important to understand the relationships between doing and thinking, and the cultural, institutional, and historical context in which it occurs (Resnick, Levine, & Teasley, 1991; Wertsch, 1998; Wertsch, Del Rio, & Alverez, 1995).

Action, even when carried out by the individuals acting in isolation, is social because it incorporates socially evolved cultural tools The term cultural tools is used very broadly to include: all cooperatively and socially organised systems such as number systems, language and writing systems as well as technological tools and devices. (Richardson, 1998). Action and activity are a social undertaking and there are two ways it occurs. The first is that an action may involve social activity with one or more people. The other is that activity is culturally situated; with 'ways of doing' determined by the social context with actions carried out on the social and individual levels. The underlying assumptions are that we have access to the world indirectly through our tools (remember this includes language and number systems) rather than directly. External tools enable action and allow the understanding of a particular action (Zinchenko, 1985). In reality action and cultural tools 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 (Wertsch, et al., 1995).

CONSTRUCTIVISM- SOCIALLY CONSTRUCTED LEARNING

Constructivists believe that knowledge does not come from a subject or an object rather that people construct their own understandings of the world in which they live. The theory of constructivism suggests that individuals develop understanding within a current framework of knowledge that they already have and can understand. This framework is built up, tested and altered as new learning occurs (Hennessy & Murphy 1999; Hill & Smith 1998). The construction of knowledge occurs through interaction with the environment (Hennessy, 1993; Maddux & Cummings, 1999; Rogoff, 1990; Vygotsky, 1978; Zuga, 1992), with problem solving an essential part of this process. Individuals develop knowledge structures in the memory (schemas) (McCormick, 1997) through experience and instruction that is within the intellectual potential of the students (Zone of Proximal Development- ZPD). In other words, students learn by doing, both independently and guided but only when it is within their intellectual grasp. For example it is unlikely that a five year old could learn and understand multiplication of two, three digit numbers no matter how well structured and child centred the learning was, because the required concepts are well beyond his or her ZPD. It is however reasonable to expect that the same five year old might learn to count to 20. Let us look at the ZPD further.

Zone of Proximal Development (ZPD)

The difference between a child's actual level of cognitive function and development and their potential Vygotsky called 'Zone of Proximal Development' (ZPD) (Vygotsky, 1978). Richardson(1998) defines the ZPD 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) first used the term to describe the difference between the level at which a child can work independently and their potential. It is the child's potential rather than their actual level that is considered (Fleer, 1995; Fleer, et al., 2006). The ZPD can be thought of as the region of activity that learners can navigate with help.

Vygotsky encouraged us to rethink social development to include the socio and cultural context in which a person lives. To understand an individual we must understand their social relationships (Fleer, et al., 2006; Wertsch, 1998) as cognitive development and instruction are socially embedded and we need to study and analyse the surrounding society and culture. Vygotsky provided the concept of ZPD in which a child's development proceeds through their participation in activities slightly beyond their competence, but within their ZPD and with assistance from adults or more skilled children (Richardson, 1998; Vygotsky, 1978; Wertsch, 1998).

Learning Activities within classrooms should be within the ZPD for all students. With support from adults, children will be able to work above their actual level. For this to happen teachers must know their children and plan purposeful activities (Fleer, 1995). A ZPD can include people, adults and children with various degrees of expertise, books, videos, wall displays, scientific and mathematical equipment and information and communication technologies intended to support learning (A. Brown et al., 1993). To work with the ZPD in the classroom implies that the teacher is aware of the developmental stages of the children and is able to make qualitative changes in teaching towards a certain goal (Daniels, 1996b; De Vies & Kohlberg, 1990). In order to stimulate and develop the child's curiosity and thinking, adults need to interact with the child at their potential level not at their actual level (Fleer, 1995). There are a number of strategies and approaches that enable teachers to plan and implement a constructivist classroom. These include scaffolding, co-construction, participatory appropriation, guided participation, and apprenticeship.

Scaffolding

The concept of scaffolding originated from Wood, Brunner and Ross (1976), and has been advanced by Bruner (1996). Bruner (1996) referred to the help which enables the learner to engage in the activity with increased confidence and competence as 'scaffolding'. Scaffolding is an metaphorical umbrella term used to describe all those strategies that an adult uses in order to help children's learning efforts, through supportive intervention (Greenfield, 1999; Wertsch, 1998). Scaffolding consists of selective intervention and adult modelling as they interact with children. (Fleer, 1995; Greenfield, 1999). In the early stages the adult does a great deal of modelling within the appropriate context, and in the later stages, with the gradual withdrawal of the scaffold, the learner becomes progressively independent (Fleer, 1995; Lave & Wenger, 1996). Over time, children will move from the social (intermental) level of functioning to the psychological (intramental) level of functioning, as long as the scaffolding provided by the adult is within a child's ZPD.

Co-construction

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. The term 'scaffold, although an excellent metaphor, does not however explain the process of internalisation nor the complexity of adult-child interactions nor the ways interactions can be framed by adults. Co-construction demonstrates how intersubjectivity (shared connections and understandings) occurs between an adult and a child. A powerful conceptual tool, co-construction helps us think about how adults and children interact together to support learning and is represented in Figure 1. As you can see the area of shared meaning is extended when the child and adult are equal partners in their interactions.

Participatory Appropriation

Rogoff (1990) uses the term "appropriation" as an essential learning mechanism to represent the movement from the social to psychological levels of understanding. Through shared activities the child develops the cognitive structures that are able to continue independently; this is known as appropriation (Wertsch, 1998). Appropriation is a bi-directional process meaning that learners of all ages and levels of expertise and interests seed environments with ideas and knowledge that are appropriated by learners at different stages and at different rates according to their current zones of proximal development (A. Brown, et al., 1993).

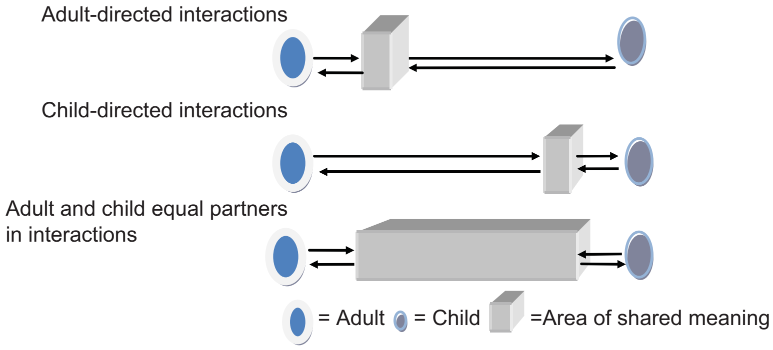

Figure 1. Jordon's Model of Co-construction.

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Guided Participation

Guided participation involves adults or children challenging, constraining, and supporting learners in the process of posing and solving problems. This occurs through the arrangements of children's activities and responsibilities and interpersonal communication while they are participating and observing at a comfortable but slightly challenging level (Rogoff, 1990). Vygotsky observed that interaction with children in the home is well above what the child is able to understand. Given this, he stated that child and teacher interaction should be at the level of the child's potential and not at their current level (Fleer, 1995). Guided participation involves children and teachers in a collaborative process of building bridges from a children's present understanding and skills to reach new understandings and skills and by arranging and structuring children's participation in activities with dynamic increasing of their input and responsibility. In the concept of guided participation, both guidance and participation in culturally valued activities is essential to children's development of thinking. Learning may be tacit (not obvious) or explicit and vary in the extent to which children and teachers are responsible for its arrangement (Rogoff, 1990).

