# From classroom teacher to teacher educator: Generating PCK through action research

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## Abstract

*This paper speculates how a model for the pedagogical content knowledge (PCK) development of novice science teacher educators in a science education doctoral programme could have wider application to future teacher educators in science (and other subject domains) who enter tertiary teaching via different pathways. When the model is aligned with other pathways, contextual differences make the need for adaptation and modification of the model inevitable and desirable. In light of her own teaching and research experiences, a science teacher educator offers suggestions for adapting and applying the model in non-doctoral programme learning pathways for early career teacher educators.*

## Introduction

Pedagogical content knowledge (PCK) is an academic construct first introduced by Shulman (1986, 1987) as an attempt to acknowledge and elucidate the very specific form of professional knowledge that only teachers expert in their content possess and enact when they teach that particular content to particular groups of students. Shulman recognised that each teacher's PCK is unique and evolves through the process of ongoing pedagogical reasoning and action that occurs as they experience teaching certain content to different groups of students over time. These experiences result in "the blending of content and pedagogy into an understanding of how particular topics, problems, or issues are organised, represented, and adapted to the diverse interests and abilities of learning, and presented for instruction … and the category [of teacher knowledge] most likely to distinguish the understanding of the content specialist from that of the pedagogue" (Shulman, 1987, p. 8). When interviewed in 2008 about the origins and development of PCK as a construct in education, Shulman commented "PCK was one way of opening up new possibilities for looking into, and better understanding the skills, knowledge and ability of expert teachers, it offered a way of examining the sorts of things that 'only teachers know, [that] only teachers can do" (Berry, Laughran, & van Driel, 2008, p. 1277).

In this paper I outline how researchers in the science education field are exploring ways to use the PCK concept to inform and enhance teacher education. I focus attention on a model for developing PCK for teaching science teachers in science education doctoral programmes recently proposed by Sandra Abell and her colleagues at the University of Missouri (Abell, Park Rogers, Hanuscin, Lee, & Gagnon, 2009). This model, I believe, has the potential to improve the quality of teacher education across all subject domains and has wider application to those teacher educators who enter the profession via pathways that differ from doctoral programmes. However, when the model is aligned with other pathways into teacher education, contextual differences make the need for adaptation and modification of the model inevitable and desirable. In the latter part of this paper I suggest how the model might be applied and adapted to develop the PCK of novice teacher educators going down other learning pathways from education doctoral programmes.

### The Abell et al. (2009) model for developing PCK for teaching science teachers

In proposing their model in the context of science education doctoral programmes where many graduates ultimately become science teacher educators, Abell and her team regard the PCK of science teacher educators as an unrecognised and neglected area of the professional learning required to be an expert teacher educator. They contend that the PCK required for this aspect of their future professional activity needs recognition and support and argue that the lack of explicit attention to developing knowledge for teaching science teachers in science education doctoral programmes is a significant deficiency. Their model for addressing this gap also has great applicability, in my opinion, to science teacher education programmes where new teacher educators are not participants in doctoral programmes but come to this role as expert science teachers straight from the classroom. For many of these people, although they may have had experience as associates or mentors to trainee teachers in their classrooms, entering the science teacher education scene requires a whole new mindset. In due course as they take on this different teaching role they need to develop the PCK that distinguishes an expert science teacher educator from an expert science teacher. Their experiences as they enter the teacher education profession are undoubtedly varied, from situations where the required professional learning is carefully scaffolded through planned and staged programmes of induction to those where novices must—"hit the deck running"—it certainly was the case in my experience! The value of the Abell et al. model is its potential to provide guidance to those responsible for the professional learning of new science educators because it gives "explicit attention to developing knowledge for teaching science teachers as an important goal" (p. 78). There are elements of the model that new teacher educators who find themselves as lone practitioners when they first begin their careers can utilise despite their isolation. In this paper I offer some thoughts about a "self-help" model, which new science teacher educators may find useful based on aspects of the Abell et al. model.

Before presenting the Abell et al. model it is helpful to understand how the PCK construct of Shulman (1987) has been interpreted over the last 20 years and what use is currently being made of the construct in science teacher education.

