Int J Technol Des Educ (2007) 17:179–195
DOI 10.1007/s10798-006-0008-8

RESEARCH ARTICLE

Teachers learning about technology and technology education: Insights from a professional development experience

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Received: 18 August 2005 / Accepted: 14 March 2006 /
Published online: 29 December 2006

Abstract The introduction of technology education in primary and secondary schools during the past 10–15 years around the world has presented a number of difficulties for teachers, primarily related to their coming to understand the phenomenon of technology and to conceptualise the technology learning area in line with national frameworks. This paper reports on a professional development experience that aimed to assist a small group of primary school teachers to develop their understandings of technology and technology education. A theoretical model framed a series of professional development interactions between the researchers and the experienced teachers who were new to teaching technology. Data sources included teacher interviews, video recordings of the activities, teacher made models, and extracts from their reflective journals. The study presented some insights into how professional development experiences for teachers new to technology could be organised and implemented to best support their developing technology practices and understandings.

Keywords Teacher knowledge development · Technology concepts · Teacher professional development · Technology education

Introduction

Curriculum developers in many countries have drawn attention to the importance for students to develop knowledge and skills of technology, and this has been acknowledged in national statements such as *Benchmarks for Science Literacy: Project* 2061 (American Association for the Advancement of Science, 1993), *Standards for Technological Literacy* (International Technology Education Association, 2000) and *A Statement on Technology*

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for Australian Schools (Curriculum Corporation, 1994). The perspective of technology described in the recently introduced Queensland Years 1 to 10 Technology syllabus document (Queensland Studies Authority (QSA), 2003, p. 1) and adopted for this study is that technology involves ''envisioning and developing products that meet human needs and wants, capitalise on opportunities and extend human capabilities''. The syllabus was formally implemented in 2003 and Technology became one of eight key learning areas (other key learning areas include—English; mathematics; science) in Queensland primary schools, which span the age group enrolled in Years 1 to 7 classes. While drafts of the syllabus existed for more than five years before the formal introduction of the syllabus, at the time of the study, not all teachers were familiar with its contents and so faced the challenges of developing their own understandings of this new key learning area of technology and then implementing the syllabus in their classrooms.

Concurrent with the initial development of the Technology syllabus, Education Queensland launched the New Basics Project (Education Queensland, 2000) designed to refocus and reorient teaching and learning in schools towards ''researching, understanding and coming to grips with the new economic, cultural and social conditions'' (Education Queensland, 2000, p. 37). The proposed way of viewing education embodied in New Basics focused on three aspects: new basics (what is taught; this covers the key learning areas of which technology is one); rich tasks (how students show their knowledge and understanding); and productive pedagogies (how teachers teach). This re-thinking of education meant that teachers were expected to develop sophisticated views and understandings of teaching for learning; and to educate students to participate within the ''supercomplexities'' (Barnett & Hallam, 1999) of a knowledge society. Themes underpinning the New Basics Project indicated the need to provide an education that stimulates ''epistemological and ontological disturbance in the minds and in the *being* of students'' (emphasis in original), while at the same time supporting the development of a mindset that would ''enable students to live at ease with this perplexing and unsettling environment'' (Barnett, 1999, p. 154). In addition, such an education would ''enable them to make their own positive contributions to this supercomplex world, while being sensitive to the unpredictability and uncontrollability of the consequence of what they say and do'' (Barnett, 1999, p. 154). Identifying what counts as knowledge, whether the individual school curriculum is expressed in the form of key learning areas or as New Basics, has thus become an important aspect of understanding for teachers of technology to develop (O'Brien, 2002). Alongside this, the need for teachers to develop sophisticated notions of the role knowledge plays in society, and to be able to create futures-oriented and equitable learning environments responsive to students needs, have become paramount (Education Queensland, 2000).

Banks and Barlex's (1999) teacher education experience, and the professional development studies undertaken by Banks et al. (2004), and Jones and Moreland (2004) have highlighted the changes and challenges to teacher professional knowledges (Shulman, 1986) when technology education is introduced. For example, there has been recognition of the important place teachers' personal subject construct knowledge has in underpinning the whole range of their professional knowledge about technology. Personal subject construct knowledge influences, and is influenced by, teachers' school knowledge, or their understanding of how technology as a school subject is different from technology in the outside world; their pedagogical knowledge, in Shulman's (1986, p. 9) words, ''the ways of representing and formulating the subject matter that make it comprehensible to others''; and their subject knowledge or their understanding of technology as a field.

Difficulties experienced by primary school teachers introducing technology education have been well documented. For example, Jarvis and Rennie (1996) argued that teachers' limited understanding of technology caused problems and teachers struggled to articulate links between technology and national frameworks (Mittell & Penny, 1997). Teachers' limited knowledge of specific tool and practice skills (Anning, 1994) also contributed to the difficulties they faced. All these struggles point to the challenges that teachers are facing as they endeavour to conceptualise teaching and learning within a new subject area context. In addition, with the gradual introduction of the New Basics Project (Education Queensland, 2000), which encourages teachers to integrate learning areas through ''rich tasks'' and to focus in a new way on how they teach, there is a strong possibility that they will feel under even more strain. Thus our interest in exploring possibilities for professional development in technology education.

