Oral Interaction in Technology Education

Learning Technologies and User Interaction: Diversifying Implementation in Curriculum, Instruction, and Professional Development.

Wendy Fox-Turnbull
Deputy Head of School
School of Education
University of Waikato, Hamilton
New Zealand

Abstract

This chapter explores perspective of a teacher educator in technology education. It identifies technology education as being very different from educational technology. Technology education is about the informed design and development of technological outcomes to meet identified needs. On the other hand educational technologies are the tools and related pedagogies of using technology to facilitate and enhance student learning. Oral interaction plays a special role in technology education. In technology there is no one right answer, with multiple solutions possible although some solutions will be more successful than others. Technology education draws on considered strategies to assist student learning. The Technology Observation and Conversation framework assists this process and facilitates teacher professional development and enhances the quality of classroom interaction. Understanding the nature of and facilitating intercognitive conversations assists this endeavour. The Technology and Observation Framework provides teachers with a bank of rich questions and observation points across key aspects of curriculum and desirable technology behaviours. Awareness of and understanding the role and values of students' funds of knowledge, assist teachers in making connections with students and ensures the taking of specific steps to provide an inclusive safe classroom where students are comfortable to take risks and fail. Using strategies such as talking partners and 'no-hands-up within this safe environment enables students the freedom to explore their thinking orally and learn in a non-judgmental manner thus enabling them to articulate and shift thinking if necessary thus sparking cognitive growth.

Introduction

Technology Education is fundamentally about the development of the technological world to enhance people's experiences of, in and with the world. Today's world is technological in nature. We engage with, and use technology from birth or maybe even before. Students therefore must be educated about technology, how it is developed, how it influences and impacts lives and how to develop it ethically and sustainably. For students to flourish in a technological world it is important that they become technological literate or develop technacy (Seemann & Talbot, 1995).

Technological literacy is defined in a number of different ways, in this chapter the term technacy is used to differentiate it from definitions of technological literacy that are narrower and restricted to the use of technologies (Seemann & Talbot, 1995). We refer to technacy as a means to acquire a level of literacy that is needed to understand, operate and develop ethical and sustainable technologies and to understand the influences and impacts of technology necessary to succeed within today's technological world.

Not only do people need to read and write (language literacy), engage with and use numbers (numeracy or number literacy), they also need to be able to engage with, critique and develop technology (technacy). Knowledge in technology is often difficult to define, but includes not only 'knowing that' but also 'knowing how' and 'knowing why'. Early philosophers of technology often identified knowledge deployed in the development of artefacts as being borrowed from science but we now know that technology is a body of knowledge in its own right and that people who use technology have knowledge and understanding that differs from that of technology developers. These knowledge categories are particularly relevant to technological knowledge; 'those who do' and 'those who use' technology (de Vries, 2017). This chapter explores the role oral interaction plays in developing technacy an ultimate goal of technology education.

Technology Education and Educational Technologies

Technology Education is not to be confused with educational technology, which involves teachers and children using technology as teaching learning tools. Technology education is a curriculum learning area or school subject sometimes taught alone and sometimes combined with other learning areas such as science. Education technologies focuses of the use of tools to facilitate and enhance teaching and learning (Fox-Turnbull et al., 2020). Table 1 summarises the key ideas differentiating technology education and educational technology.

Table 1: Differentiating technology education and educational technology

Technology Education	***Educational Technology***
In technology education students learn …….	*Engaging educational technologies teachers and students understand…..*
the impacts technology has on their own and others' lives	that educational technologies are tools to facilitate and enhance learning
the influences of technology on humans and the environment	and learn to use technology to enhance teaching and learning
the influences humans have on technological development	and learn to use technology to share teaching and learning
to critique existing technologies to inform future practice	educational technologies facilitate different ways of doing and thinking
to plan and undertake technological practice	include distance learning as well as enhancing face-to-face learning
to design ethical and authentic technological outcomes to address needs or opportunities	that educational technology does not include designing and developing digital technologies, only using them for learning
to skillfully develop the above outcomes	how to use technology to enhance teaching

	and learning
to evaluate designed outcomes using stakeholder feedback and developed attributes and specifications	technologies influence ways of learning
to develop strong technacy (technological literacy)	that different pedagogical approaches can be deployed

Adapted from Fox-Turnbull et al. (2020)

Technology education explicitly deals with the technological processes of investigating, critiquing, designing, making and appraising technological solutions to address identified technological problems or to recognised and realise opportunities within any given social and cultural context. Programmes of learning in technology education use authentic learning contexts and are particularly well suited for inquiry-based learning. Technology education frequently facilitates integration of a range of other learning areas or subjects. It is interdisciplinary and requires students to work as technologists and at times with technologists. A central aspect of technacy is the understanding that intellectual and practical resources are used to intervene in the world through the development of products and systems (Ministry of Education, 2007).