Apprenticeship

The apprenticeship model of learning involves the successful modelling of expert practice. The notion of apprenticeship is that the learner is initially in a position where observation of an expert is extensive, over time the learner does more and more while the support of the expert is slowly withdrawn. The aim is to give the learners control over their own learning and to engage them in critical analysis. The expert begins by modelling effective strategies or making explicit their tacit knowledge. The critical factor is for the provision of authentic dilemmas which may be real or imaginary (Lave, 1992).

> Ideally, in a community of learners, teachers and students serve as role models not only as "owners" of some aspects of domain knowledge, but also as acquires, users, and extenders of knowledge in the sustained, ongoing process of understanding. Children are *apprentice learners*, learning how to think and reason in a variety of domains. By participating in the practices of learning, they should be enculturated into the community of learners during their 12 or more years of apprenticeship in school settings.(A. Brown, et al., 1993, p. 190).

Situated Learning

Constructivist learning leads naturally to the idea that learning is most successful when situated within an authentic culture, context or practice. The theories of Enculturation, Situation Cognition and Cognitive Apprenticeship explore these ideas further.

Enculturation

Another approach to developing a constructivist classroom is to consider the authentic use of tools and activity by practitioners. Brown et al (1989) and Lave (1996) state that activity, concept and culture are all interdependent and learning must involve all three. In the past students were too often asked to use a tool in isolation, having little idea of the culture of the practice. The culture of a practice will determine the way a practitioner uses a tool. To learn to use a tool as a practitioner does, a student, like an apprentice, must enter the community and its culture Successful learning becomes a process of enculturation (J. Brown, et al., 1989; Rogoff, 1990).

Brown, Collins and Duguid (1989) identify a difference between much present school activity and authentic activity. They believe learning should be a process of enculturation. Much school activity is very different from the activity of practitioners. "When authentic activities are transferred to the classroom, their context is inevitably changed; they become classroom tasks and part of the school culture. Consequently, contrary to the aim of schooling, success within this culture often has little bearing on performance elsewhere" (p. 34).

Situated Cognition and Cognitive Apprenticeship

Situated cognition (Hennessy, 1993) identifies knowledge not as static 'furniture of the mind' but as situated in activity. This means that knowledge or ways of knowing are connected to cultural artefacts or situations, including tools and people (A. Brown, et al., 1993). Hennessy's theory of situated learning (1993) investigates the difference between classroom learning and cognitive practice. "Learning is most successful when embedded in authentic and meaningful activity, making deliberate use of physical and social contexts" (Hennessy, 1993, p. 15). Situated cognition encompasses thinking as a part of a culturally organised activity carried out within a community of practitioners including communities (A. Brown, et al., 1993; Rogoff, 1990). Implications for the classroom are that learning is most successful when students are engaged authentic with activity that reflects their "real current or possible future world" (A. Brown, et al., 1993; Fox-Turnbull, 2003; Lave, 1998; Turnbull, 2002). Lewis (1999) suggests a distinct advantage of the model of Situated Cognition is that it is a useful model for integration of the curriculum.

Johnson (1992) compares cognitive apprenticeship with traditional apprenticeship. "Cognitive apprenticeship uses many of the instructional strategies of traditional apprenticeship but emphasises cognitive skills rather than the physical skills. Traditional apprenticeship contains three primary components: modelling, coaching and fading" (Johnson, 1992, p. 4). Johnson states that one of the strengths of apprenticeship is the importance of real activities performed by the expert and copied by the learner. Cognitive apprenticeship uses these same strategies but during the coaching stage the expert shows the students how to complete the tasks or solve the problem while verbalising the activity. In contrast to many current school models the instruction occurs within a real context. The student learns about the complexity of the expert's thinking, that they make many mistakes and take many changes of direction in their thinking during the problem solving process (Johnson, 1992; Rogoff, 1990).

The theories discussed above highlight the issue of the disjunction between traditional classroom learning and cognition in practice. It is fundamentally important for teachers to understand the acquisition of knowledge and investigate the difference between the knowledge of novices and that of experts.

Sociocultural Conflict Theory

The basic tenant of sociocultural conflict theory is that discrepancy or conflict best sparks cognitive development. A subset of sociocultural theory, sociocultural 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 when coming up against an alternative point of view (not necessarily the correct one) in the course of joint problem solving the child is forced to coordinate his or her own viewpoint with that of another child. 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) coordination to facilitate inner coordination. 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 mental restructuring that follows 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 considers people's use of cultural tools to make sense of the world and develop cognitively. Constructivist Theory states that people construct their own knowledge as they interact with their social and cultural worlds. The use of culturally situated tools including technological artefacts and language and the use of experts are key factors making these theories particularly relevant to technology education. The literature indicates that interaction with peers and adults, the use of language and solving differences through dialogue is a critical part of the learning.

FUNDS OF KNOWLEDGE

One method of enhancing connection between teachers and students is for teachers to understand and use the cultural community and background of their students and to make use of the many and varied cultural contexts for learning that exist within most classrooms. Gonzalez, Moll and Amanti's (González, et al., 2005) work on funds of knowledge focuses on this. The theory of Funds of Knowledge draws on the perspective that learning is a social process bound within a wider social context. People have knowledge gained through their life experiences. The knowledges that students come to school with can enhance their learning and facilitate useful interactions between knowledge found inside and outside the classroom (González, 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 and 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" (González, et al., 2005, p. 20).

Considering the importance of culturally contextualised learning, it makes sense that the experiences children have in their homes and communities will impact on their interactions in the classroom and their abilities to make sense of engagement with tools and artefacts to which they are exposed. Acknowledging, understanding and using children's home and community experiences (González, et al., 2005) can advance students' understanding of the lessons being taught.

Lopez (2010) suggests that "it is the responsibility of each teacher to attempt to learn something special about each child they teach" (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 to ensure appropriate functioning 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).

Teachers need to maximise the use of interaction and integration to ensure a high level of engagement from a full range of children in any class, each of whom have funds of knowledge to draw from. Gonzalez, Moll and Amanti (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 thus facilitating authentic integration of learning. Moje et al. (2004) and Kuthlthau, Maniotes & Caspari (2007) call this integration of knowledges construction of the "third space" as it merges knowledges 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".

Implications for Technology

Technology is culturally and socially situated both in development and in use, although some argue that this is not true, technology is ubiquitous. Mobile phones are the same in Malawi, Mumbai and Manchester. I agree they may be, but are they used in the same manner and for the same reasons? A few years ago, we had a sixteen year old American Field Scholar (AFS) from a small town in Wisconsin, USA, living with us. When she arrived she had no mobile phone, neither did any of her friends back home. We were surprised! She was surprised that most teenagers at her new school had mobile phones as where she was from text messaging was very expensive and mobile phones were only used for calling. It didn't take her long to 'enculturate' into the New Zealand teenage mobile scene with mobiles readily available and texting done frequently. My point is that the ways technologies are engaged with are dependent on a range of factors including availability, cultural practices, and political and economical influences.

