Discovering New Zealand Technology Teacher's PCK

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Abstract

An important and under-researched area of technology education is teachers' pedagogical content knowledge (PCK). This concept reflects the notion that expert teachers' knowledge is a unique integration of their pedagogical technique and their understanding of technology content as applied in a particular instance.

The authors are interested in inquiring into technology teachers' PCK from a comparative perspective between New Zealand and South African teachers, who have implemented and reviewed their technology education curriculum according to a similar timeframe. This article therefore reports on the first phase of this study on lower secondary technology teachers' PCK, with the focus on New Zealand. The ultimate aim is to compare the PCK of New Zealand technology teachers and the PCK of South African technology teachers via a case study approach. The findings in this paper are reported from the interviews, classroom observations, and document reviews of four New Zealand technology teachers.

Introduction

This ongoing study aims to inquire into the pedagogical content knowledge (PCK) of secondary school technology teachers. The study is a collaborative and comparative project between South Africa and New Zealand. In this article, the authors deal with the findings from the initial New Zealand-based inquiry. According to Nicholas and Lockley (2010), curricular changes have implications on classroom practice and teachers' concepts of what being a successful teacher of technology education means. Both South Africa and New Zealand have recently experienced curriculum transformation and change, which resulted in the introduction of technology education. New Zealand introduced and implemented technology education in 1997 (Jones & Moreland, 2004) and South Africa in 1998 (Stevens, 2005). Both countries have also had curriculum reviews, the latest in New Zealand was in 2007 (Nicholas & Lockley, 2010), and the latest in South Africa was in 2000 (Department of Education, 2000) and 2009 (Department of Education, 2009). These parallel processes motivated the authors to use a comparative study to investigate technology teachers' PCK. Technology education is a relatively new subject in both of these contexts, and research into this area has the capacity to enhance understanding of what constitutes an expert teacher. Thus, the research question arises: What is secondary technology teachers' pedagogical content knowledge?

This research question can be elaborated through the following subquestions that have been derived from the literature:

- What do technology teachers understand as the nature and purpose of technology education?
- What constitutes the technology teachers' knowledge of the technology education curriculum?
- What are the pedagogies that teachers believe are suitable to teaching technology?
- What types of assessment activities do the technology teachers utilize and how are these related to the content?
- What technological teaching and learning resources do the technology teachers use?
- How do the technology teachers integrate indigenous technology in their teaching?

Theoretical Framework

Literature relates the historical treatment of content knowledge and pedagogical knowledge by teachers in a dichotomized way (Ball & McDiarmid, 1990; Shulman, 1986a; Veal & MaKinster, 1999). For example, Veal and MaKinster (1999) became aware of this problem in the area of science and alluded to the traditional polarization of content knowledge (CK) and pedagogical knowledge (PK) that exists in science teacher preparation programs; however, it is counterproductive that these two concepts are treated in a dichotomized fashion (Gore, Griffiths, & Ladwig, 2004). In technology, the parallel dichotomy is often characterized as between theory and practice

(Williams, 2002) where the pressures of timetables, classrooms, and examinations encourage teachers to separate theory and practice, each accompanied by a suite of different conventions related to pedagogy and content.

The origins of PCK date back to 1986 (De Miranda, 2008) when the coiner of the concept, Lee Shulman, gave his presidential address to the American Educational Research Association (Van Driel, Veal, & Janssen, 2001). Van Driel et al. (2001, p. 2) related Shulman's conception of the idea:

> Shulman argued that, for a long time, research on teaching and teacher education had undeservedly ignored questions dealing with the content of the lessons taught. Shulman presented a strong case for pedagogical content knowledge (PCK) as a specific form of knowledge for teaching, which refers to the transformation of subject matter knowledge in the context of facilitating student understanding. Shulman emphasized the importance of research on PCK by referring to it as a "missing paradigm."