An outcome of our past studies was a theoretical model (Stein, McRobbie, & Ginns, 2000) which incorporated a number of elements drawn from the professional development studies/models mentioned earlier (Banks & Barlex, 1999; Jones & Moreland, 2004; Shulman, 1986); elements about which learning occurs during effective professional development. Our model highlighted the key role played by active processes of reflective engagement with theoretical and practical ideas; essential processes, we have argued, to be included in professional development experiences, if those experiences are to have a positive impact upon teachers' learning (Stein et al., 2000). The study of a professional development experience for teachers, reported in this paper, was underpinned by the model shown in Fig. 1, which is an integration of the models of Banks et al. (2004) and Stein et al. (2000). By combining the two models (Banks et al., 2004; Stein et al., 2000), we attempted to devise a clearer, simpler model than the original model (Stein et al., 2000) that would underpin and guide our interactions with teachers, as well as form a framework for data collection and analysis during the study. The combined model maintains the critical component of teachers' reflections on their own and others' conceptions of technology, on pedagogical knowledge and upon technological practices in accord with the recommendations of Banks et al. (2004), Jones and Moreland (2004), Jones, Mather, and Carr (1995), and Stein et al. (2000). In this way, the approach we have attempted to represent through this model is based upon the ultimate intentions of professional development described by Cochran-Smith and Lytle's (1999) knowledge-of-practice conception of teacher professional development. This conception is where ''teacher learning begins necessarily with identifying and critiquing one's own experiences, assumptions and beliefs'' (p. 279) and where the goal of any professional development experience is ''understanding, articulating and ultimately altering practice and social relationships in order to bring about fundamental change'' (Cochran-Smith & Lytle, 1999, p. 290). While we have not replicated the knowledge-of-practice idea to its full extent in our model in Fig. 1, that is, that teachers are led to see their classrooms as formal sites for intentional, planned research, we have embedded reflection into the heart of the model. In doing so, we have ensured that the key activity in teacher-led and focussed research, that is, the act of questioning knowledge, practice and assumptions, is prominent.

In Fig. 1, the series of three intersecting circles represents the combination of knowledges that the teacher develops during professional learning (Banks & Barlex, 1999; Shulman, 1986). A professional development programme that provides experiences of a reflective, practical and theoretical nature, represented in the outer most circle, facilitates and frames any process or activity through which teachers are assisted to articulate, challenge and reformulate their knowledges. The critical role that reflection plays in supporting and enhancing professional knowledge growth has been well documented (e.g., Butler, 1996; Schön, 1987). According to Butler (1996), reflection is the means through which teachers are enabled to translate experiences and ideas gained through professional

