# Assessment for Learning in Primary Technology Classrooms

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**Abstract**
Emerging international research suggests that enhancing teacher-student assessment for learning (AfL) interactions is a key to enhancing student learning. Planning frameworks that make explicit the multiple dimensions of technology can be used to extend teacher knowledge and focus interaction. Effective AfL interactions in technology encompass the multidimensional nature of technology, help students build continuity and coherence between ideas and actions over time, and are multimodal. AfL in primary technology classrooms is complex. Yet in this complexity there are rich opportunities for effective AfL interactions that contribute to students' technology learning.

**Key words**
primary, assessment for learning, technological literacy, pedagogical content knowledge

**Introduction**
There is increasing agreement that assessment for learning (AfL) is an essential feature of classroom learning and that its development can raise achievement (Black and Wiliam, 1998). AfL is accomplished through teacher-student interactions and while these interactions can be informal they need to focus on key subject ideas and practices in a way that moves learning forward. In this paper we provide examples of productive teacher-student AfL interactions. We explain and show the need for teachers to be clear about and focus on the multiple dimensions of technology, the value of multimodal AfL conversations, and the need for AfL conversations to build continuity and coherence. These features benefit student engagement with and understanding of technology.

**Assessment for learning in technology classrooms**
People use technology to expand their possibilities, to intervene in the world through the development of products, systems and environments. To do this, intellectual and practical resources are applied. Technology education is a compulsory subject for many students throughout the world. The current focus of attention in technology education is towards technological literacy for all. This is also the case for New Zealand. In the New Zealand technology curriculum three strands are specified: technological knowledge and understanding, technological capability, and an understanding and awareness of the interrelationship between technology and society (Ministry of Education, 1995). The inter-related nature of these strands emphases a holistic approach for developing technological literacy. Technological areas are specified in the curriculum to represent the diversity of technological practice in New Zealand and include materials, information and communication, electronics and control, biotechnology, structures and mechanisms, process and production, and food. Technological learning outcomes encompass conceptual, procedural, technical and societal aspects reflecting the multidimensional nature of technological activity.

The technology tasks teachers devise for the students are necessarily complex in order to accommodate opportunities for students to achieve multifaceted learning outcomes in an integrated manner. This then means that tasks may be undertaken over time. The long-term nature of technology tasks poses particular issues for learning, teaching and assessment. These include students maintaining focus on the overall goals of the technology task, sustaining interest and engagement over time, and building connections between tasks and lessons. When teachers have students working on a technology task over time, they need to encourage students to think reflectively and projectively about the tasks they are undertaking. Teachers need to assist students to work iteratively when designing, making and testing (Kimbell, et al., 1991; Stables, 1997). Without this teacher assistance the design process can become ritualised and steplike. Students undertaking design in such a step-wise fashion can create a veneer of accomplishment (Hennessy, McCormick and Murphy, 1993; Lave, 1988). However, when students are undertaking technology tasks problems may arise that are unforeseen by them, or their teacher. These problems need to be dealt with on the spot. Teachers responding to students' emerging technological ideas and problems require an in-depth understanding of the nature of technology reflecting its multiple dimensions.

**Teachers and AfL**

Teachers are obliged to provide assistance such as the provision of models to be imitated, the orchestration of tasks and opportunities, feedback and guidance, and explicit explanations of principles and procedures (Black, Harrison, Lee, Marshall, and Wiliam, 2003; Wells and Claxton, 2002). This poses a number of challenges for technology teaching given that technology is complex. AfL is about recognising and responding to learning for the purposes of enhancing learning and is undertaken during learning (Bell and Cowie, 2001). It is accomplished through interaction and conversation. Productive teacher interactions involve descriptive feedback and discussion with students about the next steps in the learning process (Tunstall and Gipps, 1996).

