Discovering Technology teachers' pedagogical content knowledge: A comparative study between South Africa and New Zealand

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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.

This research enquires into Technology teachers' PCK in New Zealand and South Africa, using a comparative perspective and a methodology derived from the philosophy of PCK. The rationale for the selection of these two countries is the similar timeframe of implementations and review of Technology Education curriculum which has occurred in each country.

This presentation will compare the PCK of New Zealand Technology teachers and the PCK of South African Technology teachers through a case study approach. The findings in this paper are reported from the interviews, classroom observations, and document reviews of teachers in each country.

Introduction

An expert teacher is a master of the content knowledge about the subject being taught, and uses effective ways of imparting such content knowledge to learners (Ben-Peretz, 2010). This notion is commonly referred to as PCK (Ben-Peretz, 2010), the body of the teacher's professional knowledge that encapsulates knowledge of the subject taught and general pedagogical principles and skills that guide a learner to develop personal meaningful understanding. The origins of PCK date back to 1986 when Shulman (1986a) introduced the concept, referring to it as a 'missing paradigm', a description that remains applicable to Technology Education.

This study aims to inquire into the PCK of secondary school Technology teachers. The study is a collaborative and comparative project between South Africa and New Zealand. Both South Africa and New Zealand have recently experienced curriculum transformation and change, which 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 school technology teachers' PCK? This research question can be elaborated through the following sub-questions that have been derived from the literature:

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

Theoretical Framework

Traditionally, teachers' content knowledge (CK) and pedagogical knowledge (PK) was conceptualized in a dichotomized way (Ball & McDiarmid, 1990; Shulman, 1986a; Veal & MaKinster, 1999). 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.

Lee Shulman is credited with coining the concept of PCK (De Miranda, 2008) when he gave his presidential address to the American Educational Research Association (Van Driel, Veal, & Janssen, 2001). Shulman (1986a) developed a framework for teacher education by introducing the concept of PCK, such that teacher training programmes should combine CK and PK to effectively prepare teachers.

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 – including 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. Other alternative conceptualizations of PCK have been developed consisting of four (Cochran, King, and deRuiter, 1991) or five elements (Magnusson, Krajcik, and Borko, 1999).

PCK 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).

Research Design

The research design followed a case study approach to explore secondary school Technology teachers' PCK (Boyce & Neale, 2006) to address the research problem: What is secondary school Technology teachers' PCK? A convenience sample of eight schools was selected to become case studies, four in cities, two in small towns, and two in the countryside. All the schools were mixed gender, they varied in size from 600 to 1800 students, and all the classes observed were at the lower secondary level.

A convenient time was negotiated with each teacher; during which they would be teaching lessons that could be observed. 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). Generally the observation was followed by an interview. Documents and resources used by the teachers were analyzed.

In order to validate the data, all classes were observed by both researchers and the interviewees were asked to confirm what they had said once the data had been transcribed. The findings from the interviews, observations and document analysis were triangulated.

The interview data was coded first, adopting a variation of the coding strategy used by Marshall and Rossman (1999). This involved a stepped process moving from a general approach to develop themes and codes 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. The analyst-constructed themes were: subject matter, curriculum, assessment, learners, pedagogy, educational context, educational aims, purposes and values, and indigenous dimensions. The interview questions were based on these themes as well the reporting of the findings.

Once the interview data was analyzed, it was 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 eight integrated narratives about each of the cases.

Findings

In this section, the findings from the consolidated case studies are presented under the following themes:

Nature and purpose of Technology Education

Teachers in both countries related one of the purposes of Technology Education to their national context. In South Africa, the need to minimize foreign dependency in areas such as architecture and engineering is often espoused by the government, and the teachers saw Technology playing a role in skill development in these areas:

> It will help learners learn about technology so that they can add to the skills development in the country. We depend on people from other countries rather than those from our country. Technology Education will help minimise this (SA:J).

For SA teachers, to reduce foreign dependency starts with exposing learners to technology so they can become technologically literate:

> Technology is fine because it teaches learners about things that they were ignorant about before. Like now we have been doing a structures project, suspension bridge and learners do not know structures. They also need to be encouraged about how important technology is because we apply it every day in our homes (SA:L).