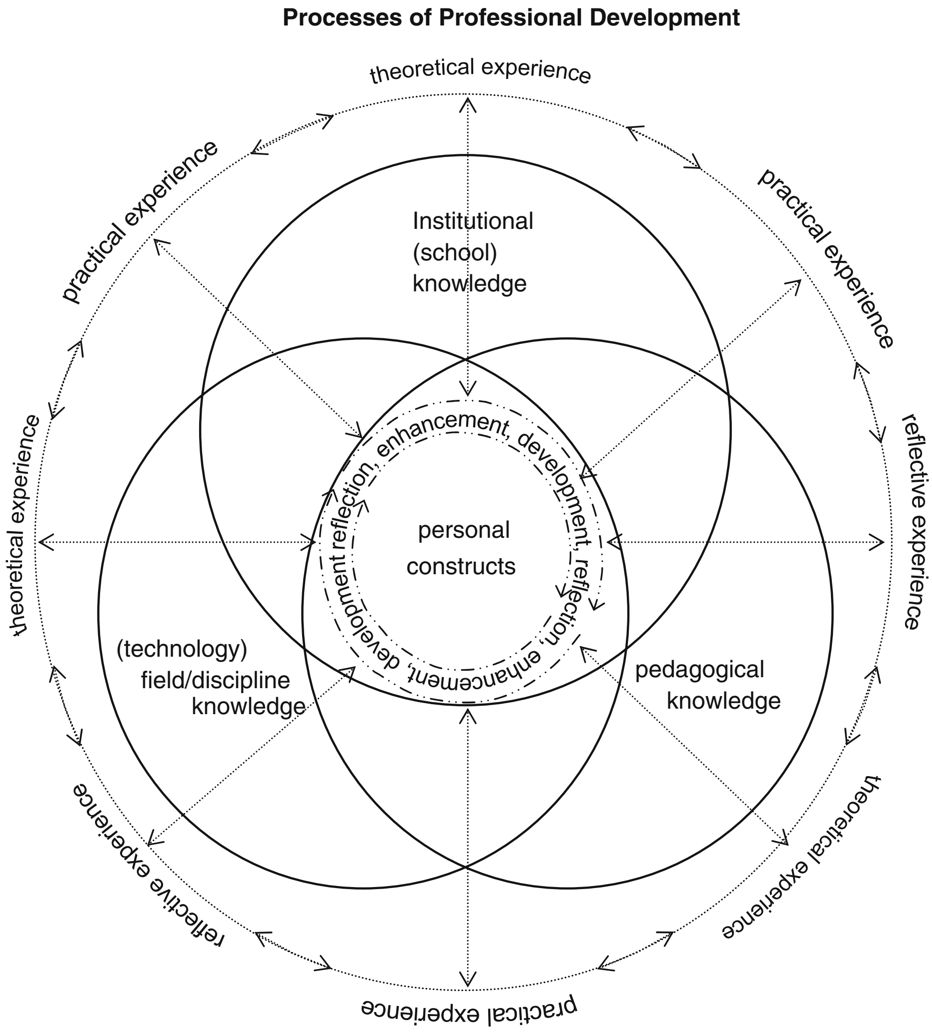

Fig. 1 A professional development model for technology education

development activities (the reflective, theoretical and practical experiences in the outer circle in Fig. 1) and make them their own, that is, embed those ideas and practices they learn about into their personal, professional, practical knowledge (represented in the centre of the model in Fig. 1 as *personal constructs*). It is through the active reflection, development and enhancement of personal constructs and experiences that this occurs. The centrality of personal constructs in our model is thus represented as influencing the meaning teachers make of their experiences and the sense they make of learning that happens in a professional development context (Fishman, Marx, Best, & Tal, 2003; Jones & Moreland, 2004). It is at the personal construct level that change in technology teaching and learning beliefs and practices will occur (Butler, 1996; Cochran-Smith & Lytle, 1999). Change of this nature can be a slow and gradual process, but the quality of change is more likely to be that of a deep and lasting nature that is on the level of belief and understanding rather than on the level of easily observed practices only (Butler, 1996). In Fig. 1, the lines connecting the practical, theoretical and reflective experience in the outer circle and crossing through to the central section, represent this need for professional development experiences to provide opportunities for teachers to make explicit connections between professional development activities and their own personal constructs.

Intentions of the study

The aim of this study was to investigate how a professional development experience enabled a small group of primary school teachers to extend their personal constructs of technology and technology education, including their pedagogical knowledge and their technology field/discipline knowledge. With some focus on technology concepts and processes, it was also important for us to consider the imperatives for education within the existing framework of key learning areas and associated syllabus documents, and emerging through the New Basics Project (Education Queensland, 2000). Hence we decided to create a learning situation for teachers that would engage the teachers in rich tasks (Education Queensland, 2000). The integration of science with technology is not only a logical combination for many primary school teachers, but also a combination that lends itself to the formulation of rich tasks. However, while the connections between science and technology may seem apparent (to many generalist primary school teachers), Zubrowski (2002) has argued that when integration of the two learning areas is undertaken from a position of limited understanding about the nature of scientific inquiry and the nature of design processes, both the science and the technology aspects of any integrated curriculum can be slighted. Even so, and considering that science education has, and continues to be, a challenge for primary school teachers (Goodrum, Hackling, & Rennie, 2001), it does not necessarily follow that science should not be teamed with technology during professional development activities. For this study, we believed that building on familiar and ‘‘safe’’ (yet admittedly, not necessarily well understood) foundations, such as primary science ideas, in order to help teachers find relevance and meaning in the newer and unfamiliar technology education context, may support their professional learning, not only about technology and technology education, but also about core ideas underpinning New Basics. Our model in Fig. 1 only includes technology knowledge as this was the focus of our attention during this study.

Design and methods

An interpretive research methodology (Erickson, 1998) was used to investigate and analyse the developing thoughts and actions of the participants in the study. Judgements about those thoughts and actions across the period of the study were made through a hermeneutic dialectic process and were based on the criteria of trustworthiness and authenticity (Lincoln & Guba, 2000). In this research approach, researchers work with participants to gain an understanding of how the participants are making sense of the experiences and phenomena they encounter. Through a continual process of making assertions about those understandings and confirming them or restating them in light of new evidence, researchers and participants come to an agreement about the participants’ views. This approach matched well with our intentions for the study, which was to monitor how teachers’ views (understandings and personal constructs) may have developed during our interactions with them.

Participants

The participants were four teachers, Gilda, Katrina, Robyn, and Martyn (all pseudonyms), of Year 7 students (12 years olds) at a suburban primary school in Brisbane, Australia. All teachers had little prior experience with technology education before the study was undertaken.