For teachers to undertake AfL interactions effectively they require particular knowledge and skill, some of which is encompassed within the idea of pedagogical content knowledge (PCK). PCK is concerned with how teachers transform their knowledge of subject matter/content to a form their students can make sense of, but at the same time maintain the integrity of the content idea. Teachers need to understand subject matter and be able to clarify subject matter 'in new ways, reorganise and partition it, clothe it in activities and emotions, in metaphors and exercises, and in examples and demonstrations, so that it can be grasped by students' (Shulman, 1987, p.13). Teacher PCK is therefore crucial to the efficacy of their AfL interactions (Jones and Moreland, 2004). When teachers lack knowledge and understanding of what is important in technology they are not able to structure their interactions around curriculum learning goals and tend to focus on the managerial and social aspects (Black and Wiliam, 1998; Jones and Moreland, 2004; Moreland, 2003). The continuity of teacher-student relationships plays an important role in interactions. Mercer (1995) argues that the interactions in one lesson can be thought of as one part of a "long conversation" that lasts for the whole of the teacher-student relationship (p.70).

Interactions are integral to effective AfL practices. Effective AfL interactions require a complex blending of teacher knowledge including their knowledge of subject ideas, pedagogical approaches for teaching those ideas, and effective student learning of those ideas. To be effective AfL interactions in technology need to encompass the multidimensional nature of technology, and help students build continuity and coherence between ideas and actions over time. Effective AfL interactions in technology invoke multiple modes such as drawing, modelling and examination of real artefacts, not just talk, for communicating and developing ideas.

**Our research**

An interpretivist methodology (Erickson, 1998) underpins the three research projects that provide the data for this paper. The researchers in the first study worked with Years 1 to 8 teachers over three years to enhance their AfL practices in technology (Jones and Moreland, 2004; Moreland, 2003). The focus of the second study was to describe biotechnology teaching and learning in Years 5 to 10 classrooms (Moreland, France, Cowie, and Milne, 2004). In the third study currently being undertaken we are working in Years 1 to 8 technology and science classrooms over three years to explore the nature of effective student and teacher interactions around technology and science ideas and the PCK teachers utilized during these interactions. In each study multiple methods were used including case studies, interviews (teacher and student; individual and group), document analysis and classroom observations (Denzin and Lincoln, 2000). Combined, the research studies represent work over a period of nine years. In all, the researchers worked with 31 primary (Years 1-8) teachers.

**Aspects of AfL in primary technology classrooms**

In this paper we present 'telling examples' (Mitchell, 1985) of AfL interactions from six of our teachers. Rachel and her Year 2 and 3 students developed mock-ups of containers for storing their classroom mathematics equipment. Ellie and her Year 2 and 3 students made masks to wear in their school production. Burt and his Year 5 and 6 students designed hand held devices to aid those with arthritis. Betty and her Year 5 and 6 students made a light tower for a model stage. Jennifer and her Year 7 and 8 students modified traditional fermented drinks. Grant and his Year 4 to 6 students made signs for their school grounds. The examples illustrate three aspects of AfL in primary technology classrooms: being clear about and focusing on the multiple dimensions of technology, AfL interactions to build connections and coherence, and the value of multimodal AfL interactions.

***Being clear about and focusing on the multiple dimensions of technology***

To help students develop a sophisticated understanding of the multiple dimensions of technology it is important for teachers to identify and include these in their planning. Teachers need to be clear about and focus on the conceptual (knowledge and understanding of relevant technological concepts and procedures); procedural (knowing how to do something, what to do and when to do it); societal (the interrelationship between technology and groups of people); and technical (skills related to manual/practical techniques) aspects (Jones and Moreland, 2003). As well teachers need to think about and plan for the establishment and sustainment of a dynamic interaction between these aspects. The findings across the three studies illustrate how planning may be a tool for clarifying and focusing on the multiple dimensions of technology. Teachers perceived that planning around the dimensions added breadth, depth and focus to their interactions.

- ***Planning as a tool for focusing on technology as multidimensional***

Planning emerged as a key tool for assisting teachers to be clear about, and focus on, the multidimensional nature of technology, and to engage with the broad spectrum of student technology ideas and actions. When the teachers were planning they were required to think about the task/unit as a whole and how the activities they outlined might contribute to the full range of intended learning; their PCK was activated. The teachers began their planning by deciding on a topic and overall task that fitted their students. In each of the three studies the researchers provided the teachers with a planning format that required them to think about the conceptual, procedural, societal and technical learning outcomes of the task/unit. The planning format included a space that prompted teachers to think about how these learning outcomes would come together in technological practice, rather than being individual and discrete. This articulation helped teachers to decide what they wanted the students to know and do within the context of the overall task. Table 1 is an example of Rachel's planning for her Year 2 and 3 students (6- and 7-years) for their task of designing and constructing an attractive, portable and durable 3D storage container for holding classroom maths equipment.