Fleer and Jane (1999) argue that technology emerges from within a social context and does not occur in isolation. Constructed within a particular culture, technology takes into consideration the social and cultural needs of the society in which it was developed (Fleer & Jane, 1999; Siraj-Blatchford, 1997) and the moral and ethical values of the technologist. I term this 'best fit technology'. Successful technologies within a culture are not necessarily the more sophisticated or complex, nor are they the most and or least expensive. It is what is most appropriate for that specific person or group of people who are situated within a specific culture (Fleer & Jane, 1999). Take for example electricity development in New Zealand. We have a nuclear free policy and therefore electricity-generating technologies reflect this value and include hydro, wind and tidal generating technologies among others. Technological solutions developed within the context of the community in which needs arise, using local skills, resources and existing technologies are likely to be the most successful (Ministry of Education, 1995). This is not to say that engineers from other places are not interested in and capable of developing such technologies. What I am suggesting is that for engineers living in New Zealand, the motivation is higher to develop nuclear free power generating technologies than nuclear technologies.

It is the practical nature of technology education that aligns it with sociocultural and constructivist learning principles because it is fundamentally about the place and role of technological outcomes in society. People within a community draw on a range of sources of knowledge, to make sense of and manipulate their world to their advantage. When given authentic opportunities to make a difference in their world, students are more likely to become motivated learners. Let me give you an example from my own research. In the process of trying to establish the impact of authentic context on student learning I gave students a task of planning an aid to assist a person with only one arm to do a simple task. Subsequently I embedded the same task within authentic technology practice. Prior to developing their final outcome students completed a number of research and up-skilling activities, similar to that of a technologist undertaking the same practice would do. I also assisted the students to see that the task required of them was a task that sat within the cultural practices of their society. I did this in two ways. The first was in the form of a recorded interview with a young man, Vernon, who lost his arm in a shark attack. In the video, he discussed his accident and the challenges it had brought. He stated his greatest challenge was wanting to do tasks for himself and not having to rely on other people. The second activity was an investigation of aids currently on the market for people with disabilities. Through engagement in the activities, the students realised that their task was relevant to their world and culture. The students redid the original design task with significantly increased success and they were highly engaged and motivated. Many students asked me if I thought Vernon would be able to use or like their aids. One child proudly informed that hers was going to her aunty who had lost her arm to cancer (Fox-Turnbull, 2003).

When undertaking technology practice, Funds of Knowledge assist students to position themselves as an expert and to gain respect or 'mana' (a New Zealand Māori term used to describe a person who has status and respect in their community) from their peers. This was illustrated in a recent study of three 10 year old children who discussed suitable materials for the construction of their project- a microphone prop for a school concert item. One child, Alan, mentioned his dad was a racing car designer and had a workshop at home and would therefore have supplies of materials they could have used for construction. Dougal chipped into the conversation in a competitive manner explaining that his dad had much more than blocks of wood because he worked in the construction industry. "My dad owns a whole yard of everything. He's got like, heaps of stuff. 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." Understanding potential construction materials is a significant aspect to planning technological outcomes. Although not a confident child Dougal was able to contribute to his group by drawing on his Funds of Knowledge associated with his father's occupation (Fox-Turnbull, 2012).

The Sociocultural and Funds of Knowledge theories are particularly relevant to technology education because of the significance placed on interaction with culturally situated tools. Much technology is socioculturally situated and value laden. This is not to say that technologies are unique and or limited to single countries or cultures, however the success of a particular technology will be determined by whether it is of value to a broad range of stakeholders and consumers, and supported by the necessary education and infrastructure.

LEARNING THROUGH INTERACTION

Adults and/or more capable peers play an important part in learning with an emphasis on peer group interactions and collaborative learning (Daniels, 1996a; Richardson, 1998). Smith (1998, p. 21) suggests children gradually come to know and understand the world through participation in their own activities and in communication with others.

Interaction theory focuses on the oral interaction between two people in which both are contributing. There is ample indication of the advantages interaction offers to learning and cognitive development. 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). Social interaction is significant in shaping children's cognitive development through the social and psychological processes of learning, development, and intellectual endeavour.

Two opposing tendencies or forces characterise social interaction. These are 'Intersubjectivity' and 'Alterity'. Intersubjectivity is the dialogue between the novice and the expert who combine working towards a shared definition of a situation and to move the novice to a state in which a task can be carried out independently (Daniels, 1996a, p. 119). It also concerns the degree to which individuals share their perspective, and 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 or how people understand the utterances of others. During social interaction the relative importance of intersubjectivity and alterity may vary but both are at work; the challenge is to 'live in the middle' (Daniels, 1996a). A Vygotskian perspective suggests mental action focuses on intersubjectivity with the expert guiding the novice from the social level - doing without understanding, to the psychological level - 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 of what is said and simultaneously takes an active response to it, either agreeing or disagreeing, partially or completely. Listeners adopt a responsive attitude for the entire duration of the conversation (Bakhtin, 1986). Any understanding of live speech is inherently responsive in varying degrees and is imbued with response, elicited in one form or another.

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. There is a need, therefore, 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 learning is embedded in the context of social relationships and sociocultural tools and practices. Children, as apprentices in thinking require the following important considerations:

- an active role in making use of social guidance
- the importance of routine arrangements of activities
- participation in skilled cultural activities that are not conceived as instructional
- shared understanding with their experts of both the goals of learning and the means by which they are achieved, through explanation, discussion, provision

of expert's models, joint participation, active observation, and arrangement of children's roles (Rogoff, 1990).

There are many ways of interacting with children. Interactions are bound by context and are specific to the immediate situation (Fleer, 1995). Fleer found that often children are not given time to think about what they are doing in relation to a wider context or previous learning and experiences. Skilfully constructed dialogue is one method used to improve interaction with students.

Dialogue

Dialogue is much more than talk, because it must involve relating to others. It is complex and dynamic and often involves very different cultures, perspectives, ideas and people. Dialogue 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 that can be highly exhilarating and powerful.

It is argued that teachers need to engage in quality dialogue with students and their parents to help students make sense both cognitively and experientially of the world in which they live and work (Mercer & Littleton, 2007; Shields & Edwards, 2005). Engagement 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. It requires that people be treated with 'total respect' (Sharrat, 1991, cited Shields & Edwards, 2005). 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" (Mercer & Littleton, 2007, p. 57). When people work together in problem solving situations they do much more than just talk together, they 'inter-think' by combining shared understandings, 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 are an important part of life and one that has long been ignored or actively discouraged in schools (Mercer & Littleton, 2007).

Teachers make a powerful contribution to the way children think and talk and they convey powerful messages about thinking by the way they structure classroom activity and talk to the children. To increase children's ability to use language as a tool for thinking they need to be involved in 'thoughtful and reasoned dialogue' (Mercer & Littleton, 2007, p. 56). Teachers should scaffold useful language strategies to extend their students' thinking and dialogue with adults and peers. Bakhtin (1981) termed this 'dialogic teaching'. When given 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. They are also able to use language to compare, debate and reconcile questions, taking their learning beyond a level that requires only answers to teachers' factual questions. 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 shared experiences from their individual perspectives. The goals of co-generative dialogue are to find common areas of agreement and understanding. Students are then empowered to use learning experiences from one situation to be transported and made meaningful in another situation. This is known as knowledge transfer or transportability. It 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.

Mercer and Littleton suggest that many children are not taught useful ways of using spoken language as a tool for learning and working collaboratively. To improve this, teachers need to engage children taking into consideration their special interests and temperaments (Fleer, 1995) and the knowledge they bring from their home and cultural backgrounds (González, et al., 2005).