Data sources

A variety of data sources were drawn upon to enhance the credibility and trustworthiness (Guba & Lincoln, 1989) of the researchers' assertions about the participants' developing thoughts and actions. They included:

a technology survey—The teachers completed a technology questionnaire (Rennie & Jarvis, 1994) at the start of the study. The outcomes of the survey provided the bases for key questions during interviews. The data gathered via the technology survey was used to bring to the fore, for the teachers, their prior knowledge and experience, to provide a common starting point for all teachers to engage in, and to initiate discussion between the teachers and the researchers and amongst the teachers.
teacher interviews (2)—These were undertaken at the beginning and at the end of the professional development experience. The first interview was conducted with individual teachers and, as part of the collaborative and reflective processes embedded in the component activities of the professional development experience, the second interview was conducted with the four teachers as a group. Key questions probed the teachers' understandings of technology and technology education, in the light of both their professional development and classroom experiences, with a focus upon their understanding of technology concepts related to materials and systems, and the science concepts of heat energy and heat transfer processes (*personal constructs*—see Fig. 1). Alongside the technology and science concepts and processes, the teachers' pedagogical understandings were also probed. The interviews were transcribed and the transcriptions were returned to the teachers for checking.
video recordings were made of the teachers as they engaged in the component professional development activities. These recordings were also used to stimulate recall during the second interview.
artefacts—The teachers wrote reflections about their professional development experiences in personal diaries. In addition, products of the teachers' practical experiences during the professional development activities were also gathered. The products included various constructions and models, as well as drawings and diagrams.
field notes of observations and informal discussions with the teachers were made by the researchers throughout the professional development experience. These field notes also included the researchers' reflections upon those observations.

Contextualising the study

A working relationship was established between outside researchers and the four teachers in order to assist the teachers to plan for the introduction, and implementation, of the technology syllabus into their classrooms. An important initial component of the collaboration between the teachers and the researchers was the provision by the researchers of a three-day professional development experience for the teachers prior to the commencement of their classroom activity with the Year 7 students.

On completion of the three day professional development experience, the researchers continued their engagement with the teachers by working with them as they implemented a technology unit of work planned in collaboration with the researchers. The engagement with the teachers was highlighted by collaborative discussions and planning of the unit and component lessons and through these ongoing interactions a hermeneutic dialectic process (Lincoln & Guba, 2000) was maintained. One or more of the researchers visited the teachers and attended their classes for all component lessons of the technology unit of work, implemented over a block period of three weeks, thus ensuring that professional contact was consistent and continual (Guba & Lincoln, 1989). The researchers also documented the development of understandings of the teachers and students' understandings of technology during the implementation of the technology unit of work.

The professional development experience

The professional development experience was based on the combined model for professional development described earlier (Fig. 1) and attempted to connect component activities with field/discipline knowledge in technology and science as well as pedagogical knowledge, with a view to challenging the teachers' prior understandings of technology and technology education. The intention was to make that connection meaningful through encouraging and promoting reflection (Butler, 1996) and engaging them in practical and theoretical activities. It was envisaged that the practical and theoretical activities and their sequencing would provide the platform for the planning and implementation of the teachers' technology unit of work for their Year 7 students. A potential outcome of the professional development experience was to ensure that during the implementation of the teachers' technology unit of work explicit attention would be given to concepts and processes of technology. The description of the professional development experience that follows is annotated with links to the professional development model (Fig. 1).

The initial activities in the first session of the professional development experience were designed to immerse the teachers into technology content, processes and activity through engagement in structured tasks. Science ideas were integrated into the professional development experience to provide a strong link between familiar past experiences and new ones. Integration also provided an excellent opportunity to illustrate the potential of rich tasks for meaningful learning. The practical activities included (a) testing and describing the properties of materials, such as strength; (b) constructing an artefact, A Breathing System, based on a prescribed design from *Primary Investigations* (Australian Academy of Science, 1994); and (c) strengthening an object made out of four identical, wooden pop sticks joined together with pins to make a stable, square frame. The immersion tasks enabled the teachers to think and share ideas and expertise about material properties, observe how components interacted in a system, and grapple with the problem of how to increase the stability of an artefact. The teachers worked in pairs throughout the entire three day professional development experience.

In the second session of the programme, the teachers acquired *practical experience* in technology (see Fig. 1) through designing, constructing and testing a container to keep an ice block in solid form for a period of one hour. The teachers were able to use materials at hand (e.g., Styrofoam, cardboard, glue, and sticky tape), and tools such as scissors and cutting knives. They were also asked to design and construct a bridge to carry a load of 1 kg out of materials that were feasible for use in the classroom, in their free time before the next session.

The third session commenced with a review of the operating performance of the teachers' ice block containers and the bridges each one had constructed, that is, the teachers discussed the merits of the features they had incorporated into their structures, reflected upon how successful those features may be in achieving the intentions of keeping an ice block cold or supporting a 1 kg load (*theoretical experience*—see Fig. 1). The review was followed by engagement in structured practical activities in which scientific principles that might underpin technology involved in the design and construction of an effective ice block container were then explored. These *theoretical* and *practical experiences* emphasised *field/discipline knowledge* development (see Fig. 1). The practical activities included, the ball and ring experiment; measuring the heat conductivity of metals; observing convection currents in water and what happens when hot and cold water is mixed in different ways; observing radiation emission from a tungsten lamp; testing the insulation properties of cloth, Styrofoam, and bubble wrap; and testing the absorption and/or reflection properties of a variety of materials placed in direct sunlight. The data collected from the practical activities were reviewed and the technological and scientific principles drawn out through analysis and discussion.