### Development of the PCK construct since Shulman (1987)

To help clarify the nature of the amalgam of content and pedagogical knowledge that expert teachers exhibit, Shulman (1987) had originally identified two components of this specialised knowledge category he termed PCK:

1. knowledge of what he calls "representations" i.e., instructional strategies illustrations, analogies, explanations and demonstrations that teachers use to make certain subject matter comprehensible to their students; and
2. knowledge of students' "learning difficulties" i.e., students' misconceptions, nad've ideas gained through interpretation of prior learning, experiences or preconceived ideas about a topic, as well as knowledge of any other potential barriers to learning subject matter, such as how concepts inter-relate and strategies to help solve problems.

Other workers in the field since Shulman have explored, argued and expanded upon the nature of the PCK construct, notably the knowledge domains that appear to contribute to a teacher's PCK, how it is generated and its components (Kind, 2009). For example, Grossman (1990) saw PCK as a transformation of various knowledge domains rather than a blend, and she believed three not two knowledge domains were involved in this synthesis: (1) subject matter knowledge and beliefs, (2) pedagogical knowledge and beliefs, and (3) knowledge and beliefs about context. She theorised that these three knowledge domains are sourced from an expert teacher's observation of classes as a student and teacher, from specific courses she/he has experienced during teacher education and from classroom teaching experience. Grossman also envisioned four components of PCK, adding conceptions of purposes for teaching subject matter and curricular knowledge to the two original Shulman components. Her argument was that an expert teacher's rationale for teaching particular content to particular students and his/her understanding of what concepts and skills needed to be learned (and when and why) by those students are fundamental elements of that teacher's classroom thinking and action. Magnusson, Mulhall, and Berry, (1999) expanded Grossman's model to include five components of an expert teacher's PCK:

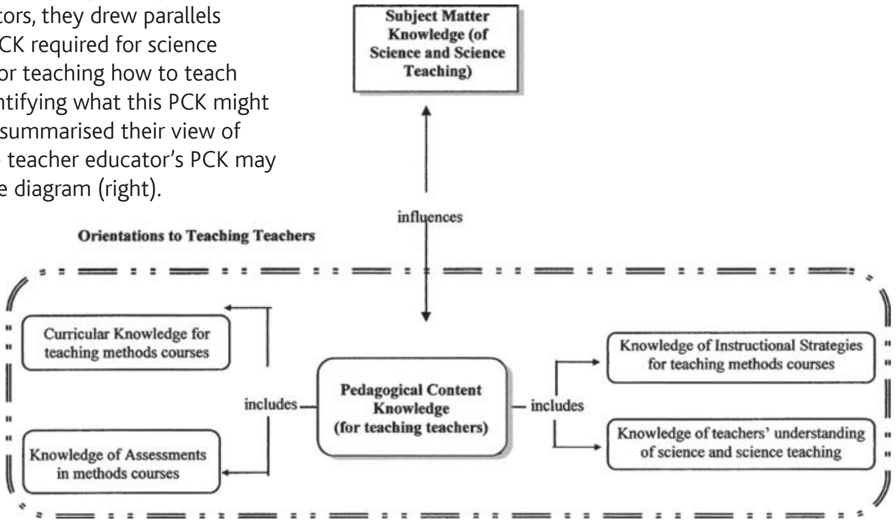
- orientations towards science teaching (since teachers' knowledge and beliefs related to their teaching goals and approaches will influence their classroom practice);
- knowledge of curriculum;
- knowledge of assessment (since what is to be assessed, how and why, also influences a teacher's practice);
- knowledge of students' understanding of science; and
- knowledge of instructional strategies.

In her overview of the PCK research field, Abell (2008) suggests a useful way forward is to take a holistic view of PCK where it is seen as more than the sum of its components. She highlights the synergistic and dynamic dimensions of PCK where expert teachers "not only possess PCK, they employ the components of PCK in an integrated fashion as they plan and carry out instruction. Teacher use of PCK involves blending individual components to address the instructional problem at hand" (p. 1407).

In another more recent and extensive review of PCK in science education, Kind (2009) makes the point that expert teachers are not "born" with PCK and for student teachers acquiring a bank of skills and new knowledge to become professional science teachers expert in their field is a lengthy process. She identifies three common factors that appear to contribute to the growth of expert PCK in novice teachers. First is the possession of good subject matter knowledge (SMK); second is classroom experience with studies pointing to significant changes occurring in the early months and years of working as a teacher; and third, the possession of emotional attributes like good levels of personal self-confidence and provision of supportive working atmospheres in which collaboration is encouraged.