In NZ the rationale was that it is a small country that does not have a broad manufacturing base, so there is a need to be cutting-edge in creativity and inventiveness, and design and technology can contribute to this end.

So the relationship of Technology Education to national needs was perceived as a significant alignment in terms of skill development, but these skills were seen as more practical in SA and cognitive in NZ. In SA, practical technological skills were highlighted. As aspects of both personal and vocational development, NZ teachers believed that student conceptual development through the medium of Design and Technology would help develop research and thinking skills which are useful regardless of the vocation students eventually pursue:

> Technology is a subject that teaches our students to think through the medium of design, construction and making things. Whether students go into a trade or carry on studying at university, it still gives them a process of problem solving and thinking about things, coming up with answers and being able to discuss ideas with other people (NZ:J).

The rationale for the nature of technological knowledge seemed to vary between countries. In NZ, three of the teachers explicitly mentioned the importance of linking theory to current practice. They only taught new knowledge (conceptual and procedural) when the students had a practical application for the knowledge, so they needed to know it and consequently saw it as relevant.

> You feed the students slowly – when they need to know it, when the time is right, when it becomes appropriate for them and is relevant, and that makes it less burdensome. You can deliver it comfortably to the students without putting them under stress, but also stretching them enough to make them think about what they're doing (NZ:J).
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> When students come into technology in Year 9, they just want to do the practical, but they have to have the understanding from early on that there is theory to be done, they have to start thinking and recording their ideas. The student's are told all the time that you can't actually make something without thinking about it. Without good research, without good analysing, without good decisions, the project will be crap (NZ:M).

In SA, the rationale was based more on the curriculum and textbook sequencing of topics, which seemed quite acceptable to students. This was in a context in most classrooms in which practical tasks were not the main organizer of technology education.

> We follow the curriculum. Today we did Learning Outcome 1 and Learning Outcome 2 (SA:L).

Knowledge of the Technology Education curriculum

All teachers were aware of the curriculum, but to varying degrees. One teacher in NZ had been involved in the development of the latest curriculum revision, and so had an intimate knowledge of all aspects of the curriculum which was evident in his assessment structures. Other teachers in both countries did not have a clear understanding of either the structure or the demands of the curriculum. These teachers consequently utilized other organizers for their planning. In NZ it was the vocationally aligned and skills oriented unit standards, and in SA the teachers were following the textbook. Exercises in the SA context were heavily reliant on a textbook to a point one teacher even produces hand-outs for learners who do not have it.

> Many of the exercises, for example the hand-outs that I used today, come from the textbook that I had. Not all learners have textbooks, that is why I produce these hand-outs (SA:J).

While both of these alternatives reflect the curriculum, they do not replace it as a full understanding of learning area requirements.

One difference between the countries derives from the nature of the curriculum. In NZ Technology extends through to the end of secondary schooling as an option for students who can use their Technology studies toward their terminal National Certificate of Educational Achievement (NCEA). In SA, continuation of Technology through to the end of secondary schooling is very limited because of the nature of the subjects and the accompanying facilities and equipment limitations, which exist in very few schools.

The teachers in NZ, therefore, tended to plan progression for their students in light of the pathways that were available to them as they progressed through schooling, developing a foundation of skills, knowledge and understanding that would support their achievement in senior years Technology.

> In Year 13 students have a client with a genuine issue that has to be solved. We don't usually let any kids into Year 13 that haven't done the preparatory work in Years 11 and 12. My role is to make sure it's not too expensive and get out of control, and that the stakeholders are available to talk to the students and it's also going to have the depth that we need (NZ:J).

> Progress in technology is reflected in the students conceptual idea development. In Year 9 students different concepts are really just the one idea modified, so progress is getting them to diversify their thinking. It really is important when they get up to the senior level that they show a good diverse range of thinking (NZ:C).

In SA the teachers were, at the most, concerned with progression over the 2 years that they knew their students would be studying Technology, and their concern was more with covering the required topics rather than developing progression.