Shulman's concern lies at the foundation of transformation in the context of teaching – teachers transforming content into meaningful understanding by learners. Having realized the gap that exists between CK and PK, Shulman (1986a) developed a framework for teacher education by introducing the concept of PCK, such that teacher training programs should combine CK and PK to effectively prepare teachers. Teaching begins with an understanding of what is to be learned and what is to be taught (Shulman, 1987). Shulman and Sherin (2004) argued further, that teaching and learning to teach must be viewed in discipline-specific perspectives. As Geddis (1993) emphasized, "The outstanding teacher is not simply a 'teacher,' but rather a 'history teacher,' a 'chemistry teacher,' or an 'English teacher' (p. 675). The purpose of this study is to research the PCK of a technology teacher.

According to Shulman (1987), PCK includes special attributes that a teacher possesses, which help him/her to guide a student to understand content in a manner that is personally meaningful. Shulman (1987), having identified teacher knowledge as central to teacher quality, developed a seven-part classification of teacher knowledge built on elements that include knowledge of subject matter; pedagogical content knowledge; general pedagogical knowledge; knowledge of curriculum; knowledge of learners and their characteristics; knowledge of educational contexts; and knowledge of educational aims, purposes, and values. In contrast, Cochran, King, and deRuiter (1991) were interested in four elements:

- Knowledge of the subject matter
- Knowledge of learners
- Knowledge of environmental contexts,
- Knowledge of pedagogy.

(cf. Veal & MaKinster, 1999; Smith & Neale, 1989).

Another alternative conceptualization of PCK was developed by Magnusson, Krajcik, and Borko (1999), which is helpful in clarifying this special form of a teacher's professional knowledge by proposing that PCK is made up of five components. In their view, an experienced teacher's PCK encompasses his/her:

- Orientations toward teaching (knowledge of their subject and beliefs about it)
- Knowledge of curriculum (what and when to teach)
- Knowledge of assessment (why, what, and how to assess)
- Knowledge of students' understanding of the subject, and
- Knowledge of instructional strategies.

PCK can further be viewed as a set of special attributes that help someone transfer the knowledge of content to others in a manner that will enable them to develop it in a personally meaningful way (Geddis, 1993; Shulman, 1986a, 1986b, 1987; Van Driel et al., 2001). Cochran, King and deRuiter (1991) defined PCK as the manner in which teachers relate their PK to their subject matter knowledge in the school context, for the teaching of specific students. The CK of PCK also implicates both Western and indigenous forms of technological knowledge. Hence, teachers also need to integrate indigenous technologies, understand their nature, and work to address the technological bias toward them (Gumbo, 2000; Maluleka, Wilkinson, & Gumbo, 2006).

There is a strong research history in the Technology Education community about pupils' attitudes toward technology (PATT) (Ankiewicz, Van Rensburg, & Myburgh, 2001; Burns, 1992; Rennie & Treagust, 1989; Van Rensburg & Ankiewicz, 1999; Volk & Wai Ming, 1999), but less related to PCK, which therefore presents an opportunity for research in technology education. The findings of a study by Rohaan, Taconis, and Jochems (2008, 2009) revealed that a link exists between teachers' knowledge and learners' concept of and attitude toward technology.

Jones and Moreland (2005) suggested that teachers require a clear understanding of the nature of technology and the conceptual and procedural aspects of the different technological areas. Reddy, Ankiewicz, De Swart, and Gross (2003) contended that technology teachers' inability to make technological experiences cumulative, purposeful, and empowering resides in their inability, for example, to see the inter-relationship between technological content knowledge, skills, attitudes, and values and technological capability.

In this article, the authors draw from this literature to continue the research into PCK in the context of technology education.

Research Design

A convenience sample of four schools was selected to become case studies, two in a city, one in a small town, and one in the countryside. In each case, the Head of the Technology Department was approached, and in two cases this person became the participating teacher, and in the other two cases, teachers in the department were delegated to be involved. In all cases, the participants were identified as expert teachers and were willing to cooperate.