Creativity and innovation are critical aspects to successful technology practice (Spendlove, 2015). Innovative technological practice is collaborative in nature and requires communication and conversation with others throughout. It is during these often meaningful conversations that students may draw on their cultural funds of knowledge. They may have cultural experience, skills and knowledge that other group members do not have and thus giving value to often undervalued cultural knowledge and skills or funds of knowledge (Fox-Turnbull, 2013). Through technological practice, students converse with peers and professionals, deploy funds of knowledge, make connections and develop new insights during the process of designing and developing technological outcomes.

Defining Oral Interaction-Talk

Constructivist theories identify talk as a result of thinking and learning, however in social constructivism and socio-cultural theories the reverse is true. Learning occurs as a result of talk (Coffer, 2017; Fox-Turnbull, 2016). This is the perspective taken in this chapter as it is particularly relevant to technology education (Fox-Turnbull, 2013). From a Socio-cultural perspective interaction between people is a central aspect of cognitive, social and cultural development (Black, 2008). As stated above technological practice is frequently collaborative. Language and social interaction are vital components of working collaboratively thus quality oral interaction is a critical component in the success of technology practice, especially in the classroom (Coffer, 2017). When undertaking technology practice students undertake collaborative problem solving and frequently work within social constructivist and sociocultural paradigms (Fox-Turnbull, 2016).

Vygotsky (1978) emphasised the need for two opposing tendencies in quality social interaction. The first, Intersubjective Dialogue occurs between a novice and an expert and works towards developing shared definition aiming to move the novice to task independence. As people interact, they construct their world. This is illustrated in technology education when a student is guided by their teacher. As a facilitator of learning a teacher must recognise when students are struggling with an issue or perhaps heading off on the wrong pathway. Teachers can probe and question students, facilitate reflection on and alter their technology practice pathway. Joint problem solving uses debate as a major force in cognitive development.

Alterity is concerned with the distinction between self and others when discrepancy or conflict of opinion occurs between personal and other's points-of-view. This sparks cognitive development if the listener perceives and understands meaning simultaneously responding actively either agreeing or disagreeing, partially or completely. Again, clearly illustrated in technology when two students working on the design of a common outcome with different initial concept designs. By discussing, reflecting on and defending their design ideas through they eventually arrive at an agreed solution that takes aspects of each of the initial designs. Their alterity led to the design of a better outcome than either of them could have achieved individually.

Language is not a system of set meanings for everyone. Single statements can mean different things to different people, thus presenting opportunity for misunderstanding and conflict disagreement (Mercer, 1995). For example the statement/question 'Did you do that?' can mean a range of things. It might mean the person is being told off for doing something wrong, or that they are being praised for doing something unexpected or challenging. Oral language is interpreted by the listener taking context, emphasis, tone and non-verbal cues into consideration in order to make meaning. Discussion that takes place during the course of education activities is called dialogue. Within everyday dialogue the speaker regularly considers the listener's response giving insight into variability of meaning. When this response aligns with the speaker's understanding the conversation is enriched. On the other hand, when the listener's understanding differs the speaker can sense resistance. Beliefs, values and attitudes inform the way people act, read, what they say and how they interact however these are not static and change as people read, experience, observe and adapt to new situations (Mercer & Hodgkinson, 2008; Shields & Edwards, 2005).

Dialogue and Exploratory talk much more than talk, they are complex and dynamic and often involve vastly different cultures, perspectives, values, ideas and people. They generally involve the use of words and require deep engagement. Dialogue can bring moments of intense connection with another person with feelings of remarkable openness, deeply affirming and highly exhilarating moments(Mercer, 2006). Exploratory talk involves retrieval and questioning of what is known (Webb et al., 2016).

> Exploratory talk might be effective because implementing it also embodies retrieval practice. That is, in order to make an argument, one has to remember the facts and concepts that one has studied to construct the argument. Exploratory talk might also implicitly provide distributed practice in that the process of developing and presenting argument is likely to involve coming back to the same material at different times. Similarly, developing an argument often requires a combination of reviewing past history, analyzing data from current findings and constructing a coherent narrative, a process that interleaves different tasks to complete a project.(Webb et al., 2016, pp. 575-576)

Exploratory dialogue is critical in learning and considerably more important than has been demonstrated in schools in the past. Educational success and failure may be explained by the quality of educational dialogue, rather than by the capability of individual students or the skill of their teachers (Mercer, 2006; Robertson & Graven, 2019).

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 rich conversation as the principle means used to establish a shared understanding, testing solutions and reaching agreement or compromise. Exploratory dialogue is about thinking together and an important part of education that has long been ignored or actively discouraged in schools (Shields & Edwards, 2005).

Teachers need to engage in quality talk with students (and parents) to assist with cognitive and experiential understanding of the world in which they live. They also need to facilitate this talk between students (Fox-Turnbull, 2019). Teachers make powerful contributions to the way children think and talk and convey powerful messages about thinking by the way they structure classroom activity and talk. Students need to be engaged in thoughtful and reasoned talk, which teachers need to model and scaffold using appropriate language strategies to extend thinking. Students need regular opportunity to practice using talk to reflect, enquire and explain their thinking to others. They need to be able to seek and compare points-of-view, debate and reconcile questions taking learning beyond teachers' factual questions. Spoken language is one of the tools students use to make sense of the world and should be a teacher's main pedagogical tool.