> Technology has 3 learning outcomes. The learners must know how to use the design process to solve problems. They must also have the knowledge of technology to solve problems. We also look at how technology affects the environment and affect the people and how it has been developing over the years (SA:M).

Pedagogies suitable for 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.

Teachers in both countries made reference to a practical – theory dichotomy in Technology. Although it was more difficult for SA teachers to have their students engage in practical work because of equipment and facilities limitations, they recognized that practical engagement was important, and felt that students learnt and retained more after doing practical activities.

> When you do practicals, they remember. Theory they easily forget (SA:M).

NZ teachers seemed to recognize to a greater degree the expectation from students to do practical work, but emphasized the need for complementary theory. So because of expectations and facilities, NZ teachers seemed to find the implementation of practical activities easy and had to work harder to integrate written work and theory, while in SA it seemed easier to focus on theory and more effort was required to incorporate practical activities.

> As students go through each year and the different programmes, we indicate progress by the projects getting a little bit more complicated each year, and there's more paperwork associated with the projects. We try to get the students to think through some of the issues themselves – not necessarily handing it to them on a plate but guiding them through the steps. I think they get better at technology by their thought processes, if they can pretty much think for themselves (NZ:C).

Physical facilities were felt to be both an impediment and a tool for certain pedagogies. One teacher used the physical arrangement of the facilities to complement his pedagogies by utilizing a long bench in the workshop to seat students for impromptu teaching incidents. While teachers in both countries used small groups extensively, the more restrictive facilities in SA schools made this more difficult. In none of the SA schools was there a suite of Technology facilities, and in just one school was there a dedicated Technology room, though it was a classroom and not a workshop.

Assessment

The teachers reflected a broad range of assessment strategies based on projects, weekly tests, end-of-year examinations, portfolios, case studies and homework. Types of assessment included teacher assessment, self assessment, peer assessment and group assessment. Assessment criteria were derived from the teachers' own ideas, assessment matrices, and curricular levels of attainment. The combination of all these elements painted a complex and inconsistent picture of assessment. In neither country was there a consistency of assessment practice, each teacher seemed to have a preferred method of assessment.

The teachers in SA tended to refer to their use of tests and examinations more frequently than the NZ teachers, whose assessments tended to be of products (projects or portfolios). One SA teacher stated:

> Tuesdays and Thursdays we have 30 minutes test. Learners are expected to diarise them (SA:J).

Teachers in both countries discussed group assessment, one using the members of each group for peer assessment within the group as a way to moderate the teacher's assessment of the group. A SA teacher used group portfolios, some sections of which contributed to a group mark, and other sections which related to individuals marks.

> They also have to produce a project that I must assess. I assess them on the design process and technological processes. The design project portfolio contains individual activities and group activities and they are assessed as such. Individual activities go up to the design stage where each group member must design at least three possible solutions, evaluate them on the basis of advantages and disadvantages of each, and choose the optimum solution. Then the members must negotiate the optimum solution from each member's best one, to adopt as a group design. Group members assign each other time frames when to complete the project within the main assigned time frame (SA: L).

And in NZ:

> We have design groups right through to Year 11 and they get looser as they progress. It gives students confidence within the group. I keep my design groups to no more than three and I try and pick the groups to mix the ability. The groups evaluate their peers' innovation and engineering. We do it at the conceptual stage, we do it at final design stage, we do it when construction has started and they've started to build their projects, and then also at the end we do them again. And students evaluate their own as well (NZ:M).

Resources

There was a significant difference between the two countries related to resources. In NZ the teachers tended not to use books as a resource, while in SA the teachers commonly used textbooks extensively. Teacher M from NZ stated that:

> As resources, I use fellow teachers as much as I can, visiting schools and catching up every time we do professional development. So I'll bounce anything off anyone that I have got some respect for. I go on the net and I spend a lot of time in toyshops looking like a paedophile. I go into home appliance and hardware shops and browse looking for project ideas and resources (NZ:M).