A convenient day was negotiated with each teacher; during which time they would be teaching a lesson that could be observed and the teachers had time free for interview and discussion. Classes were observed by both researchers, in order to help validate the data; an observation schedule based on the elements of PCK derived from the literature was used. Observation is deemed important to counter possibilities of bias that could emerge during interviews (Kelly, 2006).

In general, observation was followed by the interview. An in-depth interview can be a qualitative research technique involving intensive individual interviews with a small number of respondents to explore their perspectives on a particular idea, program, or situation (Boyce & Neale, 2006). The goal of an interview is to deeply explore the respondent's point of view, feelings, and perspectives (Guion, 2009).

Also, documents and resources used by the teachers were analyzed. According to Silverman (2005), qualitative researchers analyze a small number of texts to understand participants' categories and see how they are used in concrete activities.

Data analysis began with the interview data, adopting a variation of the coding strategy used by Marshall and Rossman (1999). This involved a stepped process moving from a general approach of listening to the recordings to initially develop themes and codes to noting the themes from the transcribed data, and then detailing the themes. The variation on this coding strategy was the use of analyst-constructed typologies, which were based on the principles of PCK developed from the literature. These typologies became the categories for analysis, but not exclusively so, in order to allow for emergent themes. The analyst-constructed themes were subject matter, curriculum, assessment, learners, pedagogy, educational context, educational aims, purposes and values, and indigenous dimensions.

Once the audio transcripts were analyzed, they were integrated with the teaching observation notes, the document analyses and incidental personal memos that the researchers had been keeping (Marshall &Rossman, 1999). The outcome was four integrated narratives about each of the cases; an alias was given in order to protect the teachers' identity.

Findings

In this section, the findings from the different sources of data are presented. Initially, each of the four cases were contextualized, noting some features of the observations that were made, and this was followed by a presentation of findings.

1. Morris

Morris, one of six technology teachers in a rural school that had approximately 700 students in Years 9-13, is 50 years old and has taught for 10 years; originally he was a mechanic.

This teacher was observed in a Year-10 class of 20 male students who were completing folios and final projects. The emphasis on folio work was in preparation for to the following year, that is, eventually to develop more significant portfolios to accompany projects. The teacher gave specific directions to students, including a handout pro forma to complete. This assignment was to be completed by the next class.

After 15 minutes of discussion, the students moved into an adjacent workshop to work on their projects. Without direction from the teacher the students continued their work. The atmosphere in the class was relaxed, and some stayed off task, but most got on with their work.

2. Fraser

Fraser is in an urban school with a population of 1800 students. The department has five technology teachers, a full-time technician, and spacious facilities. Fraser recently updated his teaching qualifications after teaching for 10 years.

We observed two classes of Year-10 students, which were team taught. Only one female student was present, who did not contribute to the class. Six male students were in an adjacent teaching room playing music from cell phones and a guitar.

After experiencing disciplinary problems with this group of students, the teacher decided to excuse them from the project, knowing that they would repeat the project during the following year. Many students wore their backpacks while in the workshop which hampered their movements somewhat, despite sufficient shelving for this purpose. Some students wore aprons, others not.

The class worked on a race car project. Each student fabricated a design from pine wood. The design specifications were met by three of the students, and all worked at their own pace with minimal supervision by the two teachers. The students were at different stages of their projects, some were consistently engaged, others were not. Some students approached the teachers for clarity on the challenging parts of the project. Eventually the teachers moved around the working stations to give support and guidance whenever needed, and to check if the projects were consistent with the specifications, and to call the roll.
The teachers responded only to individual requests for assistance, and there was no conclusion to the lesson. The teachers instructed students to clean up and put tools back in order, however, there was no structure to cleaning and packing up. Some students left immediately at the sound of the bell. Others who stayed and cleaned, did not do a good job, and the researchers helped the teacher who had to finish cleaning.