The final activity in the third session was a planning meeting in which the teachers and researchers analysed their professional development experience thus far and how the continuing professional development activities could be capitalised on to maximise the benefits for students in the respective classrooms. Thus, the focus was on applying *pedagogical knowledge* (see Fig. 1). The teachers agreed that the practical activities and sequencing of those practical activities were appropriate for their Year 7 students but they wanted to plan a final activity in the unit that would be meaningful for the students and tie in all the concepts that had been explored previously in their technology unit of work. After an extensive debate, the teachers' themselves decided that the culminating activity for the technology unit of work they were to implement with their own students should be the design and construction of a container that would keep food warm for a period of two hours. It was envisaged that a possible scenario, or design brief, might be transporting the food to a picnic area, therefore, ensuring that other design factors would need to be taken into account such as the strength of the container, and the addition of secure handles for carrying the container and food safely. The researchers' original suggestion that the culminating activity should involve students designing a sauna for a house was evaluated by the teachers and eventually discarded for an activity that they believed would have more relevance for the students, hence, their decision in favour of constructing a hot food container.

In summary, the core components of the professional development experience formed the technology unit of work, that is, the immersion activities, building a bridge, the ice block container activity, and the science principles activities. The rationale for the choice of technology concepts related to materials and systems, and science concepts of heat energy and heat transfer processes (conduction, convection and radiation) for the professional development experience was based on the expectation that the teachers would then design their units of work for their students around similar concepts. Technological processes involved in designing and making and evaluating were also a focus. Discussions and practical activities were planned to raise the teachers' awareness of their knowledge (prior experience) about technology concepts and processes (their *personal constructs*, and their *technology field/discipline knowledge*—see Fig. 1) and for them to consider the teaching and learning of technology in their Year 7 classrooms (their *pedagogical knowledge*—see Fig. 1). Consequently, the professional development experience involved the teachers in a variety of meaningful *theoretical, practical*, and *reflective* experiences (see Fig. 1) aimed to expose them to their own prior and developing knowledge and assumptions as well as to the views, outcome statements and approaches espoused by the new technology syllabus (QSA, 2003). Simultaneously, the usefulness of the activities for teaching technology concepts and processes were reflected upon. In this way, the teachers were encouraged to explore ideas for creating rich learning environments that promoted deep learning, conceptual understanding and generative thinking for their students (Education Queensland, 2000).

Transition—post-professional development experience to implementation

Subsequent to the three day professional development experience, collaborative discussions and planning of technology lessons occurred. The teachers were encouraged to reflect on their developing thoughts about technology content, technology education, and technology practice at the planning meetings. This allowed the teachers to ask questions, plan accordingly, enact the plans, review their actions, and plan for subsequent action. The role of the researchers was to provide and interpret information, and to assist with the supply of materials and consumables where necessary. The continuous process of analysis and reflection meant that all participants, including the researchers, were, as a group, able to contribute to an ongoing process of planning, action and reflection.

Data analysis

In line with the research approach, the data collected from all sources were analysed for evidence of teachers' understandings of technology, technology concepts and processes, and technology education prior to the three day professional development experience, and changes in those understandings during the professional development experience, and as an outcome of the experience. Also noted was evidence of teachers' understandings of science concepts at various stages of the professional development experience.

As indicated previously, the professional development experience was flexible and designed to stimulate teachers' thinking, and generate their own ideas, about the rich technological (and scientific) content embodied in the practical activities and sequencing of those activities as a basis for their own planning of a technology unit of work for the very first time. Hence, the data reveal the content the teachers generated and analysed themselves, not the content we, as researchers, may have presented if the professional development experience agenda were more formal and presenter driven. On occasions the data revealed teacher misunderstandings of some concepts (both technology and science related) where some ideas could have been explored in depth. These situations, although noted, were not always capitalised on because, as researchers, we were mindful that firstly, technology was a new, and largely unfamiliar, syllabus area for the teachers and, secondly we were preparing them for an extensive three-week teaching unit, therefore we should not overload their commitments during the professional development experience.

Results and discussion

The results of the study are related to how the teachers expressed their understandings of technology and science concepts and processes prior to, during, and after, the professional development experience with a particular focus on the interactions that occurred during the three days of theoretical and practical activities. In the discussion, a particular emphasis is given to the way the elements of the professional development experience (e.g., the designing and making activities; the discussions) supported the development of the teachers' conceptual and procedural knowledge of technology and provided a platform for the teachers' planning and implementation of technology units of work for their own students. For the purposes of this paper, the interviews plus two of the practical experiences in the professional development experience, namely, testing the strength of materials and the construction of the container for keeping an ice block in a solid state, are used as foci for discussion. Annotations in the discussion also indicate links to the professional development model in Fig. 1.