Recently a number of researchers in science teacher education have begun investigating and devising pedagogical approaches that help new teachers to conceptualise their professional learning and begin laying a foundation for their own PCK development (e.g., Abell, 2008; Loughran, Mullhall, & Berry, 2004; Loughran, Berry, & Mullhall, 2006; Nilsson, 2008). While there is still debate over the very nature of PCK (Kind, 2009), this new field of research offers much potential for improved teacher education but it is problematic. For example, a key issue emerging for developers of such approaches has been the virtual absence of concrete examples of expert science teachers' PCK since this highly specialised form of professional knowledge is embedded in individual teachers' classroom practice (Padilla, Ponce-de-Leo, Rebado, & Garritz, 2008), and rarely articulated within the teaching community of practice. At this point I make mention of research exploring this issue and innovation as reported by Loughran, Mulhall, and Berry, (2008) because it pertains to my later narrative. Loughran et al. (2008) recount the use of frameworks known as Content Representations (CoRes) and Pedagogical and Professional-experience Repertoires (PaP-eRs) by a teacher educator in his science education course. These frameworks were an attempt to make the links that exist between the knowledge of content, teaching and learning for a collective group of expert science teachers explicit to others (Lougrhran et al., 2004). Initial findings from this study, which culminated in students designing their own CoRes, indicate that the novice teachers gained deeper awareness and understanding of PCK and a possibly useful foundation for building their own PCK.

Abell et al. (2009) theorised that just as PCK existed for how to teach science there must also be a PCK for teaching how to teach science. When considering the professional learning required by science teacher educators, they drew parallels between the PCK required for science teaching and for teaching how to teach science by identifying what this PCK might look like. They summarised their view of what a science teacher educator's PCK may comprise in the diagram (right).

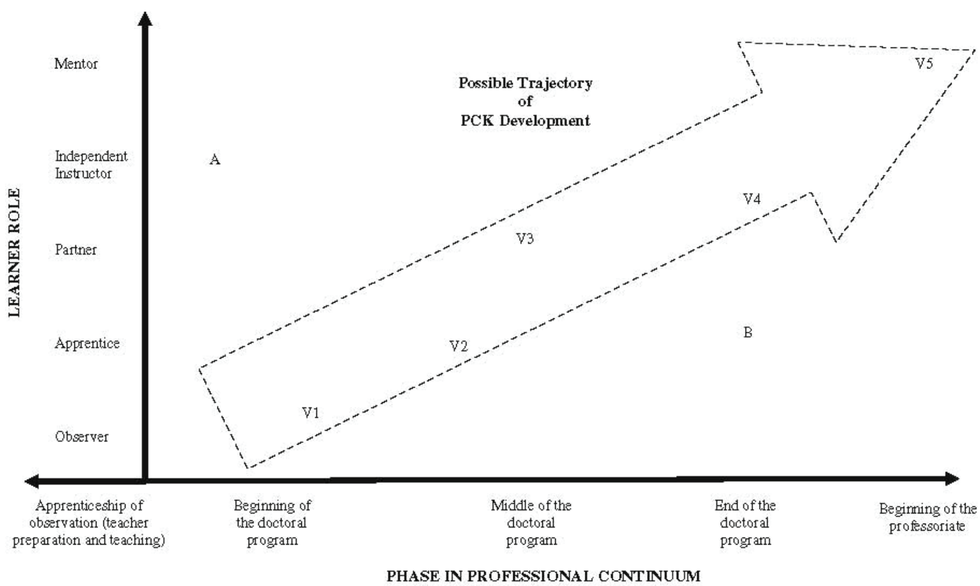



*Abell et al., 2009, p. 80*

To foster the professional learning of their novice science teacher educators, Abell et al. (2009) recommend that the components of PCK above should be dealt with explicitly in any doctoral programme, along with opportunities to draw upon these components in situations that require them to make instructional decisions. They also signal the long-term, ongoing professional learning that gives PCK its dynamic dimension as an important feature to recognise in PCK development. Using an approach based on learning through legitimate peripheral participation in communities of practice (Lave & Wenger, 1991), Abell et al. have put forward a theoretical model of PCK development for science educational doctoral students that portrays learning as phases on a continuum.