3. Cam

Cam teaches at a coeducational state secondary school with about 1400 students in Grades 9 to 13, set in a town of about 20,000 that is surrounded by rural areas. The technology department includes seven teachers, and a new technology center is being built at the school entrance.

Cam teaches graphics in adjoining classrooms at the back of the school; the classrooms share a storage room of drawing equipment. One class of 22 Year-10 students included both females and males. The traditional seating arrangement had 28 old wooden single desks organized in rows; each with a drawing board angled on top. A laptop computer and data projector were used to present the activity; students assisted during setup, and a chalkboard was used to illustrate the drawing technique.

Cam, who has built a positive teacher-student rapport over time, demonstrated how he freely related to students. The class began with a “question of the day” (for e.g., favorite comfort food), and students responded to the roll call by answering the question. The atmosphere in class was quite relaxed while students worked on drawings while chatting and moving around freely. Cam kept the noise level in check. He also provided individual support to students and reminded the class of the following 4 x B’s sequence:

Brains: first try and think it through.

Board: use black board support to assist.

Bro: ask a classmate to help.

Boss: ask the teacher.

Very few students requested teacher assistance, and most problems were solved with the help of other students. The students stopped work, packed up, and departed while the teacher was talking to the researchers.

4. John

John teaches in an urban boys' school of 660 students with six other teachers in the Technology Department. He is 50+ and has been teaching for 20 years following a career as an automotive engineer.

A Year-8 class of 14 students (both male and female) was engaged in completing a range of projects. These students spent two hrs/week in the technology workshop at the high school to which they traveled by bus from their local primary school. They were in various stages of completing a range of projects based on their individual designs. The general design context was small souvenir items of wood or acrylic, which were to represent New Zealand. A small band saw, sander, and drill press were located on the wall benches, which the students were allowed to use, but they could ask the teacher to handle cutting with the band saw. A high level of organization was evident, and the teacher trusted the students who helped themselves to supplies as needed.

The teacher wanted to get the students "hooked" on technology, give them an attractive project to take home, and enable them to engage in some design work that included skills and materials knowledge. They completed a small portfolio, which was used to assess their work against Level 1 or 2 of the curriculum.

In the following section, the authors summarize their findings in terms of research questions.

Q 1: What do technology teachers understand as the nature and purpose of technology education?

Two teachers believed that skill development and vocational goals were the main purposes of technology education, and they thought that general problem solving and creativity skills were extremely important. In a practical way, these philosophies were evident in the school provision of vocational unit standards or more general achievement standards. The external measure of success in achieving the goals of technology education was competitive for some teachers; for example it helped teachers to discuss their students' work at standardization meetings, and some teachers feared being embarrassed by the quality of student work. Other teachers mentioned the measure was the number of "Excellences" that students achieved.

Regardless of the overall purpose, all teachers recognized that student conceptual development, through the medium of design and making, was a significant goal. They believed strongly that a major goal was to develop research and thinking skills in their students because that reflects the reality of life. Using a process to make decisions is a part of everyday activity, regardless of what vocation students eventually pursue: "[Students] still have to make informed decisions about what they're doing," "it reflects the reality of life and it provides a process of problem solving and thinking about things, [that is] coming up with answers and being able to discuss ideas with other people."

Underpinning this cognitive goal was the belief that all students have this ability. This was made explicit because there are some technology teachers who believe that their students have limited abilities, which prevent the development of cognitive skills and the documenting of design processes. One teacher who had been a national assessor and moderator stated: "If the teacher says, 'I had a bad group of kids this year, they didn't work hard,' instantly you know it's the teacher's fault."

Skills that could be generalized were prioritized by one teacher to include developing an understanding of how things are made, how they work, and how they are manipulated; he believed that "[students] can learn lots of other stuff, but that practical aspect is so, so important …"

The teachers emphasized the need to progressively work toward the development of thinking and research skills, considering that students have to start thinking and recording their ideas at least in Year 9. There was recognition also that the culture of the technology area is a significant factor: "If kids come into an untidy and dirty workshop expecting not to have to think at all from day one, having the attitude that we're just going to make stuff in here and the teacher just focuses on manipulative skills, then it becomes the culture of that department and is very difficult to break in later years."