A possible reason for this difference lies in the fact that the majority of the teachers teaching Technology in SA were not trained in technology, but either began teaching Technology because of a personal interest in the area or underwent a short retraining course. Consequently they may be less secure in their understanding of the Technology content, and follow a textbook as a way of sequencing their teaching. NZ teachers often had some books in their office which were used as reference books, but there were no class sets of work or text books.

The existence of active regional professional associations in NZ means that teachers can meet with their colleagues frequently and so can use each other as a resource, whereas in SA such opportunities are less readily available.

There was greater consistency of resources in NZ schools than in the SA schools. All the NZ schools had a Technology department with a number of materials oriented workshops, a machine room, a computer lab and an adjacent class or design room. One SA school had a dedicated technology room, the others used classrooms and none had a workshop. When engaged in an activity, students had to bring materials from home. These teachers consequently felt that Technology was not taken seriously by the school or the Department of Education, and this severely limited the scope of activities they could organize with their students.

> No resources. I have provided the school with the list of items that we need for technology teaching. I have not received anything yet. There is a lot that we need to be able to teach a topic, like structures. We have to find a workshop for food technology, systems and control, and the like; we do not have any (SA:M).

Indigenous Technology

Despite expectations, there was very little more incorporation of Indigenous Technology by the SA teachers compared with the NZ teachers. This expectation was derived from the fact that Indigenous Technology is one of the curriculum content areas in the SA Technology curriculum.

Some SA teachers were guided to some extent by chapters in textbooks which dealt with indigenous technological issues and perspectives. Others had not considered the area of indigenous technology at all, and in this sense were more like the NZ teachers. There is no curricular imperative in NZ to address Indigenous Technology, apart from a general inclusiveness of Maori culture, and consequently the incorporation of Indigenous Technology was quite superficial, relating to decorations on products, the use of symbolic colored beads or wall posters. The most significant instance of Indigenous Technology incorporation was an SA teacher who, in the context of a unit on packaging, described his approach:

> We plan to include it in the packaging project. For example, we will talk about packaging by the Bushmen who used to carry water in egg shells. It will also be catered for when we do the development of packaging (SA:M).

In a number of instances, the background of the students in Technology classes was cited as an impediment. In a SA school there were students from coloured, European, Zulu and Xhosa backgrounds, and with this range of indigenous orientations the teacher felt it would be difficult to include indigenous issues in the Technology classes. Two of the teachers in NZ felt that indigenous issues were not important because of low numbers of Maori students in their classes.

One of the problems that we have is that we don't have a lot of Maori students come through, there might be two Maori students in our Technology program, so why should I be trying to convert the ones that I don't need to? But in saying that, there are great opportunities for indigenous influences, and when it's done properly it can benefit many people (NZ:J).

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.

While quite diverse PCK was revealed amongst the teachers across all the components of PCK (content, curriculum, assessment, conceptions of the learner, philosophy and indigenous considerations), there were few areas in which greater diversity was revealed between countries.

There were clear differences in the resources that were used by the teachers with NZ teachers tending to use the internet and their environment, and SA teachers tending to use textbooks. This is explicable given the absence of any comprehensive textbooks in NZ, and also the less readily available access to the internet in SA.

While the facilities in each country were clearly different, with Technology Education in SA less well established, this did not seem to have a major impact on the teachers' PCK. For example, teachers in both countries utilized a variety of assessment and pedagogical strategies, and modified these to suit the physical environment in which they taught.

In a number of instances, it seems that teachers' PCK is moderated by the context in which they teach. For example, in the facilities-poor but textbook-rich environment of SA, the sequencing of relevant conceptual knowledge is determined by the textbook and the curriculum, whereas in NZ, it is related to the needs of the practical projects in which the students are engaged.

The philosophical rationale for Technology Education, from which many elements of PCK derive, was quite clearly focused on general Technology Education for the SA teachers. For them, Technology Education was a component of general education and developed skills and knowledge which are important for all students. In NZ, there is a clear dichotomy amongst teachers' rationales for Technology Education, with many having a vocational approach to develop set competencies in select groups of students.

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