The phases are *observer, apprentice, partner, independent instructor* and *mentor,* which Abell et al. expand upon and illustrate effectively through the use of vignettes—see pages 87–89 of their 2009 paper. The vignettes are based on the actual experiences of members of the Abell et al. team as doctoral students and faculty members and presented in a sequence that is representative of the different learner roles and phases in a possible learning continuum. Each vignette also depicts the development of a PCK component.

The Abell et al. (2009) model has many direct links to the continuum of learning that an expert science teacher going directly from the school classroom into teacher education (rather than a doctoral student) may undergo in becoming an expert science teacher educator. However, given the context in which each novice teacher educator may find his/herself, there can be some important differences in non-doctoral programmes that need to highlighted and addressed if this model can be successfully translated to such situations. I use my own experiences to highlight what some of these differences might be and suggest some modifications/additions to the model that may be helpful to those science teachers who find themselves in situations similar to mine.




*Abell et al. 2009, p. 87*

### Setting the scene to my introduction into science teacher education

I began my teacher educator career some seven years ago after 30 years' experience as a secondary science teacher that also included work in teacher professional development, national curriculum and qualification development and as an education evaluator of schools. For the purposes of this narrative I will focus my comments on my developing PCK for teaching a secondary science education course at university level. This one-year course caters for students with science degrees, and graduates of this programme enter into the secondary education sector where they serve an internship for a further two years before becoming fully certificated secondary teachers. Students in this secondary science education course arrive with a wide range of experiences and views on the teaching and learning of science, and diverse learning needs in terms of developing the capacity to perform successfully as a teacher of science. Some may be experiencing for the first time an educational programme with a vocational orientation that prepares them for a professional role, rather than mastery of a knowledge domain, which can create tensions. For example, adapting to a pedagogical role in classrooms where their students are unmotivated and struggle with science can be difficult for novice teachers to accomplish if they themselves have been successful learners in science. Such experiences may challenge their long-held views about learners, and teaching and learning in science, and need to be addressed if they are to become effective teachers of all students in science. In my own science teaching career I had frequent contact with such student teachers as an associate teacher responsible for their professional learning while on teaching practice and I mentored many as they engaged in their first classroom teaching experiences. In knowing something of my future students' understanding of how to teach science, I was not a novice teacher educator but certainly I had little experience of delivering course work in a university setting.

My initial introduction to tertiary teaching did not involve participation in a carefully structured programme of preparation but rather one of "jumping in at the deep end". I was provided with a course outline that contained very generic guidelines and little by way of guidance about the specific content of the course. Within these guidelines I was expected to develop my own course including teaching and learning content, pedagogical approaches and materials and assessment. The guidelines indicated that I needed to familarise students with the structure and requirements of the *Science in the New Zealand Curriculum* (SiNZC; MoE, 1993], including how to use the document to plan effective classroom science lessons and units of work; to promote constructivist views of teaching and learning; to give recognition to the diversity of students entering the course; to encourage the reflection and evaluation of teaching and learning processes; and promote safe laboratory practice and management. With less than one month before teaching was to begin, the task of course design seemed almost overwhelming since I had other teaching commitments with similar demands and I was in my final year of my doctorate. In retrospect, as my story reveals, this challenge was of immense value to my professional learning in the long term because it provided both the impetus and freedom to develop a programme where my philosophy of teaching, pedagogy and assessment practices were aligned with the learning requirements of my student teachers.

### My professional learning pathway

Six months into my first year of teaching the secondary course I participated in a set of professional development sessions that all new University staff were required to attend as part of our induction into tertiary teaching. These workshops dealt with generic aspects of teaching University courses where participants had the opportunity to discuss the content as it applied to their discipline area, exchange ideas and receive feedback from course members and the facilitator. The professional learning that occurred for me in these workshops alerted me to issues that I needed to give careful thought to like teaching and learning goals that encompassed the notion of scholarship and the autonomous learner; the content of the course; and appropriate teaching and assessment methods for a university learning environment.