One teacher placed the rationale for his student goals within a national context, recognizing that New Zealand is a small country that does not have a broad manufacturing base; thus, there is a need to be at the cutting-edge of inventing and making things by teaching design and technology in schools.

After a review which focused the technology curriculum more on students understanding of the nature of technology, a number of teachers considered that technology wasn't adequately developing or promoting a practical approach.

Q 2: What is the technology teachers' knowledge of the technology education curriculum?

The depth of understanding of the curriculum was polarized, with one teacher being involved in the national curriculum development and implementation and another aware of neither the changes in the new curriculum nor the extensive, available support material. This latter teacher offered students a range of unrelated projects which were also unrelated to the curriculum.

All the teachers were aware of the curriculum, particularly as changes (adding two new strands, the Knowledge and the Nature of technology) were being implemented at the time of this study. The degree of curriculum accountability has changed over time. When the terminal qualification was the High School Certificate there was no external accountability for technology teachers, but since the National Certificate of Educational Achievement was introduced to Years 11-13, specified standards and levels of attainment must be achieved, which are moderated, some of which are externally assessed.

Achievement standards and unit standards have caused a division among teachers. Unit Standards are vocationally aligned, skills oriented, competency based; they were developed by industry. Achievement standards are related to technological literacy. Some teachers offer both, and others offer only one.

One teacher had a unit standards class to teach, but believed that the students were capable of achieving more than a range of skills competencies:

> I thought, I am going to teach these kids Technology. So we did a huge project, and went through it using very much the same process that I would have done with Achievement Standards, slightly watered down in some areas, and probably with a slightly more practical focus . . . . These students are just absolutely firing ahead because they can do practical stuff and they can think. The folders they produced were equal to [those at] any school around that is doing Achievement Standards.

This teacher is contrasted with another who offers vocationally oriented unit standards in areas of furniture making, carpentry, engineering and automotive technology; however, he also offered a couple of achievement standards, "Because if we don't – then we would lose the students who need the achievement standards."

One argument for the offering of unit standards is that the achievement standards are too theoretical for the type of students attracted to technology. Conversely, another teacher believed that achievement standards offered a good balance: "When they first started a lot of the teachers felt that skills had been taken out of the achievement standards, but we've demonstrated that there's plenty of room for you to make something worthwhile, which is supported by relevant theory."

A related issue is the expectation from industry that standards above Level 2 must be offered in an industrial context. Historically, Level 1-3 was aligned with the last three years of schooling, Years 11-13. Consequently, the concern is that there are few standards now available for Year 13 students.

All teachers agreed that a sequence of technology activity is necessary in order for students to achieve to their potential by the end of secondary schooling at Year 13. Students are not usually admitted to Year 13 classes unless they have done preparatory work during the previous two years. There was a strong objection to students entering technology classes "because they want to come and make something, or because timetabling says so; well, they just have to go away."

Teachers perceived the sequence, however, to involve different elements. One teacher thought progress could be measured through student conceptual idea development, where in Year 9, students' different concepts are really just one idea that has been changed slightly, and the progress toward diversified thinking peaks in Year 13 with a range of genuinely diverse ideas.

For another teacher, progress developed through increasingly broad design briefs in which there were rigorous limitations on Year 11 students, but by Year 13, it is quite open and students can mostly do what they want. "In Year 13 students [take on] a client with a genuine issue that has to be solved. The teacher's role is to make sure it's not too expensive or out of control, [that the project offers depth], and that the stakeholders are available to talk to the students."

Q 3: What pedagogies do technology teachers believe are suitable to teaching technology?

