Chapter 8
Let's Get Kids Talking in Technology: Implications for Teachers

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Abstract Classroom conversations are core to establishing successful learning for students. This research explored students' conversations in technology education in the primary classroom and suggests some of the implications for teaching and learning. It used qualitative methodology which paid particular attention to the social nature of the classroom. Participants took their own photographs which were used in conjunction with a range of interviews with participants and teachers. Students' work samples were also used to develop a rich description of classroom conversation in technology.

The Questions I Asked and Why I Think They Are Important

Classroom conversations are core to establishing successful learning for students for two main reasons. The first, dialogue between teachers and students, assists teachers by giving students insight into their thinking and understanding. This enables teachers to adjust planning and teaching to meet specific needs of their students. The second is that through engagement in dialogue with peers and teachers, students are able to expand their understanding and knowledge. This research explored the use of talk in technology education in primary classrooms and the implications for teaching and learning.

The aim of this research was to understand and describe the role talk plays in learning technology. The analysis of conversation transcripts, students' autophotographs and observations of behaviour were used to describe and analyse the nature of classroom talk.

In this chapter classroom talk is considered from two perspectives: strategy and knowledge. Strategy refers to the strategies used to ignite and facilitate the conversation in the study. Knowledge refers to funds of knowledge, learning area knowledge and technological content knowledge which contribute to students' technology literacy.

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Main Question

What is the nature of conversation in technology education?

Subquestions

1. What types of conversations enable students to participate in collaborative technological practice?
2. How do students' prior and concurrent experiences influence their technological practice?
3. What happens in the classroom to increase the likelihood of students deploying knowledge and skills from other areas into technology?
4. What insights into technology education can be gained through an analysis of students' conversations with their teachers and peers while participating in technology education?

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

The findings of the study are useful and exciting because they help us understand how students learn in technology education. The study develops current understanding of the nature of talk and the role it plays in learning technology. It also presents new findings on the impacts that cultural knowledge and skills from home and community bring to technology. It also challenges existing findings on students' ability to transfer knowledge from one curriculum area to another.

How I Tried to Answer the Questions

This was a qualitative study which paid particular attention to the social nature of the classroom. In the study I interpreted the data to identify detailed aspects of the nature of classroom talk in technology. To do this I spent many hours in the two classrooms, one Year 2 class with 6- and 7-year-olds and one Year 6 class with 10- and 11-year-olds, over the period of a year, during the delivery of two technology units, each involving the planning and implementation of a different predetermined whole school theme. I took observations and oral recordings, interviewed students and teachers and gathered teachers' planning and students' work samples to develop a deeper understanding of the nature of classroom talk in technology education. The study took place in an urban New Zealand primary school.

In this research, the culture of the classrooms and the particular groups of students being studied were clear foci points. My role was clearly understood by all participants and I was present in the classroom during data gathering. As a registered teacher myself, I was able to quickly build a rapport with the students and establish myself as a teacher. The students' ability and willingness to tell their stories and share their ideas of technological practice with their peers, their teachers and me depended on, among other things, the culture of their classrooms. Technology education is a holistic and contextualised curriculum and therefore fitted well with the research methods I selected. I interviewed students initially and then became fully immersed within the culture of their classrooms. During the first unit 'futuristic travel' (Round 1), I assisted the teachers in the unit implementation. The second unit, 'props for the school production'(Round 2), was taught later in the same year and was when most of the data gathering occurred, as the students knew me from our previous work together.

In this study, I was a participant-observer. This meant I took a role in classroom proceedings while observing. Wolcott (1988) suggests this is an important way to gain information in this type of study. Taylor and Bogdan (1998) suggest that participant observation is particularly suitable within the natural classroom setting. I stayed with the participants for a substantial amount of time to reduce the effect I as a researcher had on the participants.

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

During the analysis phase of the study, open coding was used. All interviews were audiotaped and then transcribed, and the participants recorded photographic evidence of their technological practice was added. Detailed anecdotal observation notes were taken as students worked.