Before taking on responsibility for this paper I had not observed how a secondary science education class functioned (since I undertook primary teaching training some 30 years before!) and, given I was the sole provider of this course, the opportunity to observe others in action in the university did not occur. I did have an experienced colleague teaching physics and, in hindsight, time spent observing him in action could have promoted development of my PCK components like instructional strategies for adult learners and assessment practices and requirements at the tertiary level. This opportunity did not arise but I was fortunate to have a colleague in a similar situation to me who was beginning her full-time career as a teacher educator in primary science and senior biology and with some previous experience teaching in teacher education. We were able to co-plan and teach in the primary science course, which was one of my other teaching responsibilities, and this experience did give me many insights into instructional and assessment strategies that could be translated into my practice in the secondary course.

### The contribution of scholarship to my PCK

Another factor that contributed to my PCK development in these early stages of my teacher education career was the learning I was experiencing through my doctoral study, which was in its final stages. This doctorate had no explicit elements related to the development of science teacher educators, but the study enabled me to integrate my personal experience of science teaching and learning as a school classroom teacher with findings from both my own research work and the wider science education research community. From these experiences crystallised some key concepts of teaching and learning that apply across most learning contexts including teacher education. Seminal papers like "*Understanding student thinking and learning in the classroom"* by Graeme Nuthall (1997) with his amalgamation of constructivist, sociocultural and linguistic perspectives on learning for improved classroom practice and "*Knowledge and teaching: Foundations of the new reform"* by Lee Shulman (1987) with his notions of knowledge domains for teaching and pedagogical reasoning and action strongly influenced the pedagogical approach I developed to my pre-service science education courses.

### The missing phases from the Abell et al. model

My narrative to this point illustrates that I did not come to the role of teacher educator completely devoid of the PCK components required to become expert in the teaching of the secondary science course, but the first three phases described in the model of PCK development by Abell et al. (2009), i.e., *observer, apprentice* and *partner,* did not eventuate for me in this

[1] *General Certificate of Secondary Education is the examination taken by students at the end of compulsory secondary schooling in England (aged 15-16 years).*

context. I think also that in the reality of my situation—a small department where most staff members were new and relatively inexperienced—this sequence would be difficult to achieve as described in the Abell et al. model and signals a reality that probably exists for other teacher educators in similar situations.

### The independent instructor

If I continue to draw parallels between the Abell et al. (2009) model and my own experience, it would appear that I entered the sequence at the *independent instructor* phase since I assumed independent responsibility for teaching the secondary science course right from the outset. Selecting what content I thought applicable from my existing knowledge to the task of how to teach science specialists how to teach science, while at the same time processing the incoming information about the new educational context, I began to make instructional decisions and synthesise a hypothetical PCK which was very soon put to the test. During that first year through a "trial and error" form of pedagogical reasoning and action, I began to accumulate some of the knowledge underpinning the components of an expert's PCK in science teacher education, and I was developing a rudimentary form of PCK. However, the process of acquiring this PCK was haphazard and at times quite stressful when certain of my pedagogical decisions did not produce the learning I had anticipated and/or hoped for. Setting the students planning tasks without sufficient recognition on my part of the pre-requisite pedagogical skills and knowledge they would require to carry out such professional activity with any degree of success would be one instance of a decision I needed to rethink to improve my PCK. Another instance was my decision to use student reflective journals for assessment purposes (both formative and summative). I came to realise that the information they provided served little pedagogical or learning purpose because few of my students were able to reflect in a critical way on their own learning. Again there were assumptions on my part, through my inexperience in teaching adult learners, that such skills were inherent in "mature learners".

### The role of a tertiary teaching qualification in promoting my PCK development

It was in my next few years that I was fortunate enough to become aware of, and eventually participate in, a post-graduate programme run at my university, which gave me opportunities to learn about and engage in scholarship to enhance my tertiary teaching. The programme known as the Post-Graduate Certificate in Tertiary Teaching (PGCertTT) encouraged both emerging and experienced tertiary teachers to purposefully draw on scholarship to assist in the design of teaching and learning initiatives to improve their practice and conceptualise their pedagogical philosophies and goals more clearly. My experimentation with reflective journals seemed an ideal subject to explore further, and in my third year of teaching the secondary science course I chose to use an action research design known as *practical action research* (Creswell 2005), to investigate new strategies I was introducing into the course for improving the student teachers' reflective capabilities through their writing. The action research model I adopted (and continue to use) involved a dynamic, flexible and iterative methodology that allowed me to spiral back and forth between reflections about the problem, data collection and action. Thus through a spiral of generic steps I was able to investigate potential solutions to this problem (and others) in collaboration with other researchers or mentors, and to enter the spiral at any point appropriate to my particular action research project at any given time. For a full account of the steps in the model as it applied to my first initiative please see the papers by Hume (2008, 2009). Fellow members of the course and the course leader mentored me through the process for my first initiative, with the course leader acting as a co-researcher when she interviewed the student teachers on completion of their course.