Table 1 overleaf shows that Rachel defined the task through describing the broad task boundaries including the procedural aspects of designing and constructing, the technological principles of aesthetics, portability, and durability and the artefact to be constructed (a mock-up of a 3D storage container to hold classroom mathematics equipment). She also defined three overall aspects of technological practice, which were more detailed than the task definition, but not as detailed as the more specific learning outcomes she has articulated in the conceptual, procedural, societal and technical categories. There are connections between the task definition and the aspects of technological practice. In the aspects of technological practice she has identified technological concepts (knowing about the design process, aesthetics, portability, durability, practical solutions, and storage equipment for different groups of people) and procedures (being able to design, develop, evaluate the technological principles). She has also synthesised conceptual and procedural aspects in the technological practice aspects. For example, an understanding of the design process is to be blended in with developing a solution; and an understanding of attractiveness, portability and durability is to be integrated in with developing and evaluating solutions. Finally her planning shows the intended learning outcomes itemised in detail in the four categories where connections are also made to key aspects of technological practice. The conceptual learning outcomes specify the technological principles (durability, optimisation, portability, purpose of mock-ups, aesthetics); techniques (joining of materials); and materials and structures (nature of materials and size, shape and capacity of container); the procedural learning outcomes specify the procedures and processes to be undertaken; the societal learning outcomes specify the people and environmental considerations; and the technical learning outcomes specify the technical skills required.

RESEARCH

*Table 1: Rachel's planning*

<table>
<tr><td colspan="4">Task Definition:<br>Design & construct a mock-up of an attractive, portable, durable 3D-storage container to hold classroom maths equipment</td></tr>
<tr><td colspan="4">Key Aspects of Technological Practice<br>• Knowledge: Develop an understanding of the importance of the design process in developing a solution to storage problems;<br>• Capability: Develop & evaluate a suitable & practical storage solution for maths equipment taking into account attractiveness, portability & durability;<br>• Society: Identify the differing requirements for storing maths equipment for a variety of age groups of children.</td></tr>
<tr><th>Conceptual Learning Outcomes</th><th>Procedural Learning Outcomes</th><th>Societal Learning Outcomes</th><th>Technical Learning Outcomes</th></tr>
<tr><td>Understand:<br>• Design is an important factor in making storage containers.<br>• Planning includes criteria for making.<br>• Durability (takes lots of use over a long time).<br>• Nature of material to be stored needs to fit inside container.<br>• Optimisation of materials (don't waste materials).<br>• Container needs to be suitable shape for storage space (needs to fit) & suitable capacity for equipment (right size).<br>• Portability (1 person can carry it and easily move it around room).<br>• Joining of materials (staple, glue, tape, dovetails, tabs).<br>• Purpose of a mock-up – to test out some variables.<br>• Containers can be identified with labelling.<br>• Containers should be aesthetically pleasing (eye catching).</td><td>• Examine current storage in classroom to identify main variables for designing suitable containers.<br>• Select an option that needs improving.<br>• Examine nets, 2D & 3D drawings.<br>• Make annotated concept, net, & 3D drawings and take account of capacity, durability, portability & attractiveness.<br>• Construct 3D mock-ups. Test and evaluate for shelf size, capacity & portability. Make modifications.</td><td>• Establish and understand classroom storage need/problem.<br>• Different people have different aesthetic responses – attractiveness of area & containers.<br>• Recycling material is important for minimising waste.</td><td>• Draw from different views, magnify some areas.<br>• 3D drawing.<br>• Draw lines, right angles, nets.<br>• Measure.<br>• Cut.<br>• Join by: folding, interlocking, overlapping, glueing, stapling, taping.</td></tr>
</table>