Systematic and meticulous organisation of the data was required. The steps used for data analysis in this study follow the process suggested by Lichtman (2006) and included the following:

Step 1 Initial coding and recognition of some central ideas from the raw data
Step 2 Revisiting initial coding, refining and modifying where necessary
Step 3 Developing an initial set of categories or central ideas
Step 4 Modifying of initial list after some additional rereading
Step 5 Revisiting categories and subcategories
Step 6 Moving from categories into concepts (themes and perspectives)

Broad conversation categories were identified based on the source and purpose of the conversation, how and why the conversation occurred. Initial analysis of stimulated recall conversations led to the identification of four significant unit stages: character and function, planning, mock-up and further analysis lead to the identification of the four key elements of conversation, funds of knowledge, making connections, management of learning and technological knowledge. Identification of the stages and elements led to the development of the conversation framework which facilitated in-depth analysis of conversation.

What I Found Out

The research findings show that classroom conversation in technology is situated within three themes and occurs from two perspectives. Figure 8.1 shows three conversation themes related to the perspectives of learning they offer, conversations with a strategy perspective on the left and those with a knowledge perspective on the right. Each of the two identified perspectives of conversation also has a number of aspects, also identified in Fig. 8.1. The three overarching conversation themes or purposes of conversation undertaken by students and their teachers are deployment, conduit and technology knowledge as seen in Fig. 8.1. The three themes occurred through two different perspectives: strategy and knowledge. The three conversation themes worked together rather like a set of cogs with the conversations from strategy perspective, acting as a 'conduit' between the two *knowledge* themes: deployment and technology knowledge. This is illustrated in Fig. 8.2 which demonstrates the interconnected nature of the themes.

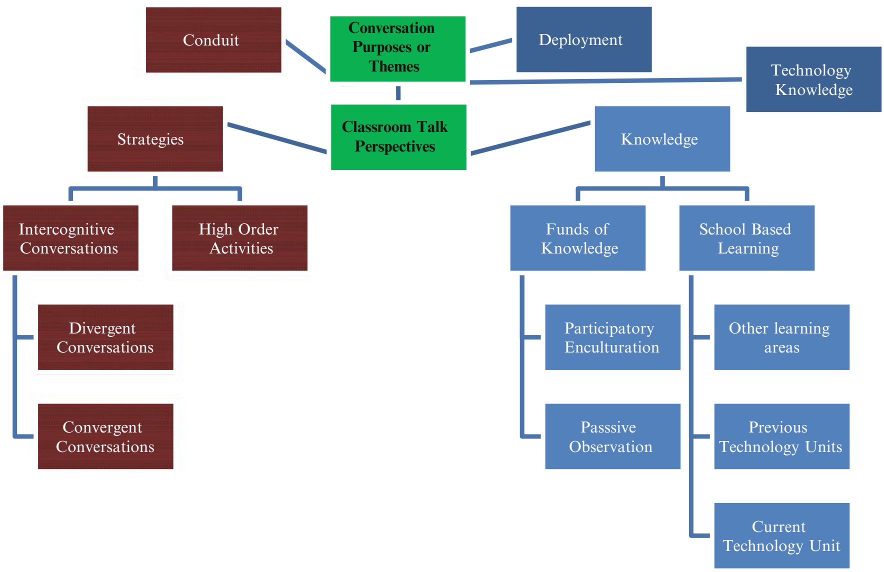

Fig. 8.1 An overview of key finding about classroom talk

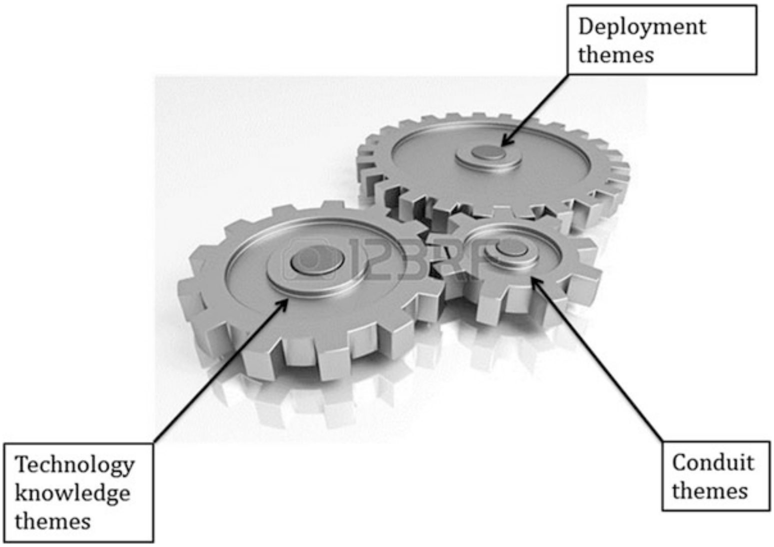

Fig. 8.2 The interconnected nature of emerging themes of conversation

Without the conduit themes, the deployment and technology knowledge themes remain unconnected and do not inform one another.