Grounding

For two people to communicate both participants need to contribute to the conversation based on a 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 is said. They also suggest that grounding, a basic component of communication, is shaped by two main factors: the *purpose* of the conversation and the *medium* (e.g. face-to-face, email or telephone) in which it is undertaken. For students to understand and react to any phrase they must share common understanding of the context of the conversation and the role of the participants, before a share meaning can be determined. For example, the simple phrase "can you do that" has multiple meanings, which depend on context, the roles of those engaged, and intonation. It may mean a simple question- can you do that?, a statement of amazement-, which could be affirming or insulting- can **you** do that!, or can you **do** that!, a request **- can** you do that?, or a demand- can you do that! So what then are the implications for technology?

Interaction and Technology Education

The collaborative nature of technology education makes quality interaction between teachers and students and amongst students critical. Quality dialogue is one way of ensuring this. It is dependent on the ability of participants to reason, challenge, and be challenged. Dialogue has the power to enhance students' experience of and achievement in technology. Theory presented in the previous section that conversation and critical dialogue play important roles in learning (Mercer & Littleton, 2007; Shields & Edwards, 2005). Ideally technological practice is a collaborative activity, with designers and developers collaborating amongst themselves and with stakeholders. Dialogue is an important aspect of this process. In technology, students must be taught to work collaboratively to ensure their practice is reflective of authentic practice and to ensure their process rigorous. Students need to understand that dialogue, differing opinions and compromise is a critical part of reaching a solution. This is particularly crucial when students are working collaboratively to develop a single solution. Consensus must be met. To do this successfully students need to be able to express their ideas and understand other's thinking, with teachers and other experts assisting as necessary. Sociocultural conflict theory (Doise & Mugny, 1984) suggests that disagreement and debate will enhance students' understanding. Children therefore must be taught not only how to articulate and defend their design ideas to others, but also to be open to new and alternative ideas. This was illustrated in the study referred to earlier in which a class of Year 6 students (10 year olds) in groups of three were required to develop props for their school production. As it was an Olympic Games year, the school production was about the history of the Olympic games. This class wrote and performed a five minute snapshot of the 'Olympic Games:1898–1936'. One group elected to develop a 1930s microphone prop for their item, so they could include radio commentary of relevant scenes of the Olympic era. Following some research the group of three, Minnie, Dougal and Alan (not their real names) each sketched a potential design for the group microphone. The researcher in the role of teacher (R) facilitated discussion to determine the type of microphone as she noticed that Minnie had sketched a more modern version than the boys as illustrated in Figure 2. She then facilitated a discussion to assist Minnie's clarification of the design.

R:	What type of microphone is it? Is it a microphone that is held in the hand or is it a microphone that stands up by itself?
Alan:	Stands
Minnie:	I thought it was one that we held.
Alan:	No because the old ones were on those things
Dougal:	Yeah, on the stand
Alan:	Yeah
R:	How did you know that Dougal?

Dougal: Because I just know from the learning and stuff like the Elvis Presley one
Alan: Yeah, and they're like quite square and on a stand

Figure 2. Minnie drawing her initial sketch of the microphone.

The extract above illustrates how dialogue assisted Minnie in the clarification of the microphone design and allowed the group to proceed with their design. Dialogue also facilitates the students' understanding about contraction techniques and materials. After the researcher left the conversation above, the three students continued to discuss the microphone and possible construction materials. The final microphone prop can be seen in Figure 3.

Alan: Yeah, I'm pretty sure we'll do the old style mike…
Minnie: And what should we use for that
Alan: Ohh, I thought we'd make a big block of wood or and then maybe get something, wire or something.
Dougal: Yeah, I thought wire too.
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
Dougal: But before you'd, like you'd need to do quite a few layers of tinfoil
Minnie: What colour should it be
Dougal: Yeah and so it will be silver, the tinfoil?

Figure 3. The final microphone prop constructed by the group.

It can be seen from these two extracts that the students were able to come to a consensus when allowed to discuss their ideas and understandings. Minnie's conceptual knowledge of a 1930s microphone altered significantly and all three children were able to reach an agreement about the construction materials if their microphone prop.

We can see from the section above that quality interaction, particularly dialogue is vital to all learning and particularly relevant to technology education due to the desirability of students undertaking collaborative technology practice. Recently we are seeing a move away from more traditional forms of teaching to a more collaborative, competency based curriculum. Gilbert (2005) talks about new ways of knowing, Bellanca and Brandt (2010) talk about 21 Century Skills suggesting that we rethink how students learn. The next section in this chapter explores thinking about learning in the future and discusses how technology is situated to assist the transition learning in the past to learning for and in the future.

LEARNING FOR AND IN THE FUTURE

Learning in future must look significantly different to that of the past in order to equip students for their rapidly changing lives in the information age. For this reason, we as educators face a huge challenge, including the development of skills in our students vital for 21st Century living such as: critical thinking and problem solving skills. One danger of this however, is that important ' curriculum content' knowledge will be lost (Education, 1998).

Sfard (1998) identifies acquisition and participation as two metaphors that guide learning. The first of these, acquisition, is the more traditional model of learning in which the mind is a vessel, which needs filling with knowledge and concepts much of which is content related. She suggests in recent studies learning is dominated by the participation metaphor in which students learn through interaction with material and people. Learning through participation is more likely to facilitate critical thinking and problem solving as students work collaboratively and cooperatively to advance learning through doing. Ongoing learning activities are never considered separated from the context within which they take place (1998, p.6). The participation model best exemplifies constructivist principles of learning and better aligns with skills students need. It also explains learning in technology education. We need to be aware of concerns mentioned above about specific content. In reality learning will occur though a range of approaches and certainly through both of Sfard's complementary metaphors. Inquiry learning in authentic contexts is one approach that illustrates participatory learning in technology education when taught through constructivist principles of learning.

Authentic Learning

The development of expert knowledge comes from the persistent solving of problems in relevant domains (Bereiter, 1992). Quality technology education programmes should be based on principles of authentic learning in which students develop knowledge and skills through engagement with authentic technological practice. Technology has a great potential to enable students to solve problems in authentic situations and so participating in active and reflective activities. "Technology Education is concerned with complex and interrelated problems that involve multiple variables that are technical, procedural, conceptual and social" (Hansen and Froelich, 1994, cited Jones, 1996, p. 1). Technology in the classroom should largely be a collaborative effort through the development of a single technological outcome by a number of students or as students work with stakeholders to meet their identified needs. When designers (students) engage in conversation they are able to add, challenge and engage with their own and others' ideas and perspectives. Altered design pathways and outcomes will be a natural progression of this interaction. It is the notion of learning through participation and collaborative thinking processes (Hennessy, 1993). It appears that in many school programmes especially at secondary level, students work individually on projects. I believe this should change. We need to explore ways in which students can work collaboratively, while being assessed individually. This could ensure students are participating in authentic practice, to facilitate conversations about learning while at the same time being able to assess for individual learning needs and to facilitate fair summative assessment practices especially when senior secondary school qualifications are at stake.

If students are solving problems using practices that are authentic to a specific practice within a technological field their knowledge frameworks are more likely to be stronger as they are able to make connections to real practice and need (Rogoff, 1990). The disability aid scenario is a case in point. In any community or culture where assisting people with disabilities to live independently is something that is valued, students were able to see that the task set for them is worthwhile and of value. An important message about the nature of activities that children undertake, taken from the theories of authentic learning is that authentic learning engages children 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 both real to their own lives and also 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).