Findings from this action research were "reploughed" back into my teaching in ways that led to a deepening of my PCK for the secondary science programme. The enhanced quality of my student teachers' reflective writing, for example, and their interview data gave me insights into the nature and extent of their learning and on the impact of various pedagogical strategies I had employed on their learning. Armed with these insights from the research and my personal experiences teaching in the workshops and observing my student teachers on their teaching practice in schools, I began to slowly but surely advance my PCK towards that of an expert science teacher educator. The students' improved reflective writing deepened my awareness of their individual learning needs and characteristics and gave me better opportunity to provide individuals with targeted feedback and feedforward (next step learning) commentary on their professional learning while in workshops, in response to their reflective journal writing or after my observations of their teaching.

A further PGCertTT task helped to address the knowledge base of another PCK component, namely my orientations towards teaching science student teachers. We were asked to compile teaching portfolios—one a *personal portfolio* tracing our teaching careers in ways that illustrated how events and experience had shaped our beliefs about teaching and learning and influenced our pedagogical approaches; and the other a <u>career portfolio</u> that might be used alongside a curriculum vitae for promotional purposes or job applications. The career portfolio was to include a personal teaching philosophy. The exercise of formulating my teaching philosophy proved very beneficial in bringing coherence to my teaching of the science education course by helping me to make decisions about course content, pedagogies and assessment methods that were all aligned my teaching beliefs and goals related to science teacher education. Here is an extract from my teaching philosophy as presented in my career portfolio.

> *Currently, as an educator of pre-service student teachers in science, I am aware that I have the added pedagogical challenge of teaching students how to teach. My teaching involves inducting students into a professional role that draws upon an extensive knowledge base gained from a range of sources or "domains of scholarship and experience" (Shulman, 1987, p. 5) such as disciple(s) content knowledge, educational research, educational contexts and materials and perhaps most importantly classroom experience. I need to instill in my students the understanding that teaching is a skilled and purposeful activity requiring a form of 'pedagogical reasoning' (Shulman, 1987), which is an acquired, often tacit professional capability that comes from the wisdom of practice. To provide learning environments that enable novice teachers to gain these insights into the nature of teaching is no easy matter. Consequently in my teaching I have sought to 'lay bare' my own pedagogical reasoning in ways that illustrate the thoughts processes I employ as I teach and in so doing exemplify/model strategies that the students can begin to utilize in their own learning of how to teach.*
>
> (Personal career portfolio. 2008)

My involvement in the PGCertTT programme, in particular the action research aspect gave me a means for ongoing development of my PCK not only in the secondary science course but in other teaching programmes I had responsibility for, such as chemistry. When I was given the chemistry course to teach in my fourth year, I possessed far more understanding of the knowledge underpinning the PCK components that an expert chemistry teacher educator displays than I had for expert science teacher education when embarking on my science course three years earlier. I was able to articulate my orientations towards science teacher education with greater conviction and clarity and my knowledge of the university education sector and its practices was more in depth. More importantly, I had increased awareness of my learners and the range of experiences and beliefs about teaching science that they brought to their learning about how to teach science. I had devised a repertoire of instructional strategies for my science education course, such as formative assessment (including sharing of learning goals and success criteria in workshops), problem-solving scenarios and the design and evaluation of learning activities for targeted science content that translated readily into the chemistry course. This underlying knowledge gave me a much firmer base on which to begin developing my PCK for chemistry teacher education.

### More action research

One component of my PCK for teaching the chemistry education course that did need consolidation was my own chemistry curriculum knowledge and this process was facilitated when I undertook another phase of action research, this time in the chemistry education programme. In my academic reading I had come across the work of Loughran et al. (2006), who were trialling Content Representations (CoRes) and Pedagogical and Professional-experience Repertoires (PaP-eRs) to exemplify the collective PCK of a group of expert science teachers for particular science topics and groups of learners (see earlier reference). It occurred to me that CoRe design for particular chemistry content and particular groups of students could be a potentially useful instructional strategy for my chemistry student teachers as a means of building a foundation for their future PCK—a form of hypothetical PCK that they could test when planning and teaching the topic for the first time.