Themes

The first theme 'deployment' described knowledge and skills brought by students to their technological practice and therefore occurred through a knowledge perspective. Deployment themes identified knowledge and skills students deployed to facilitate their understanding of and learning in technology. They were sourced mainly from students' funds of knowledge and the links and connections they made before and during their current school-based learning.

The third theme, 'technology knowledge', was the second from the knowledge perspective and showed the exact nature of technology learning obtained by the students though the bringing together of the first two themes. The technology knowledge conversations were conversations where students demonstrated technological knowledge and skills in relation to their current project. Knowledge themes emerged from a synthesis of the deployment and conduit themes, discussed below, and evidenced students' understanding and learning of technological knowledge and skills and how they made connections to prior learning in technology.

The second theme 'conduit' described techniques and strategies used by teachers and students to maximise learning opportunities and acted as a conduit between other knowledges and technological knowledges. These conversations come from a strategy perspective. Conduit themes were identified from conversations facilitated and undertaken in the classroom based on management of learning, resources, time and behaviour.

Perspectives

Knowledge and Skills

The study found that students' conversations had a significant impact on their practice in technology. In the first theme – deployment – students come to their technology projects with significant knowledge from their home and cultural funds of knowledge by making connections to prior and current school-based knowledge. They therefore deployed knowledge and skills to contribute to their learning in technology, some knowledge they already possessed and brought to their practice without specific prompting from teachers. At times teachers explicitly drew on knowledge they knew the students had. This knowledge came in a range of forms and types and included not only direct content knowledge but also process knowledge and knowledge about ways to behave, for example, strategies for working collaboratively.

Funds of knowledge, knowledge drawn from home and community, were learned through two different methods. The first was passive observation in which learning occurred by watching without interacting such as watching TV or movies or reading a book. This was exemplified by Minnie who was able to use knowledge from a song she knew it assists her recognition of a picture of a waggon. 'Oh, it's from the olden days, a cart or something. Probably [used] like a hundred years ago or sooner, like. There's that song, Little House on the Prairie'.

The second method of obtaining funds of knowledge, participatory enculturation, occurred when students were actively involved in gaining new skills and knowledge. This was exemplified by Ellis and Anne who compared the process of stuffing the mock-up fish they were constructing in order to get a three-dimensional effect with the process of gutting and/or filleting a fish, which both children had experienced at home. Ellis had been salmon fishing with his grandfather and Anne with her immediate family. Ellis suggested that rather than removing salmon flesh from the fish, they were, in fact, adding to the fish. Anne agreed but used the more general term 'meat' rather than salmon.

Ellis	Yeah, like we're actually putting all the salmon into the fish.
Anne	All the meat into the fish and not all meat out of the fish.

Evidence of students' learning in technological knowledge was also evidenced in the third theme: knowledge. As the students worked through their technological practice, they evidenced learning of generic technology knowledge and skills, such as understanding the characteristics of technology, developing a brief and drawing and constructing technological outcomes. The nature of talk during students' technological practice altered as the students worked through different stages of their practice. In the early stages, the students were engaged in finding out about props in general and then more specifically 'their' props. Subsequently, their conversations changed to incorporate design and construction skills. Throughout, students were involved in talk with their peers and also with their teachers, at times collaboratively and at times one to one.

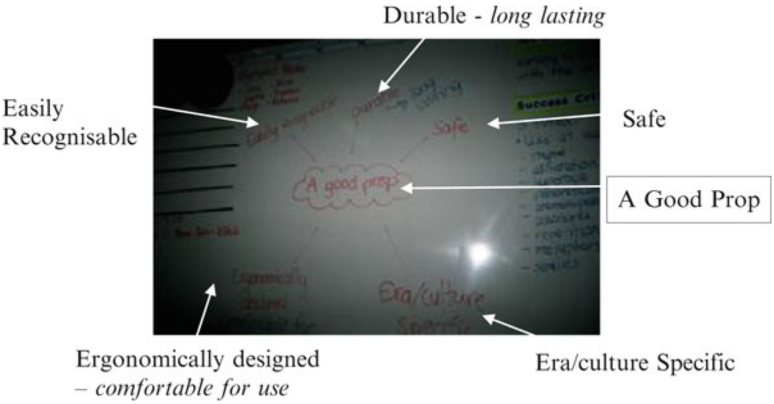

Fig. 8.3 Mandy's authophotograph of the initial class brainstorm with author added annotations for clarity