Intercognitive Conversations

As stated above exploratory dialogue occurs as students inter-think. Intercognitive conversations are conversations within which all participants learn through participation in exploratory dialogue and then have the ability and willingness to reflect on their own and others' views and knowledge. Working within a common context and engagement in the talk described students are able to assist teach other and advanced their own knowledge and understanding in their given context. Debate, argument and disagreement assist students' understanding and to reposition existing information and position new information. However this cognitive growth only occurs if and when participants are open to change and new ideas (Fox-Turnbull, 2013). Intercognitive conversations are only able to occur in a classroom where the class climate allows risk-taking and exploration. Students need to understand that the purpose of teachers' questions is not to find the 'right' answer, rather to explore thinking (Robertson & Graven, 2019).

There are two types of intercognitive conversation. The first Convergent Growth Conversation (CGC) describes conversations within which cognitive growth occurs in the same field of learning or within the same context. This is exemplified when two students have a conversation each contributing what they know. Through the conversation both participants combine and reshape their existing knowledge and skills subsequently expanding their own understanding, each experiencing a shift in cognitive thinking (Fox-Turnbull, 2013). This was illustrated in a study by Fox-Turnbull (2013). A group of three students were tasked to design a 1930's style microphone as a prop for their class production. During the initial sketch phase of their practice one student, Molly (not her real name) draw a common hand-held cylindrical microphone, the other (Alan) drew an older style rectangular shaped one set on a long stand. The resulting conversation with their teacher facilitated growth for all. Molly realised that her sketch was of a microphone from a more recent era than needed and that style assisted the audiences to determine historical period. Alan shared that he had seen older style microphones in movies but learned that microphones could either be hand-held or on a stand. The students were able to reach conclusions about an agreed final design that was true to the required era and flexible in its use. This conversation exemplified CGC. The teacher assisting the conversation gained insight into how students learning in technology and that to succeed students need to be open to critique and new ideas. This exemplified the second type of intercognitive conversation Divergent Growth Conversation.

The second Divergent Growth Conversation (DGC) occurs when participants learn in different fields and for different purposes. For example, this might occur in teachers' conversations with students as illustrated in the previous paragraph. Teacher questions assist the student to make new connections about their current context of learning. At the same time teachers gain new knowledge about students' learning strategies and successful pedagogical approaches (Fox-Turnbull, 2013). With the assistance of reflective thinking, teachers undertake personal professional development on pedagogical context knowledge and possibly content knowledge as they talk with their students.

Talk to Learn Technology- Intercognitive Talk

It is critical to understand the significance of conversations in learning. Through conversations, teachers and parents can encourage children to reshape their thoughts (Mercer, 1995). There are very clear implications here for technology given the collaborative nature of problem solving required to develop technological outcomes. Intercognitive talk is particularly relevant because students often work collaboratively on a single technological outcome. To succeed group members must talk about their ideas, listen to and accept others' ideas, clearly articulate their own thinking and reasoning and make a shift in their own thinking when compromise or change is needed. Common ground must be identified in order for a group of students to be able to design and develop a single outcome to meet the identified need (Fox-Turnbull, 2017). This was illustrated by Molly and Alan who were tasked with develop one 1930s microphone. Both had vastly different initial design ideas that needed to be modified in order to succeed. Technology cannot be learned by rote (Black, 2008; Coffer, 2017). There only way forward for these two was open dialogue and intercognitive conversation to ensure new understandings about a way forward emerged. There are five critical components to having rich intercognitive conversations in the classroom: inclusive classroom climate, rich questions, encouragement of open discussion, strategies to support participation and a willingness to have ideas challenged and to learn.

An inclusive classroom climate is one in which students feel they belong and are able to take risks. Teachers need to hold a growth mindset to learning, believing every child has the potential to learn and actively foster this belief in their students. Students need to understand that their intelligence is expandable. They need to embrace challenge, develop resilience and persistence after a set-back, understand that effort will be rewarded and learning from constructive feedback and criticism (Clarke, 2014). In Technology students need to be comfortable exploring wacky design ideas and making design mistakes. They are less likely to do this if they feel that they are different or laughed at. Funds of knowledge of other cultures are more likely to be deployed during technology practice if students understand that they are included in their classroom and that their cultural knowledge is valued.

Schut et al. (2019) also suggest that higher-level rich questions are a good tool for providing divergent feedback on design and creativity. At this stage it is important to acknowledge that rich questioning does not only occur orally, however there are several advantages of oral questioning. These include immediacy, co presence, visibility and co-temporality (Fox-Turnbull, 2013).