Rachel's planning also demonstrates that she had her students in mind when she was detailing the learning outcomes as she defined their meanings in terms her students would understand. For example, durability was defined as 'takes lots of use over a long time'; portability as 'one person can carry the container and it can be easily moved around the room'; aesthetics as 'eye catching'; suitable shape as 'needs to fit'; and optimisation as 'don't waste materials'. Rachel had changed the different technological aspects into terms suitable for her young students. These translations could be used as guides for her AfL practices, as she specified the terminology she would use when interacting with her students. She commented after teaching the unit:

> *My formative assessment was more specific, as my interactions were constantly using the vocabulary that I wanted the students to understand and use themselves.*

Teachers' PCK as evidenced in their ability to analyse tasks to identify appropriate technological learning was enhanced considerably by their use of this planning format. Burt reported that the process of articulating and specifying concise learning goals compelled him to *hone in on the technological concepts and skills* he intended students to learn and helped him to consider the ways the selected activities could support learning. As part of his planning, for example, he investigated a wide range of technological learning outcome possibilities from which he then selected particular learning outcomes that best fitted his students and the overall technology task.

During the planning stage teachers were sometimes unsure of the technological ideas and procedures that might be embedded in a task. They sought this information from researchers, each other, experts in relevant fields, the Internet and a variety of other sources. For example, Jennifer, a teacher of Year 7 and 8 students had had very little experience of teaching biotechnology, the technological area she wanted to teach. She was concerned about the demands of biotechnology for her Year 7 and 8 students. She talked with other teachers and researchers to clarify the distinguishing characteristics of technology, science, biotechnology and biotechnological processes that could be suitable for her students. She was interested in ensuring that her students gained an understanding of biotechnology concepts through, and while they were undertaking, any activities she planned.

> *One of the hardest things is thinking of a biotechnology activity for this age group that will be hands-on. I want them to be making things, to be adapting living organisms. You could just get them to do some theory and have a debate, but that is not much fun. I don't think they learn as much as when they are doing alongside the thinking. You've got to have the thinking and the activity happening together.*

Teachers consulted a variety of sources to help them tease out the ideas and procedures embedded in the student tasks. They considered that the tasks and their embedded ideas and procedures needed to be also suitable for their students.

- ***Planning for the dimensions adds breadth and depth to interactions***

Teachers planned for the multiple dimensions of technological learning and designed activities to support these multiple dimensions. They reported that planning in this way changed their interactions; they now focused on the conceptual, procedural, societal and technical aspects within the tasks. For example, Burt reported that his being aware of the multiplicity of learning outcomes meant he was better able to appreciate and respond to divergent student ideas. He explained:

> *The planning helped me to have a better look at exactly what technology is being taught and what the technology is in different activities. The activities that I am giving my children are more clearly targeted and identified. My children had a fair idea of where they were going to go but they have still gone in a thousand different directions. You can start to see the divergence coming out in children and that's neat too.*

At the end of her biotechnology unit Jennifer commented that her clarity about the learning outcomes and the science and biotechnology ideas and activities had contributed to her interactions with students. She said:

> *Having the unit planned in advance in detail was important. We knew where we were going. I really had to be clear about the big picture. Teachers must have a solid understanding of the science behind the technology, or I think the learning wouldn't be that meaningful. It would be difficult for a teacher to scaffold a child if they don't really have a deep understanding and experience with the science.*

Other teachers in the studies also confirmed that there were connections between their planning and their AfL conversations with students. The responsiveness and focus of their interactions derived from their PCK.

### *AfL interactions to build connections and coherence*

The long-term and multi-dimensional nature of technology tasks means that particular students may struggle to see the connections between days, between activities and between ideas. Teachers helping students build continuity and coherence is a legitimate and important aspect for effective AfL.

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- ***Making connections***

Teachers in our studies nearly always took time to make links between lessons. Connections were effective when the linking focused on technology. For example, Ellie open and closed lessons with discussions related to the students' task of making a mask for their school production. Ellie orchestrated class conversations at the beginning of lessons to look back at what had been achieved and to introduce the activities and ideas for that day. End of lesson conversations were also set up so that activities and ideas of that day were reviewed. Together Ellie and the students talked about what might happen the next day. For example, in the following conversation at the beginning of the third day of working on their masks Ellie asked the students to recall the ideas from the previous day. She also introduced the activity and ideas for the day:

Ellie: *Today we are going to carry on with our ideas about masks. Can you tell me about your sketching from yesterday? What does it mean?*

Tama: *It doesn't need to be good.*

Paru: *It's fast and quick pictures.*

Ellie: *Aye (yes). So what did you sketch?*

Tama: *We sketched pictures of the mask we are going to make.*

Ellie: *Aye, kapai (good). You did sketches of the masks you will make, so you could decide on what you might make a mask of, and how they might look. Today we're going to go on from there and take a look at the specifications your mask will need to have. We'll talk about specifications now. What do you think this big word might mean?*

This dialogue allowed Ellie to check student understanding. Conversations like this guided the students to see how the activities they were undertaking linked to each other and contributed to the overall task. The conversations built a sense of connectedness and continuity across the technological ideas. The students were encouraged to think ahead to next steps and to think back to what had happened and what they learned. These conversations provided a framework to help students monitor their ideas and progress over the course of the lesson and unit.

- ***Supporting coherency and continuity***

Success criteria are often advocated within the AfL as a means to support students' self-assessment. Just as importantly they can serve as a mechanism to develop continuity and coherence in students learning and understanding. In technology product specifications are encompassed in the brief that the technologist works to. Teachers and students may use product specifications to the same effect as success criteria. Betty and her Year 5 and 6 students were involved in designing and making a light tower for a model stage. Betty used success criteria as product specifications as a tool for students to independently assess their product. They contributed to building a sense of coherency. Students used the success criteria to assist them in the design and evaluation of their model. Betty encouraged the students to use the success criteria, which were posted on public display. The success criteria were an on-going point of reference and therefore provided coherency in the design process.

Betty: *Now, how big is it? (the model light tower) going to be? Look at the success criteria, how big is it going to be?*

Kyle: *25-35cm.*

Betty: *That's right. So you have to think of a material Kyle that you can make it out of that would fit that. Okay. Now we did choose that height because, look at our stage, our stage is about 30 cm (she measures again). So your light tower has to be between that height and that height (she points to height criteria specifications written on the board).*

Betty told the students that the criteria were to *help you keep focused on what we are doing, what we are working towards.* It was this explicit and ongoing emphasis on the main task and its success criteria (product specifications) that provided for coherence of student experience.

***The value of multimodal AfL interactions***

Technologists draw, make models and prototypes to develop and test ideas. In technology teachers typically engage students in tasks that have a practical aspect. As teachers and students work together on technological tasks, meaning is constituted through the interplay of linguistic, pictorial, material and gestural resources (Kress, et al., 2001; Roth, 2005). These experiences provide students with access to multiple modes for developing, representing and communicating their technological ideas. An analysis of the teacher-student interactions in our studies revealed that the teachers deployed a range of strategies when interacting with students to assess and come to a shared understanding of the task and related ideas. The strategies incorporated multiple means for representing and exploring student ideas and designs. Drawing, modelling and manipulating materials contributed to, and became integral to, teachers and students exploring tasks and negotiating ideas together.

- ***Helping students to understand and particularise the task***

Students may need teacher guidance to understand and particularise the task so that it is meaningful to them. Students need to make connections with the task if they are to draw on their prior experiences. Because technology briefs are often multi-faceted and complex, students may require help to define, and refine, the task they will work on. For example, Ellie and her 6- and 7-year-old students were involved with designing and making masks for their school production about Maui (a Mäori mythical person). Ellie set up an introductory activity where the students examined real masks and books about masks to get ideas in preparation for creating their own. Two boys had the following conversation:

Rakai: *Let's look in the books and get a (sic) idea to choose then.*

Tama: *Yea.*

*(The boys looked through the mask book together. They were very taken with the patterns on a photograph of an African mask.)*

Tama: *Look at that.*

Rakai: *Yea.*

*(Ellie joins the boys to check their progress.)*

Ellie: *What have you got there?*

Tama: *Patterns on a mask.*

Ellie: *Oh, it says here [pointing to the text] this is an African mask. It looks a bit like moko (traditional Mäori facial tattoo).*

Rakai: *Let's do a warrior then. They can have that (pointing to the patterns on the African mask).*