Early views about technology (personal constructs and prior experience)

At the commencement of the first session of the professional development experience, the teachers were interviewed about their views about technology and technology education. The interview questions were structured to probe, for example, the meaning the teachers attributed to the words ''technology'' and ''design''; the meaning they gave to ''technological literacy''; and the sort of activities they would classify as ''technology activities''.

The following statements from each of the teachers give a sense of the meanings they ascribed to the word ''technology'':

Katrina: methods of doing, making, creating, designing...the way something is put together, for example, a bridge, creating strong points, weak points; designing a new type of paint, designing carpet.

Martyn: means by which the world has developed better ways of doing things more effectively or efficiently...design—has to be a starting point for design. There has to be a need for it—a change needed or a new creation needed. Once decided, the design process begins, including thinking about, creating, putting together and using it.

Robyn: I just associated it with the classroom. It is just the way we use computers, and design, and solve problems within the classroom.... The achievement of a purpose, you have a context for what you want to design, you give those boundaries.

Gilda: It's the means by which many things in the world are created and used and operate....create was my way of saying designing. What do I want? What's my purpose again? It's got lots of tangents you could go off. Is it just to look at or does it have a practical purpose?

Most of these responses seem to be broad, in that they expressed technology as more than artefacts, making reference to the thinking and processes involved. This is commensurate with the QSA (2003) definition of technology. However, later in the interview it became apparent that, in their experience, the teachers had not often been able to translate the ideas they expressed about technology into classroom situations. Indeed, their attempts to undertake such a translation meant that there was often a mismatch between their espoused views of technology and their technology education practice. For example, in the following extracts two of the teachers appeared to equate technology education with the use of software as a means to vary student presentations.

Robyn: With PowerPoint what they're doing now is just learning to put together a PowerPoint presentation—there isn't a purpose. It's not really linked to anything at all. It's just learning how to do it—it will provide another option for presentations, that is, posters, models, PowerPoint etc.

Katrina: There are new ways to present—students used to do a chart, now they can do slides, filmstrips, PowerPoint. Similar activities but presenting them in a different way...We're looking perhaps to have more fun—now, it's apply it and let yourself go—go and find a book from the library, look on the Internet.

When discussing how they may have integrated technology into their teaching in the past, the teachers talked about activities that resulted in students working with computers in limited ways.

On the other hand, there was also an indication that introducing technology education into their classrooms meant that activities they were already familiar with could be approached, or thought about, in different ways to offer other options for doing tried and tested things, or for expanding and enhancing learning experiences. For example:

Gilda: We've been doing it (technology) for a long time but not been conscious of it. We've been saying to kids we want you to do this with a purpose in mind, not just because we have told you to do it. Now we are saying to them, 'How does this fit into your life? What can you do with it?'

Robyn: [Technology education means] providing motivation, giving children ownership of their work.

Martyn: [Technology education means] problem solving. Allowing them to make decisions for themselves.

Engaging in the professional development experience (developing technology field/ discipline knowledge and pedagogical knowledge)

During the practical activities that made up the professional development experience, the teachers engaged in learning situations similar to those they would offer to their students in the units of work they would develop and implement. The series of structured, loosely structured, open-ended and closed experiences stimulated them to think about technology education and led them to think about implementation of technology in their classrooms. In addition, they were faced with limitations of their own knowledge about technology as well as science concepts and processes.

During one activity, the teachers tested the strength of materials by gradually adding weights to suspended threads (cotton, silk, and polyester). The activity stimulated the teachers to work through the reasons for their observations of different threads breaking under the strain of different numbers of weights. This can be seen in the following extract taken from an interaction between Katrina and Robyn as they tested the thread samples of cotton, silk and polyester.

Katrina: This is poly silk, so I think it should be stronger...This is poly cotton so one would imagine it would not be as strong.

Robyn: As the last one, but it will be stronger than the silk. It's man made.

Katrina: I don't know. Silk broke at 6 [weights], so more than 6...I think because you think of silk as something so fine, that doesn't mean it's not strong, though, does it?

After 7 weights:

Katrina: It's stronger than silk.

After 10 weights:

Katrina: I didn't think it would be stronger, because it's not as thick.

Robyn: (*testing the cotton sample*) I wouldn't think this would be as strong as the poly...stronger than the silk though.

Katrina: Cotton things often give the appearance of being stronger than silk.
Breaks after 7 weights.
Robyn: The strongest fibres were man made and the one that was strongest was the thickest.

Katrina and Robyn made predictions about the comparative strengths of the threads and discussed and analysed the nature of the materials in relation to the results of the weight bearing tests they were conducting. They then attempted to connect their observations and their reasoning for their observations to technology and design, as in the following excerpt.

Katrina: Are man made things combinations?
Robyn: I don't know. What is polyester?...I don't know how polyester is made.
Katrina: Silk's spun, silk's animals, cotton's plant or vegetable and polyester's probably mineral actually...The very fact that [polyester is] man made means [that it is] probably designed to be strong.
Robyn: That's why they were designed. These ones [cotton and silk] weren't found to be strong enough, so [that led to the problem:] can we design something better.