An inclusive classroom climate will go some way to encouraging of open discussion in the classroom, however there are also additional strategies to support participation. The use of talking partners and the ‘no-hands up’ rule are a start. Talking partners are selected randomly and changed often. They are peers with whom students discuss their thinking, ideas and learning. Students need to be taught how to be a successful talking partner. Rules guide behaviour. These include acceptance of what is being said, understanding that accepting ideas is not the same as agreeing with them, giving eye contact, looking interested, avoiding distractions, thinking about what the talking partner is saying, staying focused, letting go of some ideas so as not to disturb the talker’s train-of-thought, saying more than one or two words and being prepared to compromise or constructively persuade (Clarke, 2005). This strategy is often couple with ‘No-hands up’. When deployed this strategy infers that everyone in the class has something to say and that any pair of talking partners may be called on to share their collective thinking. These two strategies promote deeper level thinking and talking enabling opportunities for students to evaluate, analyse and synthesise rather than merely recall and comprehend ideas (Bloom, 1956). Understanding the importance of, and facilitating student-teacher and student-student dialogue is also particularly relevant to technology education because of the practical nature of many lessons. Teachers are often easily distracted by organisation of activities and management of the children’s behaviour. Discipline is needed to ensure these things do not distract them from engaging the children in conversation about their learning and practice. Technology education allows children to use creativity and innovative thinking, to move in directions very different from current thinking or thinking of their peers, offering teachers unique opportunities and insight into their students’ thinking.

The difference this can make for some students was illustrated in a study undertaken by the author. The class task was to design a futuristic car. Issy, a very quiet shy six year old, rarely contributed orally in class. After talking her ideas through with her talking partner about her design ideas, she began to share with her class for the first time. Her teacher saw for the first time, her creative and innovative thinking. Issy’s design was a car with wings rather than wheels. She had identified that cars in the future might have wings instead of wheels. During the same conversations Issy was able to reflect on some of the issues associated with flying cars such as flying over people’s houses and stopping for other ‘cars’. Dialogue between her teacher and Issy enabled insight into her forward thinking and understanding that previously has not been identified by the classroom teacher. Her ideas were considerably more sophisticated than those of her peers. This is an example of a DCG intercognitive conversation. The conversation enabled Issy to identify and articulate potential issues of her designed technology outcome. The classroom teacher learned about Issy’s sophisticated designerly thinking.

Another conversation with a child, told in first person for effect, is worth sharing here as it again illustrates the power of teacher-student conversation. The conversation occurred between Rex (not his real name) an eight year old boy from a low decile school in Christchurch New Zealand and the author in her role as a technology education lecturer at the local pre-service teacher education provider. Rex was in a Year 4 class. In appreciation of some work undertaken with the class I offered to resource and teach a technology unit with the class. The classroom teacher requested a Christmas theme. At my suggestion, the classroom teacher bought a Christmas tree for the class and we posed the problem that the tree had no decorations and with no money to buy them we suggested the children designed and developed chocolate Christmas tree decorations to adorn the tree. Over a period of a week the students undertook a number of activities to enhance their understanding of Christmas decorations, symbols of Christmas, of physical and functional features of moulds and the vacuum forming process used to construct the plastic moulds for chocolates. Subsequently the students sketched three possible ideas for their decoration, selected one and created a pattern of their intended design in ceramic dough, cooked for hardening. During the sketching process, I circulated around the room looking at the students' options and preferred designs. I noticed that one boy, Rex, had three sketches on his paper; two tradition Christmas designs and one that looked like a sausage with a face rather like a papoose. I asked him which one he was going to develop into the actual decoration. He pointed to the papoose. 'A strange choice', I thought and wandered on to the next child. Later that week when the students had completed their patterns I noticed Rex carefully cradling his 'papoose' in his little hands. I stopped and asked him to tell me about his design. He explained to me that his design was for his mother. He went on to say that two years previously he had had a baby brother, born prematurely, who lived only two days. Every year the family hung a decoration on their Christmas tree to remember him. Rex had designed a representation of his little brother that he was going to give to his mother to hang on their tree at home. The story still moves me every time I read it or retell it. On reflection, I realised how easily I could have missed this conversation with Rex. From my perspective, his design could have just been a sausage with a face. On hearing his story, I had a much better appreciation of the thinking and reasoning that had gone into Rex's technological solution. I began to wonder how much teachers miss when they don't have these conversations with their students and what insights these conversations give us into learning in technology.

Understanding the power of exploratory dialogue and intercognitive conversation led to the development of a conversation framework aimed to assist student-teacher conversations. It must be acknowledge here the student-student conversations are equally if not more important that teacher-student conversations, however in order to teach students to talk to each other constructively to facilitate higher thinking their teachers must first model then scaffold appropriate conversations. The Technology Observations Conversation Framework (TOCF) assists this process.

Technology Observations and Conversation Framework (TOCF)

Developed to assist teachers' facilitation of quality exploratory dialogue and intercognitive conversation while they work in technology the TOCF framework offers a large number of questions teachers can select from to initiate conversations with students, it gives suggestions as to the types of comments that might be useful and makes suggestions for behaviours to observe. The TOCF has a dual role, also assisting to develop teachers' understanding of technology and facilitating students-teacher higher level thinking in technology. Using the framework teachers facilitate exploratory dialogue with students, some of which will become intercognitive in nature.