Strategies

All talks identified within the second theme 'conduit' were conversations used to facilitate and transfer learning to build understanding to technological practice. They therefore took a strategy perspective. Conduit conversations assisted students in recognising the relevance of prior knowledge and learning and gave students ample opportunities to explore, talk about and use pre-existing knowledge to enable this process. Talk in the conduit theme also included the implementation of teaching and learning strategies used to assist students' learning, managing their behaviour and resources. By explicitly drawing students' attention to potential sources of knowledge, teachers assisted deployment of this knowledge to learning in technology. Learning was facilitated through the careful implementation of planned and focused activities which enabled students' engagement in the synthesis, analysis and evaluation (Bloom 1956) of a new material. This study demonstrated that students' technological knowledge, skills and outcomes were enhanced through these planned learning activities and strategies. Two such strategies occurred in the Year 6 class, both illustrated below by Mandy's autophotographs. The first (Fig. 8.3) demonstrated brainstorming as a strategy to assist students' understanding of their topic. Mandy was able to tell me this about the photograph 'that was when we were thinking about a good prop, and we had to make it durable, safe, easily recognisable, ergonomically designed and specific to the era or culture'.

The second strategy illustrated in Fig. 8.4 is a PCQ chart, in which the students needed to identify the pros, cons and questions about, first, existing props and, second, their intended designs.

PCQ Idea:________________________ **Names:**________________

Pros	Cons	Questions
List all the benefits, strengths, plusses, advantages of an idea from as many points of view as possible.	*List all the negative aspects, contra ideas, disadvantages, weaknesses of an idea from as many points of view as possible.*	*Offers an opportunity to questions, curiosity, probing and 'what ifs'.* *'I wonder…'* *'What if…' or* *'It would be interesting to know…'*

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Fig. 8.4 Teacher template of the PCQ chart

Strategy Perspectives

Elements of conversation identified in the study indicated that students' conversations had a significant impact on their practice in technology. Of the three major themes of students' conversations, the conduit theme included strategies for learning to talk to advance thinking and strategies implemented by the teacher to assist students' higher-level thinking. Both impact on teaching and learning in technology.

From a strategy perspective, the conduit conversation theme was used to facilitate and transfer learning and understanding to students' technological practice. Conduit conversations included conversations and teaching strategies that assisted students' recognition of the relevance of prior learning. An implication for teachers is that students need to be given ample opportunities to explore, talk about and use pre-existing knowledge. Conversations in the conduit theme do this by acting as a pathway between the first theme, knowledge with the potential for deployment within technological practice, and the third theme, technological knowledge and skills. Conversations in the conduit theme also include the implementation of teaching and learning strategies used to assist students' learning. They assisted students by teaching them how to engage with their peers and by explicitly drawing students' attention to potential sources of knowledge. Learning can be facilitated through the careful implementation of planned and focused activities which enable students' engagement in the synthesis, analysis and evaluation (Bloom 1956) of new materials. This study demonstrated that students' technological knowledge, skills and outcomes were enhanced through these planned learning conversations and activities and strategies.

Teaching Strategies

The following sections illustrate a number of successful teaching strategies that can be used in technology. These are only a range of suggestions and the reader may have equally valid alternative suggestions. Using the context of this study, imagine teachers Fleur, working with 6-year-old, Year 2 students, and Clara, a teacher working with Year 6 (10-year-olds), asking their students to design and make props for their upcoming school production.

Through dialogue with each other, students were able to take knowledge and skill development further than they would have been able to do individually. This was exemplified by Rex (aged 6) who early in the study identified that working in his group was difficult but in the final focus group interview stated that by working together the group he had achieved more than he could have by himself. This has important implications for planning and teaching in technology. Talk is a vital component of learning. Teachers need to plan for and teach students to talk constructively, using debate and discussion as a tool for advancing thinking and understanding. During implementation students also need to be taught how to listen to and accept others' ideas without necessarily agreeing with them. Teachers also need to assist students to understand that, although their own ideas are not always accepted, their contribution may be still important because conflicting ideas and opinions force all members of the group to question and justify their decision making, thus making stronger connections to key concepts and knowledge.