At the same time as engaging in discussions about the nature of the materials they were testing, the teachers automatically, it seemed, linked their observations and discussion with real world applications. For example, in the following extract Martyn and Gilda discussed links between strength of the threads they were testing, and conjectured how strength may be linked somehow to the amount of heat that needs to be applied to fabric made from those materials to iron out creases.

Martyn: Where's the silk [setting] on the iron? Is silk around to the...?
Gilda: Silk you iron cooler than cotton. Cotton needs a fair bit of heat.
Martyn: Does that means it's stronger?
Gilda: I would have said the reverse. Heat takes away the pressure to get the creases out of the cotton. I think it's got to be less, don't you reckon? (*reweighs*)

As this interaction illustrates, technological and scientific misconceptions were expressed by the teachers on a number of occasions. These led to numerous discussions with the researchers and amongst the teachers. However, the detail of those discussions is beyond the scope of this paper.

Similar interactions, conjecturing, and discussion occurred during the practical activities that formed the focus of the second and third professional development experience sessions. In the second session the teachers were asked to solve the problem of keeping an ice block solid. It was through the opportunity provided by the (open-ended and loosely structured) ice block activity that the teachers found the need to explore both technological and scientific questions and to apply ideas developed through the more structured immersion experiences. The following extract from researcher field notes on the activity undertaken by Katrina and Robyn provides an indication of the types of interactions that occurred.

Katrina wonders whether to use damp or wet newspaper. Robyn not sure. Relates to terracotta coolers which are wet. Katrina talks about prac at colleges where hot tea without milk cooled quicker than tea with milk ''because it had more heat to lose''. Relates this to ''by wetting it (newspaper) you're keeping it at the same temperature''.
Robyn: ''Normally when you wet something, the water evaporates...no air should be getting in there to help it evaporate though''. They decide to wet it.

Robyn: ‘‘If it starts melting, the paper will absorb the water, and it’s cold water, and it keeps the rest of it cold.’’ Robyn remembers wrapping ice blocks in newspaper to take them home as a child—the newspaper ‘‘wasn’t wet’’. Katrina says it was probably a convenience thing of not getting it wet.

Katrina and Robyn wanted to use an ice brick [plastic container with frozen coolant inside] but not allowed. They also brought in a stubbie cooler (material not polystyrene). Both said that their design was to be compact, therefore needed to decide on a cube or a rectangular prism.

Decided on polystyrene, which looks the most dense (from 2 samples). Robyn and Katrina construct artefact.

Researcher tells teachers that they will need to take the temperature of their ice block and to take this into account when they are building their artefact. Robyn and Katrina use masking tape over the entire artefact to ‘‘cover all the seals’’ and fill the entire box with extra pieces of polystyrene. (Field Notes, Session 2)

This example shows how Katrina and Robyn drew ideas about the nature of materials and their insulating properties into their discussion and activity. It also provides another instance where the teachers related their observations and their predictions to past experiences and real world applications.

At end of the three day professional development experience

By the end of the three day professional development experience, the teachers were better able to express their ideas about science and technology concepts and processes as well as technology education. While it was not clear that they had developed better understandings, they were better able to articulate their questions. This indicates some growth in their understandings as they had begun to seek ways to identify and then articulate the differentiation between technology concepts and processes and science concepts and processes, as well as the implications for teaching technology, hence their informed decision about the culminating activity of the hot food container.

The professional development experience, with its integration of *practical, theoretical and reflective experiences* (see Fig. 1), stimulated the teachers to discuss learning in technology in terms of needing to acquire deep understandings of contextually situated technology concepts and processes, rather than in terms of a series of facts and skills. The nature of the practical activities (mix of closed and open-ended, ill-defined and defined) that made up the three day professional development experience challenged the teachers to design, make and evaluate artefacts and to consider the selection, use, relevance and generation of technology and science concepts and processes (*field/discipline knowledge*—see Fig. 1).

For example, as mentioned earlier, during the activity, in which the teachers designed and made the container that would prevent a cube of ice from melting, with little prompting from the researchers, the teachers contextualised the problem (they considered why could ice need to be kept from melting); they considered the insulation properties of the materials (the teachers drew upon, for example, prior knowledge, information on the Internet and in books, from colleagues, family and friends); drew sketches of possible containers; and experimented with cutting and shaping the materials (Field notes, Video). As well as contextualising the problem, the teachers engaged in discussions about the technology and science concepts related to strengthening structures, insulation, heating and cooling. The teachers incorporated into discussions their everyday experiences of these technology and science concepts and processes (e.g., they noted the way eskies (commercial insulated food containers) worked, and how polystyrene was used in packaging as well as for insulation—Video, Field Notes). Reflection upon the activity led to discussion about the difference between technology and science and the way different kinds of experiences afforded different kinds of responses from learners; the open-ended experiences stimulating interest and purposefulness, as well as creative thinking. In other words, the activity facilitated the *development* and *enhancement* of, and *reflection* upon, prior experiences and *personal constructs* (see Fig. 1) as the teachers explored and developed their *field/discipline knowledge* and their *pedagogical knowledge* (see Fig. 1).