The framework identifies five desirable behaviours for success in learning technology: resilience, transference, flexibility and sophistication, reflection and socialisation. These desirable technology behaviours (DTB) were identified from Claxton, Chambers, Powell, & Lucas's,(2013) work on building learning power. Given the collaborative, academic and practical natures of technology education, the author identified and modified them to suit. The first 'resilience', includes capabilities of perseverance especially after initial failure, managing distractions from peers, other activities and people around them, and absorption in any given task. Absorption, likened to Csikszentmihalyi's (1990) state of 'flow' is described as a state of deep absorption in an activity that is intrinsically enjoyable, as when artists and athletes are focused on their play or performance. This is clearly relevant to technology. Students must be able to fail repeatedly when designing and testing technology outcomes. Modelling should be about discovering what works; mistakes celebrated, each identifying something that does not work "yet" or that a solution may lie elsewhere.

The transference of knowledge occurs when students develop understanding in one context and transfer it successfully to another context. It may not occur naturally for students; however, teachers can facilitate transference with a keen awareness of their students, good understanding of content knowledge and the ability to make authentic connections. Transference includes making links to technologies experienced or seen, and experiences undertaken previously and draws on students' Funds of Knowledge (Fox-Turnbull, 2012). It also includes students reflecting on and questioning the relevance of previous experiences and knowledge and skills and what transfers to the current context. Again the relevance to technology is clear. As students design and develop their technological outcomes, opportunities to use knowledge and skills from other subjects arise. Mathematics, writing, reading, social studies and science are significant contributors to technology, however teachers frequently need to bridge the learning between the learning areas (Jones, 2009).

The ability to think flexibly and sophisticatedly includes questioning others to learn more, getting below the surface of ideas and artefacts. Flexibility and sophistication indicate a depth to understanding as well as an openness to potentially strange ideas. Critical components include the use of reasoning to evaluate, the ability to distil information in order to understand, planning ideas and actions and capitalising or making the best use of resources. There is an intuitive connection between creativity and cognition. Increased sophistication is linked to thinking creatively and flexibly. Spendlove (2015) identifies strong societal benefits of being creative within technology education. We can illustrate this through the New Zealand (NZ) context where important documents that assist teachers' understanding of how technology knowledge and understanding develops in sophistication and flexibility as students' progress; the achievement objects in *The New Zealand Curriculum* (NZC) (Ministry of Education, 2007) and the *Indicators of Progression* (Ministry of Education, 2009). Table 1 illustrates increased sophistication and flexibility of thinking across two of the achievement objectives: brief development and characteristics of technology, guided by the indicators. The third column in the table explicitly identifies ideas that are developed between curriculum levels 1 and 4 representing learning expected at Year 1 (5-6 year olds) and Year 4 (11-13 year olds) respectively (Fox-Turnbull et al., 2020).

Table1: Sophistication and Flexibility of Thinking across two NZC Achievement Objectives

<table>
<tr><th>Achievement Objective</th><th>Indicators of Progression</th><th>Increased Sophistication and Flexibility</th></tr>
<tr><td colspan="3">Brief Development:</td></tr>
<tr><td>Level 1:The students will describe the outcome they are developing and identify the attributes it should have, taking account of the need or opportunity and the resources available.</td><td>Students can…..
• communicate the outcome to be produced
• identify attributes for an outcome.</td><td rowspan="2">The students develop sophistication and flexibility by progressing from the ability to...
● articulate what they are developing to identifying a need or opportunity within a given context
● identify some attributes for their intended outcome to writing of a conceptual statement that describes and justifies their outcome
● identify list of attributes to establish and justify key attributes developed from stakeholder’s needs and feedback</td></tr>
<tr><td>Level 4: justify the nature of an intended outcome in relation to the need or opportunity. Describe the key attributes identified in stakeholder feedback, which will inform the development of an outcome and its evaluation.</td><td>• identify a need or opportunity from the given context and issue
• establish a conceptual statement that communicates the nature of the outcome and why such an outcome should be developed
• establish the key attributes for an outcome informed by stakeholder considerations
• communicate key attributes that allow an outcome to be evaluated as fit for purpose.</td></tr>
<tr><td colspan="3">Characteristics of Technology</td></tr>
<tr><td>Level 1:The students will understand that technology is purposeful intervention through design.</td><td>Students can….
● identify that technology helps to create the made world
● identify that technology involves people designing and making technological outcomes for an identified purpose
● identify that technological practice involves knowing what you are making and why, planning what to do and what resources are needed, and making and evaluating an outcome.</td><td rowspan="2">The students develop sophistication and flexibility by progressing from the ability to…
● identify that technology creates the ‘made-world’ to understanding that technology changes people's abilities, perceptions and experiences of the world
● understand that technology is around us to understanding technology has short and long term impacts on the world
● understanding people make technology for a reason or purpose to understand people</td></tr>
<tr><td>Level 4: understand how technological development expands human</td><td>● identify examples where technology has changed people’s sensory perception and/or physical</td></tr>
</table>

possibilities and how technology draws on knowledge from a wide range of disciplines.	abilities and discuss the potential short and long term impacts of these ● identify examples of creative and critical thinking in technological practice ● identify and categorise knowledge and skills from technology and other disciplines that have informed decisions in technological development and manufacture.	think critically and creatively when developing technology to meet a need or opportunity ● understanding the process of making technology involves knowing what is being made, the resources needed and why ***to*** understanding technology practice involves recognising and deploying skills and knowledge from technology and other disciplines ● understand technology practice involves design and outcome evaluation ***to*** understand that evaluation of technology design and outcomes includes technological development and manufacture.