CoRe design entails the identification of key ideas or enduring understandings with an analysis that includes justification of the key ideas choice, any difficulties students may encounter learning these ideas, related misconceptions students may hold and appropriate instructional sequences and strategies for the intended learning. To complete this design task requires thorough familiarisation with the content to be taught, the sources of that content and the rationale for that content choice. Working with students to help them complete their CoRes enabled me to re-familarise and/or update my knowledge of current national curriculum statements, qualifications requirements, common chemistry misconceptions, and sources of appropriate instructional strategies such as text, electronic resources and the Internet. The gathering and interpretation of data from sources such as observations, students' reflective journals and artefacts (their finished CoRes) to identify signs of emerging PCK greatly enhanced my understanding of what curricular content I needed to teach in this course. The act of researching CoRe design, as a useful pedagogical tool in my chemistry education course, had simultaneously deepened my own knowledge of a PCK component (curriculum knowledge) and allowed me to synthesise new PCK. For a fuller account of this research see the paper by Hume and Berry (2011).

### Some possible strategies for a 'lone' independent instructor

Thus as an independent instructor with no partner or veteran to call upon, as might be the case in a doctoral programme or large science education department, I needed other means to build expert PCK. I believe that engagement in scholarship like the academic course work required for a tertiary teaching qualification and ongoing action research into aspects of teaching a particular course is one way forward for tertiary teachers who find themselves in similar situations to mine. Applying the knowledge gained from such learning experiences and day-to-day teaching can help in the continual modification of course design, instruction and assessment of the science education courses, which are inevitable results of PCK growth.

### The mentor phase

Entering the *mentor* phase of the Abell et al. (2009) model of PCK development is a future progression that I look forward to since mentoring is vital to succession planning if there is to be a continuity of expertise in science teacher education. However, for mentoring to happen in ways that result in PCK growth for both parties, those involved in teacher education leadership have to give this role due recognition. Time and space need to be provided for meaningful and productive interactions to occur between mentor and mentee, such as those advocated in the *observer, apprentice, partner* and *independent phases* of the Abell et al. model.

### On reflection

As I reflect back over my experiences in relation to the Abell et al. (2008a) model, I can now see possibilities for the early phases of the model (*observer, apprentice, partner* and *independent phases*) to be approximated in contexts where new teacher educators find themselves as solo acts. Such opportunities for PCK growth could include:

- short periods of leave to visit, observe and/or co-teach, and discuss teaching practices with expert colleagues engaged in science education at other tertiary institutions;
- viewing of videoed sessions where expert science teacher educators are teaching groups of science student teachers;
- inviting colleagues from other teacher education disciplines within your institution to appraise your teaching in given sessions; and
- arranging for your teaching to be videoed in a particular science education session and sending to an expert science educator at another institution for feedback.

I would also strongly encourage all novice science teacher educators to carry out action research into their own teaching as a viable and potent way of building your PCK.

## Conclusion

With its roots in science education doctoral programmes, the Abell et al. (2009) model is based on the premise that individual science teacher educators possess and utilise a unique PCK, and this PCK is different to that they may possess as an expert science teacher and, like all forms of PCK, it can only be built up over time and experience. The model is concerned with the process of acquiring this form of PCK and raising awareness that it needs to be recognised, promoted and nurtured in novice science teacher educators wherever and whenever possible, ideally by experienced colleagues with expertise. However, this ideal might be difficult to achieve in some educational contexts, where novice science educators find themselves isolated. It is hoped that points raised in this paper can alert such novice educators to strategies they themselves can employ to foster their own PCK growth.

More importantly, I believe the model can be readily transferred to other curriculum areas and serve as an important catalyst for further thought and research into professional learning for all teachers of student teachers. While PCK is highly specific to individuals, the principles underpinning PCK development (Shulman, 1987) can be widely generalised. In my view, the processes depicted in the Abell et al. model (2009) are readily applicable to other subjects. Hopefully more teacher education programmes will give credence to the idea of a PCK for its teacher educators and devote more time and resources to this specialist form of professional learning. The Abell et al. model gives a strong lead for those wanting to promote such learning.

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