After the completion of the technology unit of work

When given the opportunity to reflect on the processes of professional development after the completion of the technology unit of work in their own classrooms, the teachers indicated that the students enjoyed the activities, particularly because of the hands-on aspect. They also found that they did not have to ''feed'' the students with a lot of information because they were highly motivated and anxious to proceed with the entire unit. They believed collectively that the students learned a lot and enjoyed having the additional people (the researchers) in the classrooms to work with the students and with whom they could discuss their own ideas (Field Notes).

Implementing the unit continuously across a period of three weeks was of benefit compared to the usual one learning experience per week over a longer period of time, which was the typical approach all the teachers had taken when they had scheduled their science classes in the past. All four teachers felt more confident to teach the unit because of the professional development experience, and the fact that the researchers were available to give support and assistance through providing ''content backup'', if and when required, and helping them to scaffold students' understandings on several occasions during the teaching of the unit of work. The teachers appeared to have developed some better-informed understandings of technology concepts and processes, and scientific principles underpinning the technology unit of work. Yet they continued to claim that they needed more technological/scientific knowledge to successfully teach the unit. This feeling was summed up in the Gilda's statement, ''Probably the only concern I had was whether at times I was really feeding them what was correct, and I hope I really did get this bit of information right,'' which is indicative of the teachers' desire that they should be prepared to give explicit attention to the concepts and processes of technology, an outcome the researchers anticipated from the professional development experience.

They also exhibited more comprehensive views of technology at the conclusion of the technology unit of work. The following interaction gives an indication of how the teachers were continuing to wrestle with technology education as a curriculum area and their understanding of the relationship between technology education and science education.

Researcher:
If technology is similar to science or art why have it as a separate curriculum area?
Robyn: I don't know. Are we expanding science? Is it 'new' science? Is the technology thread embedded into it?
Researcher:
It is a separate key learning area.
Robyn: What is it then?

Katrina: We are heading somewhere and we need a science background to get there. Because it is called design and technology, we would need some prior knowledge to help us.

Gilda: I think we may have had tunnel vision as to what technology is, thinking it is just computers.

Educational importance

Problem-based and contextualised problems can form the basis of ‘‘rich tasks’’, which are an important feature of the New Basics Project in Queensland (Education Queensland, 2000). Rich tasks have demonstrable and substantial educational outcomes of intellectual and educational value; they are transdisciplinary, problem-based and relevant to everyday work and life; they are recognised as important and valid by educators, community and parents; and they have significant and appropriate intellectual developmental and cognitive depth (Education Queensland, 2000). It seemed that the nature of the practical activities set within the professional development experience described in this paper afforded a response from the teachers that was commensurate with the aims of the new Technology Syllabus (QSA, 2003) as well as the New Basics movement (Education Queensland, 2000).

This study is important because it presents some insights into how professional development experiences for teachers new to technology could be organised and implemented to best support their developing understandings about technology and technology education. The introduction of technology education into primary schools means that teachers' professional knowledges will be challenged. Additional pressures on teachers to ensure that education is preparing students for future participation within a supercomplex knowledge society (Barnett, 1999) also act as an imperative. Providing a professional development experience which helps teachers to engage in real and relevant learning for themselves, and opportunities to engage in discussions about complex issues that enable them to reflect on what counts as knowledge within a learning area such as technology, gives them a chance to develop the more sophisticated views of teaching that are necessary, if they are going to be able to provide their own students with learning opportunities which encourage deep learning, conceptual and procedural understanding and generative thinking (Education Queensland, 2000; QSA, 2003).

The model in Fig. 1 used to frame the professional development experience discussed in this paper, highlighted aspects of teacher knowledge previously identified by Fishman et al. (2003), as well as issues for professional development of teachers in technology education underscored by Banks et al. (2004), Stein et al. (2000) and Jones and Moreland (2004). The outcomes of this study were such that some indications of change in the teachers' personal constructs about technology and technology education were identifiable, thus the professional development experience helped teachers to experience real learning for themselves and opportunities to engage in discussions about complex issues. It is acknowledged, however, that because the connection between teachers' personal constructs and their practical classroom experience are intimately bound together (Butler, 1996; Cochran-Smith & Lytle, 1999; Fishman et al., 2003; Jones & Moreland, 2004), significant change for these teachers may be a long term process: the result of further experience of trying and testing new ideas in practice in order to develop more sophisticated views of teaching, and reflecting on their content knowledge and experience in the light of the curriculum and broader educational environment in which they work. We have already acknowledged that any complications for deep professional learning caused by the introduction of science concepts to form the basis of rich tasks was not explored. Our model only highlights the place of technology. In the light of arguments made by Zubrowski (2002) where integrating technology and science are concerned, further investigation of the use of this model for framing professional development around rich learning environments is warranted. However, in conclusion, we believe that professional development, planned within the framework represented by the model shown in Fig. 1, and described in this paper, may be a useful way of conceptualising and improving the professional development experiences in technology and technology education for many primary school teachers.

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