Intercognitive Conversations

Intercognitive conversations describe a situation within which all participants learn through the talk and associated reflections. When participants are learning in, and about, a common context and engaged in constructive talk or dialogue, they actually assisted each other and advanced their own knowledge in and about technology. Debate, argument and/or disagreement also assists students' understandings in technology, but only if and when participants are open to change and new ideas. In situations where conflict arises, and because in technology students are often developing one outcome per group, they have to find a single solution, which means either acceptance of others' ideas or reaching a compromise.

In order to facilitate intercognitive conversations within their classroom, Fleur and Clara set up a classroom culture in which the students did not raise their hands to answer teacher questions. The students were taught to think independently, discuss, question and challenge their own and others' thinking without attacking or experiencing feelings of being attacked. They were also shown how to let go of

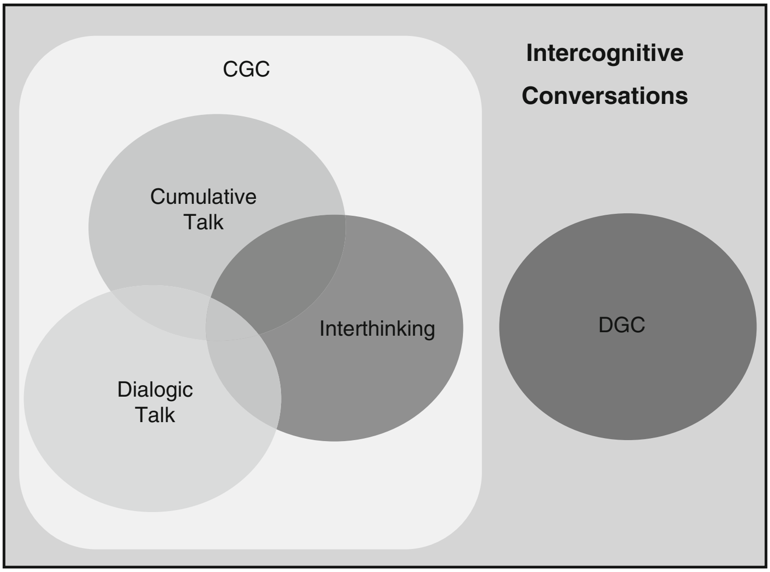

Fig. 8.5 The relationship between convergent and divergent growth conversations within intercognitive conversations

some ideas, to be open to the opinions of others and to alter opinions as new information come to light. When this occurred convergent growth conversations (CGC) happened with all participants moving to new understandings within the same context.

Intercognitive conversations are not restricted to students-students conversations. In this study while listening to the talking partner discussion, both teachers gained insight into how their students thought about technology and gained new knowledge about students' learning in technology. This type of conversation is characterised by divergent cognitive growth for all participants and is called divergent growth conversations (DGC). The relationship between the two is illustrated in Fig. 8.5.

Teacher Knowledge and Understanding of PCK and Students' Higher-Order Strategies

Strategies used in the study to enhance students' deeper understandings of technological process and the context of learning included 'no hands up' and 'talking partners'. The teachers carefully planned a series of questions for the students to discuss with their pre-selected 'talking partner'. The students understood that their talking partners changed weekly and that they were selected randomly. Strategies 'no hands up' and 'talking partners' were simultaneously implemented to assist students' conversations and thinking skills. After having an opportunity to discuss

Fig. 8.6 A sample of props brought by the props manager of a local theatre company

their responses in pairs, Fleur and Clara randomly selected pairs to share their conversation ideas with the rest of the class. Students understood that any one person could be selected to respond on behalf of their pair. These questions followed targeted experiences and activities such as a visitor from a local theatre speaking about props and the showing of video of a stage play with clearly distinguishable props. In these cases teacher questions included:

1. Why are props important to a stage play?
2. If your bedroom was to become a scene for a play, which things would be the most important props? Why?
3. Tell us how you think props make plays better?
4. Of the props the theatre props manager showed us which one was the best and why?

   Imagine a play in which there is a scene with children having dinner in front of the television watching their favourite show.

5. What props would be needed?
6. What would they be made of?
7. Rank them according to their significance (Year 6 only).
8. What attributes would the props need to display if the play was being repeated for five consecutive nights? Justify the inclusion of each one (Year 6 only).

When facilitating these strategies, teachers must ask open-ended questions; students first discuss their ideas and think with their 'talking partner' before sharing their ideas with others. Students do not raise their hands in response to the teacher questions; rather the teacher randomly selects several 'pairs' to share their views.