Another example of engaging students in authentic activity comes from my current research in which the students were asked to design and develop props for their school drama production. It was authentic because the props were needed, there was no money to buy them, and the setting of the production in the early 1900's made items difficult to locate. It was also authentic to the culture of the students in which live. Stage productions were common in their city. Students learned that prop development was a significant part of this practice though listening to a props manager from a local theatre demonstrate and talk about props and their role. Figure 4 and 5 show a range of real props used by the local theatre.

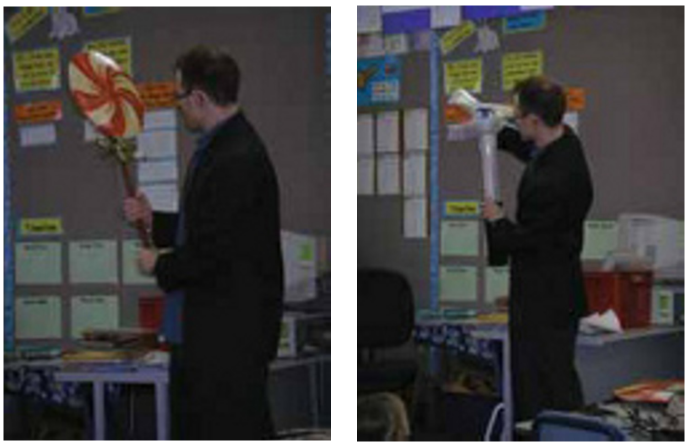

Figure 4. A props manager with two fictitious props.

Figure 5. A fake banana and plastic knife with a retractable blade.

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 children's learning (Fox-Turnbull, 2003). The knowledge students bring from their home and community (funds of knowledge), will influence what each child identifies as culturally authentic. In other words if the activities students engage in during technology reflect practices that are undertaken within their culture and community I suggest they are more likely to be engaged and motivated. This has implications for teachers as they determine culturally appropriate activities for their students.

Guided Inquiry Learning

Guided Inquiry learning is based on constructivist foundations of learning (Kuhlthau, et al., 2007). Knowledge develops through interaction with the environment (Hennessy, 1993; Maddux & Cummings, 1999; Rogoff, 1990; Vygotsky, 1978; Zuga, 1992). Problem solving is an essential part of this process. The guided inquiry approach reflects the belief that, for learners, active involvement in construction of their knowledge is essential for effective learning (Kuhlthau, et al., 2007; Murdoch, 2004). Guided Inquiry involves systematic learning that proceeds through a number of teaching/learning phases (immersion). It is very different from 'open' discovery learning because teachers have a major and continuing responsibility to structure a range of activities sequenced to maximize the development of skills and thinking processes of the learners. Guided Inquiry uses a wide range of teaching approaches from teachers' exposition to independent student research (Murdoch, 2004). Inquiry methodology and integrated curriculum are also supported by Caine and Caine (1990, cited in Murdoch, 2004) who argue that the brain seeks patterns, meaning and connectedness - methods that move from rote memorization to meaning-centred learning (Murdoch, 2004). Integrated Guided Inquiry involves students in developing deep learning through the process of self-motivated inquiry that strives towards development of 'big understandings' and 'rich concepts' (Kuhlthau, et al., 2007; Murdoch, 2004) about the world and how it functions (Blythe, 1998). Like technology education guided inquiry learning is centred on both process and content (Murdoch, 2004).

Development of higher order thinking is a key concept to constructivism and guided inquiry (Kuhlthau, et al., 2007). The path to developing higher order thinking is assisted through understanding of Vygotsky's (1978) ZPD. From this notion comes the underlying assumption that psychological development and instruction are socially embedded (Wertsch, 1998). Higher order thinking is fostered within the ZPD (Kuhlthau, et al., 2007). In order to stimulate and develop the child's curiosity and thinking, adults need to interact with the child at their potential level not at their actual level (Fleer, 1995). Guided Inquiry is a recent approach that teachers can use to enable them to plan and implement a constructivist classroom that meets the learning needs of individual students.

In the Guided Inquiry process there are distinct phases that students go through, some more difficult than others. Guided Inquiry is instigated through a need for investigation into a pressing issue, fundamental question or troubling problem, which may well be determined by the teacher. Exploration and question formulation then facilitate significant learning. Investigation leading to the collection of significant facts and information follow and task completion and preparation for presentation complete the process (Kuhlthau, et al., 2007). This process is outlined in Kuhlthau's model of the Information Search Process (Table 1).

In the first phase the teacher announces, or the students select a topic of study that requires research and thus initiates the inquiry process. During the first phase the students are involved a range of strategies to motivate and engage them. Learning is more likely to include learning through 'acquisition' than later in the unit. During this phase, it is usual for students to feel confused and perhaps a little lost.

The second phase identifies broad questions the students will be working on. Topics are determined by certain parameters, such as: points-of-interest for the students, assessment requirements, time available and resources or information available. During this time students may feel anxious before selection and possibly elation after. Anxiety can again set in, as they become to understand the extent of the task ahead.

Exploration, the third phase, involves sifting through the information available to narrow their focus. Students need to be well informed about the general topic in order to find an area to focus on. At this phase in the project many students want to drop or change their projects as they come across inconsistencies within the information they find or incompatibilities what they already knew. This is the most

Table1. Model of the Information Search Process

Stages	*Initiation*	*Selection*	*Exploration*	*Formulation*	*Collection*	*Presentation*	*Assessment*
Feelings (affective)	Uncertainly	Optimism	Confusion Frustration Doubt 'bogged down'.	Clarity	Sense of direction/ confidence	Satisfaction or disappointment	Sense of Achievement
Thoughts (cognitive)	Vague			Focused			Increased Self-Awareness
Actions (Physical)	Seeking relevant information Exploring				Seeking pertinent information Documenting		

(Kuhlthau, 2004, cited Kuhlthau, et al., 2007, p. 19)

difficult phase with confusion and confrontation when students can become easily frustrated and discouraged.

The fourth phase, Formulation is a time when students identify ways to focus their topic and information gathering. The next phase, collection, follows naturally with an extended focus on how to present the new understandings. Students' sense of ownership, confidence and interest increases at this stage of the project. The assessment phase concludes the project as both teachers and students judge what is learned about content and process. This is a time to reflect on the inquiry process as a whole. This phase is not to be confused with the formative assessment of content and process that is ongoing throughout the project (Kuhlthau, et al., 2007).

When well taught, Guided Inquiry offers students an opportunity to learn through active engagement in, and reflecting on, an experience thus building on what they already know. This enables them to develop high-order thinking skills through guidance at critical points in their learning. It allows different ways of learning to be catered for and facilitates learning through social interaction with others. Students learn through instruction and experience that aligns with their cognitive development. Guided Inquiry is often mistaken for 'Free Learning". It is not, it requires careful planning, close supervision, on-going assessment and targeted intervention (Kuhlthau, et al., 2007).

When students participate in the development of a technological outcome they go through a number of steps which parallel those outlined in Table 1: Guided Inquiry Information Search Model (Kuhlthau, et al., 2007). They begin by identifying a technological need or problem to solve and investigate related issues. This is the initiation phase, ideas are vague and students seek information and explore relevant contexts. This has been described as the hazy or fuzzy front end of technological development (Coates, 2011) and can be likened to the first phase in inquiry learning. Kimbell's APU model (Figure 6) (1991, cited in Staples. K. & Kimbell, 2005, p. 4) also illustrates the hazy nature of the early scoping stages of technological practice.