Adapted from Fox-Turnbull et al. (2020)

Reflection is a critical component of technology practice. It describes the strategic and self-managing aspect of learning. It includes distilling information for potential or future use, the planning and anticipation of issues and metacognitive thinking. Evaluation of prior learning is a part of distilling information to identify relevant learning for a new context. Self-generated questioning and self- monitoring of progress by being cognisant of what, how and why learning is taking place are critical. To successfully design and develop technological outcomes reflection must be active, continuous, and informative.

Socialisation identifies with the inherently social nature of being human. Technology is a human activity with significant physical, social and environmental impacts. Whether engaging in the use of or the developing technology students interact socially. When collaborating with others to develop single or parallel technologies, they experience interdependence, thus balancing of self-reliance and socialisation. Even when interacting with technology in a solitary manner children are still engaging with people. Their evaluation of the technology and decisions about whether to come back for further engagement will impact other people in the long-term if not sooner, for example teachers will not purchase a technological device, toy or piece of equipment that their students choose not to engage with. Technology practice also requires students to engage with clients and stakeholders.

The DTB outlined in the above paragraphs each incorporate a number of capabilities as seen in Table 2. These assist teachers in their recognition of the behaviours and teaching of technology through enhancement in the DTB.

Table 2: Capabilities within Desirable Technology Behaviours

Behaviours: Demonstration of:	**Resilience**	**Transference**	**Flexibility & Sophistication**	**Reflection**	**Socialisation**
Capabilities	Perseverance Managing Distractions Absorption	Making Links Imaging Noticing Questioning	Planning Distilling Reasoning Imagining Capitalising Evaluating	Questioning Distilling Revising Meta Learning Evaluating	Empathy & Listening Collaboration Interdependence Imitating

This TOCF uses the above behaviours and capabilities coupled with the components of technology identified through analysis of three national technology curricula (England, Sweden and New Zealand) to create sets of questions enabling the facilitation of teachers' exploratory dialogue with students to assist learning in technology. It is aimed at both improving learning for students and to develop teachers' understanding of technology content and pedagogical content knowledge. The framework was originally produced to work with students aged 4-6 years of age. This version has been published in the International Journal of technology Education (2019)29:1133-1152.

Parts of the TOCF version for students 11-13 years of aged are included in Table 3. When using the framework to assist conversations with students teachers should concentrate on one technology component or objective. Table 3 focuses of aspects of the nature of technology. By drawing on questions from this framework teachers are able to facilitate conversation and thinking about the deeper features of technology. Note where 'X' is used a specific technological product or system should be substituted.

Table 3: TOCF Nature of Technology

Strand and Achievement Objective	**Desirable Behaviours to Support Technology Learning**				
	Resilience Look for …. Evidence of understanding the developing technology may require repeated failure and modification Perseverance with and through issues Total absorption while others are working around them	**Transference** Look for students drawing on knowledge from other learning areas and technology learning to enhance their understanding of technology and to inform their technology practice	**Reflection** Look for … Critical analysis of technologies from the past, present and future Questioning and critique of existing technologies Questioning and critique of their own design decisions	**Sophistication and Flexibility** Look for advancement of key ideas and the ability to take thinking in different directions when considering past, present and future technologies.	**Socialisation** Look for understanding that…. Technology is for people. Technology impacts and influences people People influence technological design and development Technology practice is a collaborative process Technologists rely on others even when working on an individual project

What is Technology	How has repeated failure from the designer improved the functionality of this technology?	Tell me which knowledge and skills from other learning areas (e.g. maths, social sciences) assist the technologist as they design and make technology?	There are two ways of making a critical technology. One requires an extra month to manufacture it and the other requires extra material to manufacture. Either way the manufacturing cost is the same. Which way would you choose and why?	How has this example of a technology that has changed human physical limitations - either positively or negatively	Some technologies work but was not accepted by people? (Google Glasses, Segway are good examples) Why do you think people did not accept some technology?
	Identify three potential negative impacts of technology. What causes this impact?	Tell me which knowledge and skills from other areas of technology (e.g. digital, foods technologies) assist the technologist as they design and make technology?	If everyone could have X technology, how would your life change?	Give example of features in technology that you think are creative and well thought. Why is it so?	How does the role of the society affect the way in which technology in is used and produced?
	What could be done to prevent this impact or make the impact less sever?		How would your life change without technology?		