Other strategies included the bringing in of community experts who can assist the students to make authentic connections to the real world. As mentioned above, in this study the props manager from a local theatre company visited both classes, demonstrated and discussed the characteristics and function of props in a stage show. Figure 8.6 shows a number of the examples he brought with him.

Fleur also used an activity called true/false, in which she made a series of statements that the students discussed in their talking partners, one at a time. Each pair

Fig. 8.7 Three of the final props designed and developed by students, the first two by Year 6 and the third by Year 2

considered whether the statement was true or false, with reason. The statements included the following: props must be big; a thimble is a good prop; and a banana cannot be a prop. After each pair discussed their ideas with each other, they then shared their discussions with the class when requested by Fleur.

At Year 6 Clara also used true/false and another activity called PCQ. In this activity the students discussed the pros and cons and identified questions to critique existing props in the first instance and later their own designs. One child in his final interview stated that this activity ‘helped us think about what we needed to do to make our props’.

Engaging students in activities such as those outlined above facilitated their evaluation and synthesis of ideas to new situations. This is particularly useful in technology as when students are designing technological outcomes so they can draw from a range of experiences and knowledges to enhance their design ideas, process and the quality of their technological outcomes. Structured activities can result in a real change in learning. Evidence of learning, presented from this study, suggests this to be the case. The success of the final props, some of which can be seen in Fig. 8.7, was clearly evident at the final production.

Knowledge Perspective

The deployment conversation theme contributed to students' learning through a knowledge perspective. At times teachers explicitly drew on knowledge they knew the students already have; at other times students automatically deployed knowledge they had and which they understood would contribute their team's project. The fishing example used earlier illustrated this. Another group member suggesting that an oval is a good description of a fish shape recalling her learning in mathematics. In Clara's Year 6 class, the students were able to deploy measuring skills to design a scale model. They also brought knowledge from their parents' occupation to their technological practice, such as working with specific materials, wood and plastic, for example, or using bracing to join two sections of wood.

Funds of Knowledge

Students deployed knowledge and skills from their home and community, known as funds of knowledge, to assist and contribute to their learning in technology. This was the knowledge they already possessed and brought to their practice at times without specific prompting from teachers. Funds of knowledge influenced what students brought to their learning in technology. Student acquisition of knowledge, and then deployment of that knowledge into their technology project context, was a significant aspect of their learning. The analysis of the classroom talk indicated that students gained their knowledge for later transfer, from either their participation in activities with their families, interactions with artefacts or through social structures at home. I have called this use of funds of knowledge 'participatory enculturation'. This was illustrated by Alan and Dougal from Clara's class when they were selecting suitable materials for the stand of the microphone. Dowelling may come up as a possible option and a question was raised about how large (in diameter) it can be obtained. Dougal, whose father is a contractor, mentioned his dad had some quite large dowelling, which Alan then liken to a broom handle.

Dougal	My Dad had stuff about that big [indicates circle approximately 25 mm using the thumb and first finger].
Alan	Yeah broom handles are large dowelling.

Also to assist their technological practice, some students deployed knowledge from more passive activities such as watching TV or reading books. I have called this use of funds of knowledge 'passive observation'. This was illustrated when students recognised a waggon from a TV show and had knowledge about the 1930s microphones from watching old movies and their knowledge of fishing from reading a book.

When students brought knowledge from their home and culture to their technological practice, they were able to contribute to not only their group's technological outcome but their own and peers' technological context knowledge. By understanding the value of their own cultural practices, students put themselves in a better

Fig. 8.8 Mandy's autophotograph and comment about joining timber at 90°

position to assist their group, which in turn assisted the development of their self-esteem, a major contributing factor in students' learning. Students learned they had valuable contributions to make. The knowledge they took for granted as an integral part of their home and community culture was not known to their peers and subsequently they contributed significantly to their groups' technological practice.

An interesting finding from this study was that on a number of occasions when things got difficult for the students they drew on their funds of knowledge; such as when Mandy's group from Clara's class was attempting to join timber slats at 90 ° angles. Figure 8.8 shows Mandy's autophotograph of their challenging task. The text is the conversation Maddy and I had during her final stimulated recall interview about the photograph.