Though some teachers found it difficult to explain their pedagogies, through discussion and observation it became clear that these varied. One teacher had a limited repertoire of strategies to use with students; mainly consisting of demonstrating skills followed by responding to individual needs. On the other hand, another teacher indicated a range of pedagogical strategies, which varied by year of the students, the goal of the activity, and the nature of the project.

Often, pedagogy was linked to the nature of the laboratory. One teacher emphasized that the physical state of the workshop affected students' attitudes and productivity, and if the workshop is dirty and untidy, then the students will respond in kind and not take pride in their work.

Another teacher used the physical arrangement of the workshop to complement pedagogies. Three hexagonal island benches with vices were available as was one long bench where the entire class could sit to work on their portfolios. This bench arrangement, according to the teacher, demonstrated a balance between theory and practice in the teaching of technology by enabling students to move easily between practical work and theoretical work on their portfolios.

One teacher commonly used small groups, which were observed to be engaged and cooperated in completing their projects. The teacher generally decided on the group members to ensure that weaker students were teamed with stronger designers, and like-minded students did not always work together.

All teachers mentioned some form of sequencing student work. It was a common perception that when students begin technology classes, they just want to do practical work, but they must have the understanding from early on that there is theory to be done.

One teacher particularly stressed that students only need to know what they need to know at a specific point in time. For example, "I'm not going to waste their time telling them how steel is produced because they don't need to know about it." Another teacher reinforced this just-in-time approach, by providing new information and demonstrating new skills to students when they need to know it, when the students see it as relevant. This teacher saw a fine line between teaching the students so they are not put under stress, but stretching their cognitive skills enough to make them think critically about what they were doing.

This teacher considered it important to initially develop a toolbox of hand skills, thus providing a foundation from which the students can move on to solving problems and dealing with briefs and stakeholders, and, finally, researching and presenting their work.

In contrast, the experience of another teacher was that if students are left to their own devices to work at their own pace, "they tend to back off a bit, so we need to keep onto them." But conversely, he also found that too much pressure on students to progress had a negative effect. He provided one sheet or one section of a workbook at a time to the students so as not to overwhelm them and thought this was effective.

The ability to have a flexible approach to classroom management and to respond to the needs of students at a given time was a common thread among the teachers' methods. All the teachers reinforced the need to have a personal relationship with students, though through observation this did not seem to be the case in reality with all the teachers. One teacher only taught content areas or projects that he personally found interesting and exciting.

Another teacher's focus was on the pedagogies of management, which "is quite difficult at Year 10, where one student is making a skateboard, another is making a scooter, and another a surfboard." He found this management a lot easier at the higher levels of study, for example in Year 13, because the students have stronger skills, a grasp of personal management issues, and a level of maturity that facilitates focused constructive work.

Q 4: What types of assessment activities do the technology teachers utilize and how are these related to the content?

Student achievement in the New Zealand curriculum in each subject is described by means of progression through eight levels of attainment, from entry to school to Year 13. Years 11-13 are the post-compulsory years and students in these years can achieve, accordingly, the National Certificate of Educational Achievement (NCEA) at Levels 1, 2, or 3. The NCEA is comprised of a range of achievement standards around which teachers can organize the learning programs they offer to their students. The Achievement Standards at Level 1 line up with progression indicators of the preceding years.

The coverage of technology education at middle schools (Years 7-8) in New Zealand is various, and students progress to Year 9 and secondary school with a range of different experiences and performing at different levels. Many secondary schools attempt to develop students' performance to Level 6 of attainment by Year 11, which corresponds to NCEA Level 1. This reasonably enables students to finish their secondary schooling in Year 13 with an NCEA Level 3 qualification, but teachers noted such progress was often difficult for students in years 9-10.

Within this context, the assessment strategies used by teachers were diverse, some involving the simple addition of numerical values for certain specified criteria seemingly unrelated to the formal curriculum, and others developed from assessment matrices that, in turn, were based on statements of levels of attainment. For all teachers, however, assessment was based on activity rather than a task (e.g., examination) designed specifically for assessment purposes.