What Characterises Technology Outcomes	Take any obsolete technology from the past (example typewriter, pagers). Why are they obsolete today? What has replaced this technology? Why?	In this product design, what knowledge has been used from other subjects or areas like science or maths?	What about this design that confuses you? What kind of knowledge do you think you might lack to understand this thoroughly?	What is the key or primary function of this *technology*? How do you know this?	How do you think people in a colder, hotter, richer, poorer, more religious country would rate this product? Why? Do you think they would find it meets their needs in the same way?
	If you were a technologist, what steps would you take to make sure that your designed technology does not become obsolete?	In this product X, how has the technologist used understanding of function and aesthetics to make their design better?	If it was your job to design this technology X, what information do you think you would need to get a good outcome for your stakeholder?	Look at X. Identify a technology that has alternative functions to that of its original design. What influenced/ instigated this alternative use?	What kind of attributes do you think your parents/ grandparents/ Captain Cook *(or other famous person from history)* wanted for travel/communication/ food? How are your criteria for that different?
				Give an example of a technology from the past that we no longer use. Why do you think this technology was developed in that time and why isn't it around now?	Think of your life without X (name a specific technology), how would your life change?

Sources Funds of Knowledge in Technology

Technology education gives students unique opportunities to draw on their cultural knowledge to enhance their own and possibly others' learning. It facilitates useful interaction between knowledge found inside and outside the classroom and provides opportunity for rich conversations between students and teachers and between students. For students who have English as a second language oral dialogue about their cultural funds of knowledge has the potential to assist making connections with their classmates. For teachers it provides opportunities for insight into the worlds of their students. González et al. (2005) found that the more teachers know about the home and cultural activities and experiences of their students the better informed they are to maximise learning opportunities, thus making the most of knowledge and skills already accessible to some students. Students deploy of funds of knowledge in technology education from two sources: participatory enculturation and passive observation (Fox-Turnbull, 2012). Awareness of these two sources can again assist teachers' facilitation of conversations with their students, enabling students to value and transfer their cultural knowledge to their technology practice, gaining recognition and helping their peers as well as enhancing their technology practice.

Participatory enculturation

Gaining knowledge through participatory enculturation provides students with opportunities to learn and share information their peers may be unfamiliar with and involve practices unique to their family and culture. Skills and knowledge learned from active engagement in activity resulting in transferable knowledge are funds of knowledge through participatory enculturation. This engagement includes active participation, where the student is involved in the activity, or peripheral participation where they are on the periphery of the activity but able to engage through questions, conversation and 'helping out'. This might be a part of the gaining knowledge and skills from expert to novice such as mother to son or grandparent to grandchild. Knowledge gained from these experiences can provide students status within their peer group. This is more likely to occur in an inclusive class climate discussed earlier in the chapter. There are a number of avenues from which students gain funds of knowledge through participatory enculturation: family cultural, social and cooperative practices, family activity, after school activities, parents' occupation and interests and artefacts used at home. This was illustrated when Maddison (10) assisted her peers design and build their play prop, a representation of a large 1930's style radio. The frame was to be built from trellis wood. She had recently helped her dad build a tree house and knew that tylock plates (Figure 2) assisted the joining of flat wood. She assisted her group by sharing this information and requesting the purchase of some from her teacher, thus leading to a successful outcome which otherwise would have been difficult to achieve for this group of students.

Figure 2: A tylock plate for wood

Edgar also illustrated this use of FOK when he helped Debbie to create a papier-machè fish, again as a prop for their school production. Before the layers of paper and glue were added the children stuffed the stomach of their fish with paper to give it a three-dimensional affect. As he was pushing paper into the stomach Edgar said to Debbie that it reminded him of gutting a fish, only backwards. Edgar and his grandfather often went fishing. He recognised that fish normally did have "stuff" in their stomach and therefore their task was authentic.

Passive Observation

Learning technology through Passive Observation FOK occurs when students are non-participatory passive observers, for example, through watching movies, television or reading books. This knowledge is then applied it in their technology practice. This includes the location of technology in historical and cultural contexts. The story below illustrates using FOK through passive means to make sense of a historical location. A class of 10-year-old students were required to design and make historically situated props for their school production. They had learned that props assisted in the historical location of a play or setting. In an activity aimed at understanding the role of props in a play the students were given a range of photographs of play props. Minnie recognised a cart and knew they were from the past. She seen them in a video Little House on the Prairie - set in pioneer times in the Midwest of the United States of America. Minnie used prior observation to assist her personal construct of an object from a different era. In addition, a class of six year olds listened the props manager from the local Court Theatre explain the purpose and function of props. He illustrated his talk with a range of props his company used in the past. He discussed how each was used in situ. Issy was reminded of a show she has seen in the previous school holidays. As an audience member, she observed one particular prop used in a variety of ways. She was able to use knowledge gained from attending the theatre to assist her understanding of the definition of a technological outcome. Issy's input to the conversation indicated that she understood that props might have multiple purposes.