It is also illustrated by Rex's attempt to assist Debby and Issy to work cooperatively by suggesting they adopt his Dad's strategy for cooperating. 'What I used to do is if you there was two and there was one, so I did this, because my dad always says, "which one" and then the other two wanted two and then if there's one person who likes it, then we, we don't like it though' (interpretation-taking turns).

These findings have implications for teachers because they demonstrate that students learn from each other, and they all have home and community experiences that may contribute to others' learning. Teachers need to understand that students bring knowledge gained at home and in their community to technology education and use it to assist them in understanding and contributing when developing technological outcomes in a collaborative manner. It is therefore useful if teachers know their students and have an understanding of their cultural knowledges, skills and customs in order to assist deployment and enhance students' learning, social skills and self-esteem. With this understanding teachers are in a better position to plan units of work within authentically situated contexts and have the potential to motivate students by enhancing opportunities for them to implement cultural practices and knowledge from their homes and communities, to assist their own and others' learning. In order to be able to do this, teachers must first have knowledge of their students' cultural backgrounds and practices.

School-Based Learning Knowledge Transfer

While undertaking technological development, students also deployed knowledge from a range of other sources, to assist and contribute to their technological practice. They use knowledge learned in other learning areas and previous technology activities to assist their understanding of technological practice, for example, measuring and geometry mentioned above. As a technology unit progresses, students also deployed knowledge learned earlier within the current technology unit. Again imagine Clara and Fleur's classes. Early in the unit, they learned about props and their desirable attributes such as that props need to be durable and lasting, safe to use, easily identifiable, able to be seen and be in keeping with the historical and geographical location of the play. This knowledge was then be deployed later in the unit when the students designed their own outcomes.

This study found that the Year 6 students particularly implemented ideas they had gained from other school subjects without specific instruction to do so. Year 2 students also did this but less often. This counters research by Moreland and Jones (2000) and my own experience that students need to be specially taught to transfer knowledge from one learning area to another. One possible explanation is that the students in this study were highly motivated to develop quality outcomes, because they would be open to scrutiny from all those attending the school productions. Increased motivation to complete quality outcomes meant that students searched for ways of doing things well and therefore drew on knowledge and skills they had on hand as well as undertaking research where necessary. Teachers need to be cognisant of the impact an authentic context has on students' motivation to achieve in technology.

An implication of this for teachers is that students come to their technology projects with significant knowledge from their home, cultural and school communities. This knowledge comes in a range of forms and types and includes not only direct content knowledge but also process knowledge and knowledge about ways to behave and strategies for working collaboratively. Understanding this breadth of knowledge will enable teachers to prompt students' deployment of existing knowledge and skills through questioning and direct statements.

How This Might Be Used to Improve Teaching and Learning

The three most significant ways that teachers can use the findings from this study to improve teaching and learning are utilising funds of knowledge, planning and undertaking intercognitive conversations with their students to gain insight into students' learning in technology and planning opportunities for intercognitive conversations between students.

Teacher awareness that students' funds of knowledge can contribute significantly to their technological practice means that teachers can plan and implement opportunities for their students to be cognisant of and explore their own and others' relevant cultural knowledges related to their current project. The intercognitive conversation is a useful tool in this process. By using a range of activities and strategies such as the ones outlined in this chapter, teachers are able to engage with their students in a fashion that enhances the students' undertaking of their technological practice and will also assist teachers in developing deeper understanding of how students learn in technology, thus engaging them in 'teaching as inquiry' as outlined in the Effective Pedagogy section of The New Zealand Curriculum (Ministry of Education 2007, p. 35).

Further to this by facilitating the undertaking of student-to-student intercognitive conversation, teachers shift the focus of learning from the teacher to the students, thus embracing a student-centred approach to learning. To successfully implement student-to-student intercognitive conversations, teachers must teach specific strategies and attitudes to ensure students are open to others' ideas and flexible with their own thinking. Once achieved and intercognitive conversations are a natural part of the classroom culture, students are in a sound position to drive their own learning and assist their peers in theirs.

What Might Be Investigated Further

Although a number of potential investigations were identified as a result of this research, in this section I mention the five most relevant. The participants in the study worked collaboratively to design and construct their intended outcomes. In order to develop a single outcome as a group of three, collaboration and cooperation were essential. This study highlights the difficulties students had when working collaboratively. When working collaboratively students were forced to use intercognitive conversation with their peers in order to reach common understandings when different ideas were put forward. I believe there is potential for further study into students' ability to work collaboratively on a single project, while implementing a number of conversation strategies to assist in the collaborative process while protecting self-esteem. This would be particularly relevant to senior secondary schools where students are less likely to engage in collaborative technological practice despite it being commonplace in industry-based technological practice.