One teacher saw progression through assessment as a theory – skills balance: "In Year 9, I'm probably looking at 80% skills and 20% theory; in Year 10, I'm probably presenting 60-65% skills and the rest of it is in the theory; and of course once they get to Year 11, the theory side of it is just as important as making it."

Another teacher's focus for assessment was to evaluate the students' level of planning, their understanding of the processes, and their ability to evaluate whether they have achieved their goals.

The teacher who used small groups extensively in his class organization also used the groups to determine peer assessments. One teacher was concerned about the reporting of student achievements to parents. This teacher did not explain achievement in terms of levels to the parent but instead explained students' work in terms of "excellent ability to select materials." At the upper secondary levels, the assessment structure is predetermined. The assessment of vocational pathways consisted of noting the mastery of skill achievement, and the assessment of Achievement Standards according to the standard and developed from the indicators of progression.

Q 5: What technological teaching and learning resources do the technology teachers use?

Resources used by teachers tend not to be books, unless some specific information is required. Technology education departments had libraries of technology education books, but no class sets, so these were used mainly as reference resources.

Colleagues commonly used each other as a resource to bounce ideas off, either visiting each other in schools or meeting at the regular opportunities for professional development. The internet was also commonly used, both in general terms as a source of information, and by specifically using the TechLink website, which has been developed with government support as a resource for technology teachers and contains a significant amount of curriculum support material. One teacher, however, was not aware of any available internet based support material.

Teachers maintained a constant lookout for resources, one stating: "I spend a lot of time in toyshops … I go into lots of home appliance and hardware shops." It seemed common for teachers to utilize a range of technologies that they coincidentally come into contact with.

In the senior curriculum, one of the objectives is for students to work with an external client; consequently, some teachers build a significant network of industry contacts for their students. One teacher used these contacts as his main resource.

Q 6: How do the technology teachers integrate indigenous technology in their teaching?

The teachers were generally a bit bemused about indigenous issues in their technology education program. Two teachers related the issue to the low numbers of Maori students in their classes, and so believed it was not important and did not incorporate it into their practice. However one teacher believed that when this was done properly, it can benefit many people: "Other students need to know about it but we also need to know about other things as well, so it's a matter of getting the mix right."

Teachers' understanding about the incorporation of indigenous technology seemed fairly superficial. One school included cultural heritage as a faculty goal each year, but examples which achieve that goal seemed elementary.

In a context in which students are encouraged to develop their own designs as solutions to problems, teachers seemed content to allow that latitude to encompass the inclusion of indigenous influences, often exhibited as a form of decoration that has cultural significance. There was no structure evident in any of the sources of data to permit a planned instructional sequence that would enhance all students' understanding of indigenous technology.

Conclusions

Teachers' PCK varied significantly in these case studies, which confirms the research that PCK is individual, unique, varies from class to class, and changes over time. As a framework for developing an understanding of teachers' PCK, the methodology used in this project seems to be appropriate. The observation of the teachers' context and of their teaching, the interviews, and to a lesser extent the document analysis provided for the collection of a rich data source for each teacher, and generally triangulated to provide valid results (Cohen, Manion & Morrison, 2007). Where triangulation did not validate data, for example, where the teachers' interviews did not match the observations of their class, the dual sources of data are particularly important.

Although all the participating teachers in this project were teaching the same year span of students and followed the same curriculum, quite diverse PCK was revealed across all the components: the subject matter that was taught, the interpretation of the curriculum, strategies for assessment, conceptions of the learner, and the purpose and aims of technology education.

The curriculum context in which this research took place possibly had a clarifying effect on teachers' PCK. A revised technology education curriculum was currently being implemented, which was perceived by many to present a more theoretical approach to the subject, at the same time that the opportunity for schools to offer vocational qualifications was being limited.

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