Conclusion

Teachers need to engage in quality intercognitive conversation with their students to help them make sense both cognitively and experientially of the world in which they live, learn and work. Technology education involves a rich combination of academic and practical activity and requires students to take risks and work collaboratively. Teachers need to know and understand their students and their communities and cultural practices to maximise learning opportunities in the classroom. Presented in this chapter, a number of considerations and strategies to assist this. Teachers must have a rich understanding of technology education. Understanding the nature of and facilitating intercognitive conversations will assist teachers in this endeavour. This chapter includes a number of strategies to facilitate teacher professional development and enhance the quality of classroom interaction. TOCF assists teachers with student questioning. It may also provide teachers with scaffolding needed to enhance their understanding of technology. Awareness of and understanding the role and values of students' FOK, assist teachers in making connections with students and ensures the taking of specific steps to provide an inclusive safe classroom where students are comfortable to take risks and fail. Using strategies such as talking partners and 'no-hands-up within this safe environment enables students the freedom to explore their thinking orally and learn in a non-judgmental manner thus enabling them to articulate and shift thinking if necessary thus sparking cognitive growth.

References

Black, P. (2008). Formative assessment in the learning and teaching of design and technology. *Design and Technology Education: An International Journal, 13*(3), 19-26.

Bloom, B. (Ed.). (1956). *Taxonomy of educational objectives: the classification of educational goals* (1st ed., Vol. 1). Longmans, Green and Co Inc.

Clarke, S. (2005). *Formative assessment in action: weaving the elements together*. Hodder Murray.

Clarke, S. (2014). *Outstanding formative assessment: culture and practice*. Hodder Education.

Claxton, G., Chambers, M., Powell, G., & Lucas, B. (2013). *The learning powered school: pioneering 21st century education*. TLO Limited.

Coffer, C. (2017). Exploratory and dialogic talk and creative learning In C. Benson & S. Lawson (Eds.), *Teaching Design and Technology Creativiely*. Routledge.

Csikszentmihalyi, M. (1990). *Flow: The psychology of optimal experience*. Harper-Perennial.

de Vries, M. (2017). Philosophy of technology: themes and topics. In M. de Vries (Ed.), *Handbook of technology education* (pp. 7-16). Springer.

Fox-Turnbull, W. (2012, 26-30 June). *Funds of knowledge in technology education* PATT 26 Stockholm, Sweden.

Fox-Turnbull, W. (2013). *The nature of conversation of primary students in technology education:implications for teaching and learning* University of Waikato]. University of Waikato.

Fox-Turnbull, W. (2016). The nature of primary students' conversation in technology education. *International Journal of Technology and Design Education, 26*(1), 21-41.

Fox-Turnbull, W. (2017). Let's get kids talking in technology: Implications for teachers. In P. J. Williams & D. Barlex. (Eds.), *Comtemporary Research in Technology*. Springer.

Fox-Turnbull, W. (2019). Assisting teachers' understanding of student learning in technology. *International Journal of Technology and Design Education, 29*(29), 1133-1152. https://doi.org/doi.org.10.007/s10798-018-9484-x

Fox-Turnbull, W., Reinsfield, E., & Forret, M. (2020). *Technology education in New Zealand: A guide for teachers*. Routledge.

González, N., Moll, L. C., & Amanti, C. (Eds.). (2005). *Funds of knowledge* (1st ed., Vol. 2009 Reprint). Routledge.

Jones, A. (2009). Towards an articluation of students making progress in learning technological concepts and processes. In A. Jones & M. de Vries (Eds.), *International handbook of research and development in technology education*. Sense Publishers.

Mercer, N. (1995). *The guided construction of knowledge-talk amongst teachers and learners*. Multilingual Matters Ltd.

Mercer, N. (2006). *Words & minds: how we use language to think together*. Routledge.

Mercer, N., & Hodgkinson, S. (Eds.). (2008). *Exploring talk in school*. Sage Publications Ltd.

Ministry of Education. (2007). *The New Zealand curriculum*. Learning Media.

Ministry of Education. (2009). *Indicators of achievement*. IPENZ. Retrieved 9 March from http://www.techlink.org.nz/curriculum-support/

Robertson, S.-A., & Graven, M. (2019). Exploratory mathematics talk in a second language:

a sociolinguistic perspective. *Educational Studies in Mathematics, 101*, 215–232. https://doi.org/https://doi.org/10.1007/s10649-018-9840-5

Schut, A., Klapwijk, R. M., Gielen, M., & de Vries, M. (2019). Children’s Responses to Divergent and Convergent Design Feedback. *Design and Technology Education: an International Journal,, 24*(2), 67-89. https://ojs.lboro.ac.uk/DATE/article/view/2611

Seemann, K., & Talbot, R. (1995). Technacy: Towards a holistic understanding of technology teaching and learning among Aboriginal Australians. *Prospects, 25*(4), 14.

Shields, C., & Edwards, M. (2005). *Dialogue is not just talk- a new ground for educational leadership*. Peter Lang Publishing Inc.

Spendlove, D. (2015). Developing deeper understanding of design. In P. J. Williams (Ed.), *The future of technology education:contemporary issues in technology education* Springer.

Vygotsky, L. S. (1978). Mind in society: the development of higher psychological processes. In M. Cole, V. John-Steiner, & E. Souberman (Eds.). Harvard University Press.

Webb, P., Whitlow, J. W., Jr.,, & Venter, D. (2016). From exploratory talk to abstract reasoning: a case for far transfer? *Educational Psychology Review, 29*(3), 565-581.