Tama: *OK. (Enthusiastically)*

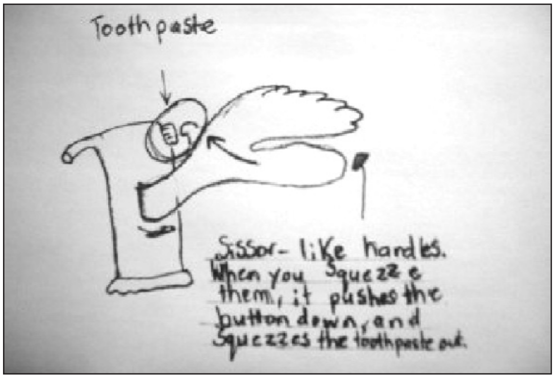
Ellie: *That's good. Now I'll give you some more books to get some ideas for making a warrior mask.*

In the first part of their conversation Tama suggested they get a book to help them find ideas. Ellie entered the conversation when the boys' attention was focused on a decorated African mask. She asked about it; Tama told her the features they were looking at 'patterns on a mask'; and then Ellie gave them new information 'this is an African mask'. She connected the patterns on the African mask to the boys' cultural experience of moko. This customization opened up new possibilities for the boys because of the explicit connection to their past experience of moko, something that Maori warriors had tattooed on their faces. In response to her comment Rakai proposed that they make a warrior mask. Ellie praised the boys for reaching their decision. She gave them some books to help them think about their next steps around how to make such a mask.

- ***Establishing a shared understanding***

The complexity of technology tasks can pose a challenge to shared understanding between teachers and students. Teachers need student ideas to be manifest before they can interact with them. Multimodal conversations provide rich points of entry into discussion of ideas. The necessity for a conversation to involve more that talk is evident in the following example. Burt had noticed that Danielle, a 9-year-old student, was sitting looking at her concept sketch of a device she was designing to help people with arthritis get toothpaste out of toothpaste tubes more easily. The first drawing is Danielle's concept sketch.

RESEARCH




*Danielle's concept sketch*

Burt asked Danielle to explain her sketch to him.

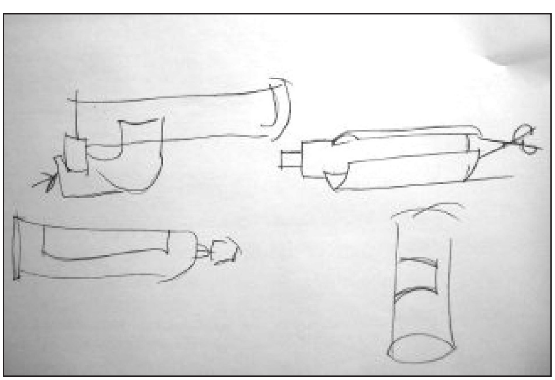
Burt: *I'm not sure how this works? (He pointed to the scissor-like handles at the side of the toothpaste tube). Does this go in to the toothpaste tube and push against it?*

Danielle: *No. That joins onto it, so you clip it on. (She pointed to the piece attached to the side of the tube).*

*Burt (looking puzzled) OK. But what does this do? (He pointed to the scissor-like handles again).*

Danielle: *There's a button that you press there and then you pull up the handle and the toothpaste comes out.*

Burt was puzzled and began to draw his interpretation of her ideas. The second drawing presented here shows his sketches. The top two are his ideas for getting toothpaste out more easily. The bottom right-hand sketch is another view. As he drew the bottom left-hand sketch he described the sort of toothpaste tube he was designing.



*Burt's sketches*

Burt described his toothpaste tubes as being soft-sided and with screw tops. Danielle then realised he was thinking of a different type of toothpaste tube from her. She explained that her drawing was of a pump toothpaste tube, not a squeeze tube. Burt then sought confirmation he had understood her correctly using her sketch as a referent:

Burt: *Oh, those pump ones. So you are making a device that will depress the pump easier.*

Danielle: *Yes.*

Burt: *(Pointed to Danielle's concept sketch and the handles). So this is your device and it is going to go on here and basically you are going to have a bigger device to press down the existing depressor. Is that where you're going?*

Danielle: *Yes.*

In this example, the combination of talk, gesture and drawing were pivotal to Burt and Danielle coming to understand each other's ideas. The drawings served as tools that contributed to the meanings that were taken-as-shared by Burt and Danielle.