As students continue through their technological practice, they move closer to their final designed outcome, haziness clears and concrete ideas emerge, which are subsequently developed. During this time students undertake two parallel, fully integrated and inextricably linked processes; to research, identify and develop necessary skills and knowledge specific to the context of their study and technological outcome. The other is to build and develop their generic technological knowledge and understanding(Jones & Moreland, 2001). Again, comparison can be drawn here to the process of Guided Inquiry as students work through the formulation, collection, presentation phases. Final stages typically include assessment, evaluation and or critical appraisal.

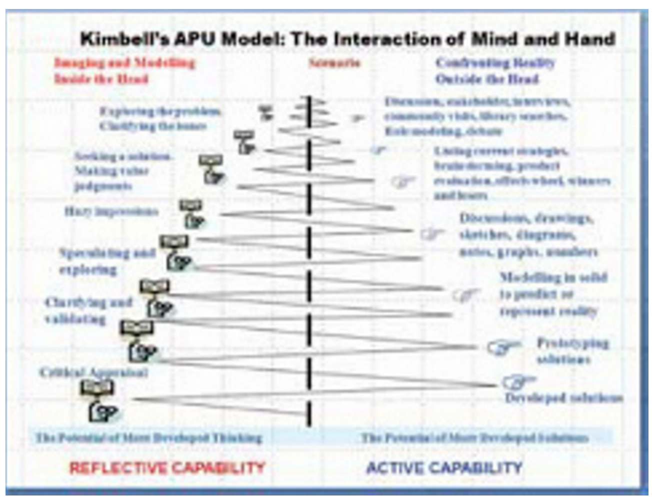

Figure 6. Kimbell's APU Model: the Interaction of Mind and Hand.

AVOIDING 'MUCKY BROWN PAINT'

One of the main problems with Guided Inquiry Learning in schools that my colleagues and I have observed is that if it is not structured and targeted as suggested by Kuhlthau and colleagues(Kuhlthau, et al., 2007), and if teachers do not have the curriculum and pedagogical content knowledge then students are very busy, but learning very little. I call this a "Mucky Brown Paint Syndrome". Let me explain; imagine each curriculum area is a colour of the rainbow. When taught in a planned and structured manner Guided Inquiry enables students to learn and employ specific knowledge and skills from a range of curriculum areas, to help research and solve identified problems and issues as an ongoing part of their inquiry. Imagine vibrant swirls of colour similar to that of a rainbow, each colour, or curriculum area, maintaining its integrity while enhancing and supporting its neighbour as in the first image in Figure 7.

However often the reality is that students are left to their own devices and are free to study or investigate what they wish, how they wish, with very little intervention and guidance from their teachers. Specific skills and knowledge from curriculum areas are not taught and discrete curriculum knowledge disappears. Colours blend, each loses its identity, mucky brown paint emerges as represented in Figure 7's second image.

Figure 7. Preserving the Rainbow and Avoiding the Mucky Brown Paint.

Studies in New Zealand have shown that student curriculum content knowledge has decreased in areas such as science. The following quote illustrates this. The National Education Monitoring Project (NEMP) assesses achievement in each curriculum area every four years. This comment comes from the 2007 science report comments on trends noticed between 1999 and 2007. "The percentage of Year 8 students disliking science at school increased substantially, from 15% in 1999 to 37% in 2007" (http://nemp.otago.ac.nz/forum_comment/2007_reports.htm).

In New Zealand there has also been an increased emphasis on literacy, numeracy and key competencies in recent years (Jones & Compton, 2009) with other subjects usually confined to afternoon "topic time" and often taught through Inquiry (Brears, MacIntyre, & O'Sullivan, 2010). With the introduction of the 21st century, we are seeing a significant shift in teaching philosophy and approaches to learning. Technology education is well situated to maximise its potential and increase its impact as learning in the 21st century moves towards a holistic model of child centred inquiry based learning. One way to avoid "mucky brown paint' is for teachers to identify and purposefully teach specific knowledge, skills and concepts in relevant identified curriculum areas as a part of a planned and structured approach to Guided Inquiry (Brears, et al., 2010).

Integration and Technology

To avoid 'Mucky Brown Paint" when integrating, the integrity of each curriculum area must be maintained. Technology has the potential to become an excellent model for other curriculum areas. This is not to say that skills, knowledge and concepts in other curriculum areas are not specifically taught, nor that technology skills and knowledge are not taught. In an integrated programme centred around the solving of a technological problem and the development of a technological outcome students are given authentic opportunities to measure, speak, write reports, discuss and consider social and health issues, and so on. "In the process of studying technology and learning technological concepts, other areas of the curriculum become more accessible" (Hennessy, 1993, p. 3). Other curriculum areas become accessible through the authentic nature of technology education.

During their technological practice, students have a right to be assisted by teachers who have the necessary generic and specific skills and knowledge to advance their skills, thinking and understanding. Students also need to utilise skills and knowledge learned from elsewhere in the curriculum and from their cultural communities to participate successfully in technology education. Technology Education is problem based student- centred learning. It is an ideal match for Inquiry Learning.

There is a clear difference between craft studies, technical studies and 'manual training', the predecessors of our current curriculum in technology education. When engaged in 'manual training' children were taught and practiced skills in isolation according to a pre-described curriculum. Technology education is different in that skills are taught on a need to know or 'just in time' basis and frequently involves the students working collaboratively in problem solving processes to develop technological outcomes that meet identified needs (Ministry of Education, 1995). It is intervention by design (Ministry of Education, 2007). When considering the above theories and discussion there are very clear implications for technology given this collaborative problem solving.

For example when I was eleven years old, during 'manual', I was taught to cook and sew and yes, as a girl I didn't get to go into the workshop, much to my annoyance! The purpose of the programme was to develop a specific skill set. In order to learn these skills I was allowed to make stuff. Everyone in the class made the same thing at the same time, perhaps with a little variance- my gingham half apron was teal blue with brown cross stitch, my friend's was red with navy blue cross stitching. In technology education students are presented with a problem or opportunity, with the apron scenario it might be parents complaining that clothes get splattered and stained with food when cooking, or a local sheltered home has just opened a new kitchen for residents and needs a set of aprons. After appropriate learning activities have been undertaken, including the introduction and practice of a basic skills set, and interaction with stakeholders, the students design, model and make the required aprons according to the needs of their client. All aprons are designed to meet specific needs. There will be some students who need to be taught further skills and techniques to ensure they are able to create their designed outcome successfully. This latter skill acquisition is call 'just in time' skill acquisition as the students are taught it on a need to know basis.

TECHNOLOGY KNOWLEDGE AND SKILLS

In a number of countries the explicit aim of technology education is the development of technological literacy (de Vries, 2009; Ministry of Education, 1995, 2007; Moreland & Cowie, 2007) and thus providing students with necessary capabilities to live successfully in a technological society. Students also need to be able to use, critique and control technological systems (de Vries, 2009). This includes the knowledge and understandings required to skilfully and knowledgably undertake technological practice. Such knowledge should also include the ability to critique existing technology and to understand its complexity, including how technology interacts with humans and the environment (Moreland & Cowie, 2007). This means students may have to develop a technological solution for a technological problem. Initially the problem is communicated to them, possibly through a design brief. Students then engage in a selection of planned activities as a part of the unit of work to allow them to develop the necessary skills and knowledge to design and develop an appropriate technological solution.