In this study students needed a range of knowledge and skills to assist their outcome development and construction process. The study identified two new sources of funds of knowledge. The first being participatory enculturation, in which students brought knowledge gained through active engagement in activities such as building tree houses with a father or fishing with a grandfather, and passive observation, in which knowledge gain came through noninteractive observation, such as watching movies and television. There is therefore potential to investigate these sources of funds of knowledge, to establish further insight into each and to determine the effectiveness of each and whether these are the only two sources of funds of knowledge, or are there others not identified through this research.

This study found that students in early primary school were able to develop mock-up designs to evaluate and modify their design ideas using a limited number of attributes to guide them. The Year 2 participants were able to articulate what a mock-up was and why it was made. This contradicts earlier findings and therefore opens opportunities for further research into how young primary school students' evaluate their technological outcomes using intermediate outcomes and attributes.

The study also found that students in Year 6 evaluated their outcomes using a greater number and more complex attributes than students in Year 2. In Year 6, students considered all their identified attributes: easily recognisable, durable, safe, era specific and ergonomically designed. In Year 2 only two of the five attributes were considered by any one participant in their product evaluations. This field has the potential for further investigation given the qualitative nature of this research and the small number of participants. It would be interesting to investigate whether it is a typical difference or whether it was unique to this study. Investigation could also be completed in related areas, such as the number and complexity of attributes able to be used by students at various levels of primary school.

In Year 6, the students understood the influences materials had on the quality and function of their final product. For example, Mandy understood that the wood would make a good frame for their radio but that it needed to be joined carefully. The radio group also realised that plastic coreflute could cover the frame and be painted to assist their design's authentic appearance. In Year 2, the students were not given an option of selecting suitable materials for their final outcome. Their teacher determined that the flying fish would be made from papier-mâché. This poses the question about the age and stage at which students are able to select appropriate materials for their outcomes to benefit the quality of outcomes and increase its likelihood of success, thus offering an implication for a researcher with the potential of a new field of investigation.

How Teachers Might Contribute to These Investigations

For teachers to be able to access the learning from this study, I recommend that they get their students working collaboratively on authentic technology projects. I suggest they facilitate students' movement out into the community to identify a real need with real clients and major stakeholders. By working collaboratively and embracing learning from a range of cultures and disciplines and working within an authentic context, students are able to extend their capabilities, knowledge and skills through the deployment of funds of knowledge. When engaging students in conversations, which facilitate synthesis, analysis and evaluation of materials and information, teachers are able to gain valuable insight into students' development of technological knowledge and concepts. In order to teach technology effectively, teachers need to have a good understanding of what students learn in technology and how that learning occurs (Jones and Moreland 2001). Also important is that by understanding the sources of deployed knowledge, teachers are in a better position to assist student deployment of this knowledge. Therefore, in classrooms where conversations about learning are a commonplace and a constructive environment is prevalent, then cognitive development is more likely to take place. Through conversation with their students and through listening to conversations among students, teachers are also able to gain insights into particular students' cognitive understanding in technology.

Teachers could further contribute to the above investigations by being aware of the importance of and undertaking the co-construction of outcome attributes as a guide to assist peer and self-product evaluation. They could also be purposeful in explaining to students how undertaking a range of modelling processes increases the likelihood of the development of successful outcomes.

Conclusion

Teachers should be encouraged to share their successes in technology education with their peers. Technological practice is usually a collaborative and cooperative activity. Classrooms are increasingly so, as teaching and learning pedagogies and practice align with learning in the information and digital ages and beyond. Successful teaching strategies and approaches could be shared on subject association websites such as TENZ (Technology Education New Zealand) and DATA (Design and Technology Association, UK). Subject association conferences are also another forum for sharing successful classroom practice. Such conferences frequently offer opportunity for teacher workshops in which ideas can be shared and discussed. The Ministry of Education in New Zealand also offers another medium (technology online) for sharing successful technological practice. I believe the current shift in many countries to collaborative teaching and innovative learning practices will assist this process and therefore assist researchers in technology education in the identification of potential research projects and participants.

An electronic copy of this PhD thesis can be found at this URL: http://researchcommons.waikato.ac.nz/handle/10289/7787

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