- ***Extending technological thinking***

Multimodal interactions are productive when teachers interact with students to extend their technological thinking. This happened in the continuation of Burt's conversation with Danielle. Once he understood Danielle's idea his goal turned to helping Danielle think about the functionality of her device if it were to be used. Burt helped Danielle develop her device by focusing her attention on the key features of functionality for a workable device that could be attached to a pump toothpaste tube.

Burt: *I see. You're saying that as you pull this one up (Pointing to a handle) it's going to push down like that. So you might need a **hinge** in here (Pointing to the space between the handles).*

Danielle: *Yes, I suppose I will.*

He prompted Danielle to think about attaching her device to the pump and to stability issues.

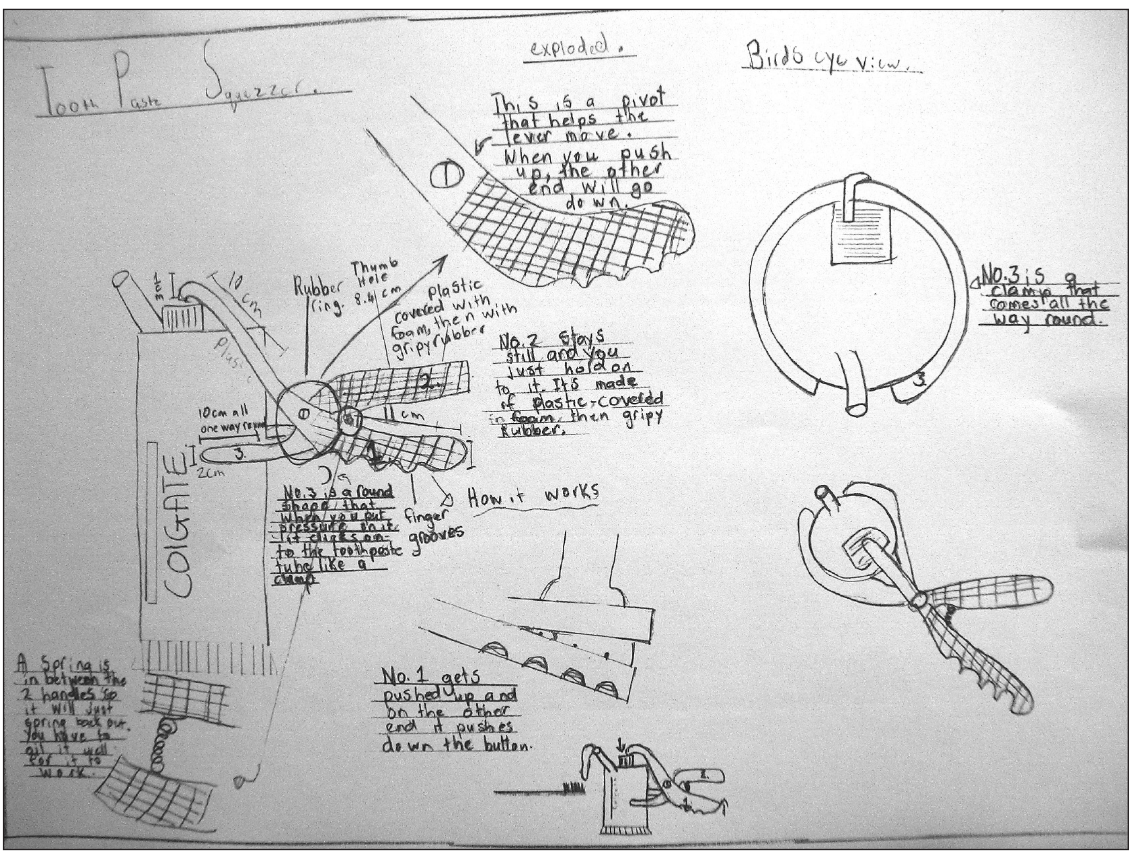
Burt: *And this one is going to be locked on. I want you to think about how you are going to* ***lock that on*** *and think about how you* ***attach*** *it to there (Pointing to the pump). You will need to draw them as exploded drawings. My one concern is, that I've got this device and it is attached to the toothpaste pump here, (Pointing to the joining point). I'm wondering about how to make sure the pump doesn't fall over, I'm wondering about its* ***stability****. That's what I want you to also think about. What an interesting idea. It's different.*

In this sequence Burt's AfL conversation utilised Danielle's concept sketch to alert her to aspects of functionality relevant to her device: hinging, attachments and stability.