An important aspect of Guided Inquiry is the presentation of their findings. They may also develop a tangible solution for an identified issue. To this end they could be undertaking technological practice by designing presentations and tangible technological solutions, even if the nature of the Inquiry is say social studies or science based. This presents teachers with an unique opportunity to teach both social studies (or science) curriculum knowledge as well as technology curriculum content knowledge such as planning for practice, outcome development and evaluation and brief development (Ministry of Education, 2007).

Teacher Knowledge

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 (Fox-Turnbull, 2003; Kuhlthau, et al., 2007). The Learning in Technology Education (LITE) Research project (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 their learning. Formative teacher - student interactions become distorted when there is a lack of subject knowledge. Teachers must teach and assess learning in technology based on a thorough knowledge of the relevant technological practice and knowledge (Compton & France, 2006; Fox-Turnbull, 2006). Shulman (1987) 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. Rohaan's (2009) study on the influence of pedagogical content knowledge of teachers also found that sound teacher knowledge had a positive impact on student achievement in technology.

Domain Knowledge and Skills

Moreland, Jones and Chambers (2000) identify that effective teaching and assessment in technology is positively influenced by the development of a knowledge base in four domains: conceptual, procedural, societal and technical. Conceptual knowledge refers to knowledge and understanding of key concepts or ideas and procedures. Procedural knowledge refers to the applications of procedures and processes. Societal knowledge refers to understanding the relationship between technology and people. Technical knowledge is the practical use of tools and techniques (Jones, 2009). Teachers must have specific knowledge within the identified technological practice and generic technological knowledge across a range of technology areas to plan, implement, and assess quality programmes of work in technology education.

Knowledge in technology is often difficult to define. Ryle's (1984) definition of knowledge considers not only 'knowing that' but also 'knowing how' and this is particularly applicable to technological knowledge. Ryle believes there is a distinction between the two. Early philosophers of technology identified that knowledge employed in the development of artefacts was borrowed from scientific knowledge supporting the notion that technology is applied science. However, today most believe that technology is a body of knowledge in its own right. Users of technology also have a body of different technological knowledge. The two categories are particularly relevant to technological knowledge; and could be thought of as 'those who do' technology and 'those who use' technology. De Vries (2005) also considers the knowledge of processes involved in the functioning and or making of the object an aspect of technological knowledge.

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, which is common technological development and also applicable across the four domains of knowledge mentioned above.

There is considerable relationship between the Ryle's (1984) categories of knowing that and knowing how and procedural knowledge domain identified by Jones & Moreland (2001). Jones and Moreland's 'technical' and 'procedural' knowledge have direct links to Ryle's 'knowing how' category, with a focus on the practical elements of technological practice. Societal knowledge has a very clear link to users of technology and the interface between technology and people-'those who use' technology and 'knowing that' knowledge.

De Vries (2005) states that artefacts have a functional and physical nature. 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 - 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. Technologist knowledge also includes the relationship between the physical and functional features and knowing how materials contribute to the artefact's fitness for purpose. For many technologists this knowledge is intertwined and they are unable to separate how they know and are able to do the practical knowledge and 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). 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 also be seen here to procedural knowledge domain identified by Jones & Moreland (2001) and Ryle's'(1984) knowledge of 'those who'.

Context

Context is a word that is used widely in education and refers to a specific area of study in which learning takes place. Difficulty can occur when individual understanding of the term 'context' varies. 'Context' in technology education has been used to refer to the overall focus of a technological development or of a technological learning experience within technology education (Ministry of Education, 2010, p. 12). When talking about the context of a technological development, 'context' refers to the wider physical and social environment in which the development occurs for example rebranding an airline or wind generation for sustainable energy. When 'context' refers to a technological learning experience, it refers to all the aspects that need to be considered to situate the learning, for example outdoor eating within a school environment or programme development in ICT (Ministry of Education, 2010). Later in this chapter when I discuss the idea of identifying context free learning it is the latter definition of context to which I refer.

PLANNING FOR LEARNING

Fleer and Quiňones (2009) state that to understand and to be able to assess children's technological knowledge teacher need to understand the social and cultural context of their learners. Learning starts from a student's existing knowledge (Harrison, 2009). Having established this, teachers are then able to engage and motivate students by selecting relevant and culturally appropriate technological contexts for learning. When teachers have the mindset that all students can improve and that students bring their culture and experiences to learning they are in a good position to plan effective learning that will engage their students (Clarke, 2008; Harrison, 2009).

The identification and writing clear learning intentions in technology will inform students what aspect of technological knowledge and skills is to be the focus of learning within any one lesson. Consider the knowledge (conceptual, procedural, societal) and skills (technical and information) students will need to undertake an experience which will subsequently enable relevant learning. For quality technological learning to occur each lesson much have a clearly articulated learning intention. To do this, teachers need to be able to identify and articulate key learning to students. It is important to note here that when I refer to 'lesson' I refer to a learning episode, not specific period of time (session). One lesson may occur over several sessions (periods of time allocated to subject areas in a typical schooling situation) or conversely one session may contain several smaller lessons.

Following the identification of the learning intention teachers, must then plan and organise a suitable learning experience. A learning experience is an activity that facilitates learning of relevant knowledge and skills. They need to be purposefully planned and logically sequenced. This is to ensure students have enough relevant information about both the context of their study and the necessary technological knowledge and skills to be able to develop their intended technological outcome and to understand the societal, environmental and global issues that may impact on their decision-making.

Each learning intention and associated experience usually produces some form of tangible (written, oral, visual, dramatic, graphical) evidence of learning and is able to be used formatively by students and teachers for assessment. They may include such things as: posters, charts, interviews, written summaries/ reviews, products systems or environment plans, discussion or oral explanation, concept maps, annotated drawings, 2D and 3D planning, functional and prototype models and or the final outcome. Proof that the predetermined learning outcomes have been met can be used formatively or summatively for assessment when clear specific criteria have been identified.

One of the key strategies in formative assessment is the establishment of pupil generated and owned success criteria (Clarke, 2008). Success criteria describe what successful learning looks like. This may involve a systematic approach when learning is a fixed right or wrong process as in solving a mathematical equation. Or it may set out to describe key attributes of a successful learning example (Clarke, 2005). Co construction of success criteria with students involves enabling effective dialogue and questioning and pupil analysis of what excellence consists of. This does not mean showing students how to just meet, but best meet success criteria (Clarke, 2008).

When teachers are planning and writing units of work they can use this pattern to ensure a clear focus on both technological knowledge and contextual knowledge through the development of technology learning intentions, learning experiences, technological learning evidence, and the co construction of success criteria. In summary to plan a learning episode consider the following:

What is the learning needed?	Learning Intention
What can the students do to learn this?	Learning Experience
How can learning that has taken place be identified?	Technological Learning Evidence
What will successful learning look like?	Success Criteria

Identification of Context Free Learning

When writing learning intentions for specific technological knowledge and skills it is easy to muddle context and technological learning, so that neither become clear- developing 'mucky brown paint' is a risk in this situation in that technological learning gets buried in busy activity related to context. The separation of learning objective and context ensures that students and teacher clearly focus on technological learning. Clarke (2008) suggests separating context from learning intention can have a dramatic affect on teaching and learning. Context, the activity or "vehicle" through which learning occurs (Clarke, 2005, 2008), is however vitally important. Examples of Context free learning intentions in technology are given below in Table 2.