- ***Artefacts as a source of ideas and feedback***

Technological development may involve the analysis and refinement of existing technologies. With appropriate teacher guidance real artefacts are a rich and powerful source of ideas and feedback. For example, Ellie used books with mask photographs for this purpose. In a continuation of the previous sequence Burt encouraged Danielle to examine the range of devices for arthritis sufferers that he had previously collected. Burt also provided her with examples of how mechanisms are represented in exploded drawings. Danielle studied these. She also talked with peers and looked at their work, practised drawing skills and participated in follow-up conversations with Burt. Danielle's final designs presented here indicated she had made coherent sense of the task. She had appreciated and addressed the task as a technological one.

RESEARCH




***Danielle's final concept sketches***


*Sarah's pool sign*


*Ann's car park sign*


*Hine's office sign*

In another example Grant's students made outdoor signs for their school. Initially he took his students on a 'discovery walk' around the neighbourhood to examine signs in situ to discern their shape, their visual impact and fitness for purpose. He also took photographs of many signs around the town and neighbourhood, placed them in a *PowerPoint* presentation, which he showed to the students. In addition he gave printouts of the photographs to each student. His students initially examined the *PowerPoint* photographs as a class and discussed their salient features. With this information, and the information they had gleaned from their walk, they established the specifications for their own signs. They referred to the printouts over time for more particular detail and usually as individuals. Features such as suitable materials, weatherproofing, structural stability, and sign and lettering size and colour were evident in the students' final products. Incorporating these features was critical given that the signs were to be actually used in the school grounds (see photographs of some completed signs).

The analysis of existing artefacts, systems and environments provides a source of ideas for students when they design and produce their own artefacts, systems and environments. They provide a vehicle for students to think about and a forum for teachers and students to talk about. Teacher guidance is important in helping students to analyse and transform and translate the salient aspects of examples into something that is useful for their context and purpose.

**Discussion**

In this paper we have illustrated some of the ways the teachers we have worked with have been able to establish and sustain effective AfL interactions in primary technology classrooms. Teacher pedagogical content knowledge plays a crucial role in assisting teachers to plan for student learning and to think about how they might interact with students around technology ideas and practices. Planning is a powerful tool for helping teachers clarify the intended learning, deepen and extend their pedagogical content knowledge, design learning activities and anticipate AfL interactions. Planning formats that make explicit the multiple dimensions of technology, and that require teachers to detail the accompanying activities, support teachers to envisage and build links between the learning goals and effective interactions. The teachers indicated that the planning had changed their AfL interactions to focus on each of the conceptual, procedural, societal and technical aspects of the tasks and the relationship between these aspects. The teachers in our studies considered that detailed planning increased their ability to respond to student understanding of technology ideas and, at the same time, increased their confidence to allow students to pursue divergent ideas and interests.

An important goal for AfL interactions is to help students build a sense of continuity and coherence between ideas and actions over time. Technology tasks are usually complex and multifaceted. Product/artefact specifications are integral to students understanding and achieving technological solutions. Product specifications provide a touchstone in the design-make-test process thereby acting as a means to connect and provide coherence to these activities. In technology AfL success criteria can be the same as product specifications. Hence, in technology success criteria/product specifications can support students' genuine involvement in AfL and enhance their technology learning.

Multimodal interactions provide rich entry points into students developing ideas. In technology teachers can use different modes singly, and in combination, to help students understand and particularise a technological task. For example, drawing and the examination of real artefacts are authentic activities that can help students access a range of ideas and solutions. Teacher and student use of multiple modes in technology helps develop shared understandings and extends students' technological thinking.

Technology is a multidimensional and multimodal subject. This means that the challenges teachers and students face in AfL interactions are complex. Yet this very complexity provides teachers with rich opportunities to find out about, and engage with and enhance, student learning.

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