Table 2. Learning Objective with context separated

Learning Intention *Students are learning to*	*Context*
draw 3D detailed plans of a structure using a suitable software programme	A home for a guinea pig
Plan technological practice through the development of a critical path to ensure maximizing all team members use of time	Meals for "International Week" at School
Understand how the physical and functional nature of an outcome impacts on performance	Puzzles for young children
Understand the importance of making a mock-up has, on the quality of a final outcome	School senior ball gown

When technology learning intentions are combined with context or when they are contextualised students can become very focused on the context and may lose sight of the actual technological learning.

Table 3. Learning Objectives Muddled with Context

Muddled Learning Intentions *Students are learning to*
draw detailed plans for a suitable home for a guinea pig
create a critical path to ensure meals are ready for the international banquet
Understand the physical and functional nature of puzzles for young children
Understand why making a toile of ball gown is necessary

By making the learning objective and the context very clear to students, they are then able to transfer skills and knowledge through to other contexts within and across curriculum areas (Clarke, 2008). There are however, some learning intentions within any unit of work that will be focussed specifically on context for example a historical study of ball gowns or understanding the stages of child development enhanced through doing jigsaw puzzles. Again the learning intention must be clearly articulated to students so that they may understand the purpose of their learning.

All these points align with an Inquiry model of learning. Evidence from literature presented here suggests Guided Inquiry Learning, technology education, and formative assessment are perfect partners. Quality technology education exemplifies inquiry learning and formative assessment is the perfect tool for advancement of student learning.

FORMATIVE ASSESSMENT

The process of teachers giving students critical guidance and feedback to enhance learning opportunities involves ongoing formative assessment (Black & Wiliam, 1998). “Formative practice is about providing guidance for learning” (Harrison, 2009, p. 450). 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 child can improve and an awareness of the value of self esteem (Clarke, 2005). 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 stage of learning from planning, decide context of study, establish intended learning and associated success criteria and critically engage in analyzing learning through classroom talk (Clarke, 2008).

Clarke (2008) suggests that to ensure maximum impact on motivation and achievement schools needs to make their curriculum creative and flexible. Pupil engagement in preplanning and planning will ensure learning is pitched at the correct level, increasing motivation and achievement. Teachers need to present pupils 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 and if curriculum coverage is not compromised.

THE NATURE OF PROGRESSION

Progression in technology is related to understanding and using generic technological knowledge and skills in an increasingly complex and varied way. Progress in technology is not linear, nor is it a sum of individual parts, but rather a holistic process which cannot be assessed in absolute terms (Kimbell, 1997). Achievement in technology is not only about factual knowledge but also a students' conceptual understanding of subject matter and their ability to transfer concepts to future learning and new and unfamiliar situations (Pellergrino, 2002).

Progression is about planning for and managing student progress and requires an understanding of students' current level of technological literacy and what subsequent learning might look like. Progression does not mean that something extra is added or by doing something differently. "Improvement may amount to doing the same thing but in progressively richer ways" (Jones, 2009, p. 410). Jones (2009) defines progression in learning technology in the following categories:

- the nature of technology- the broad understanding of technology and the relationship between technology and society
- student technological practice- brings together different technological tasks and the brings together of knowledge and skills to solve technological problems
- generic conceptual, procedural, societal, and technical aspects- aspects common to more than one technological area
- specific conceptual, procedural, societal, and technical aspects- aspects specific to a particular technological area or context.

In technology education students engage in critical appraisal of existing technologies and employ design processes to develop new outcomes. Design, innovation, invention, form and function are features of technological thinking. Students are required to work reflectively and in an iterative, holistic fashion (Moreland & Cowie, 2009). Moreland and Cowie suggest that young students often have difficulty working iteratively when engaging in technological practice and therefore need significant teacher assistance. Effectiveness of this assistance will depend on teachers' understanding of progression in technology. The categories mentioned above assist teachers in understanding the needs of their students and advancing their learning.

In New Zealand the Ministry of Education has funded the development of Indicators of Progression (Ministry of Education, 2009). In this case progression is based around key components across eight levels of achievement from Years 1 to 13.

These key components include: brief development, planning for practice, outcome development and evaluation, technological modelling, technological products, technological systems, the characteristics of technology and the characteristics of technological outcomes. I suggest that there is some correlation between the Jones' aspects and the Ministry's Indicators of Progression. Table 4 shows this correlation.

Table 4. Correlation between the Jones' (2009) aspects and Indicators of Progression (Ministry of Education, 2009)

Jones' Aspects of Progression	*Definition*	*Relevant Indicators of Progression*
The nature of technology	The broad understanding of technology and the relationship between technology and society	The characteristics of technology and the characteristics of technological outcomes
Student technological practice	Brings together different technological tasks and the brings together of knowledge and skills to solve technological problems	Context specific brief development, planning for practice, outcome development and evaluation Technological modelling with in context Technological products, technological systems
Generic conceptual, procedural, societal, and technical aspects	Aspects common to more than one technological area	Technological modelling (purposes of) Technological products relationship between materials and fitness for purpose Technological systems, "understanding of input, output, transformation processes, and control" (Ministry of Education, 2009) Brief development, planning for practice, outcome development and evaluation
Specific conceptual, procedural, societal, and technical aspects	Aspects specific to a particular technological area or context.	Specific technological modelling Technological products, technological systems Brief development, planning for practice, outcome development and evaluation

International literature on the exact nature of progression in technology education and information of the specifics of what learning looks like across levels and across components or aspects is light. National or state curricula such as New Zealand's national curriculum achievement objectives (Ministry of Education, 2007) and the United Kingdom's Key Stages (National Curriculum website team) goes some way to identifying progression in general terms. For teachers to be able to have a clear picture of students' learning further support documents such as New Zealand's Indicators of Progression (Ministry of Education, 2009) are required. These not only identify and break down learning steps but also supplies clear teacher guidance and teaching strategies. I would certainly agree with Compton and Harwood, (2005) Jones (2009) and Pellegrino (2002) who suggest that more research needs to be done around the notion and specifics of progression in technology education.

CONCLUSION

This chapter began by investigating literature in what I believe to be key theories that influence the nature of technology education. Sections began with a macro perspective through sociocultural and constructivist theory and concluded with micro approach through classroom teaching strategies. Sociocultural and constructivist theories cite the learner at the centre of learning, along with culture and culturally situated tools and their influence on cognitive development. Because interaction occurs as a direct results of a learner based approach theories in this area were also discussed. Guided Inquiry and 21St Century Learning were then summarised because they offer insight into the potential of collaborative, practically based curriculum such as technology education.

Technology is well situated to lead learning into the 21st century with student centred, needs-based programmes. The latter part of the chapter was focussed implementation of technology education. It discussed how and why the macro-theories influence technology education. Discussion in the second part of the chapter was included on the nature of technological knowledge and impact of teacher content and pedagogical content knowledge has on learning. Technology classroom practice including technology process, learning intentions, learning experiences and evidence of learning was discussed. The chapter concluded with the concept of how context free learning can be employed to enhance learning in technology for students along with discussion about formative assessment and the nature of progression.

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