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Pedagogy: Making Sense of the Complex Relationship Between Teaching and Learning

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ABSTRACT

It is uncommon for an academic to be asked to review ideas developed in his own books (with a particular focus on Loughran, 2006, 2010; Loughran, Berry, & Mulhall, 2012). However, considering the focus of the journal, the editor was interested in pursuing the theme encapsulated in these works—the notion of pedagogy. As this review illustrates, pedagogy is a major construct in education that has been defined, interpreted and used in many ways in the educational literature. In much of the literature, pedagogy is portrayed as a synonym for teaching; something this article suggests is narrow and superficial. In this article, pedagogy is understood as being embedded in the relationship between teaching and learning. Therefore, how the teaching–learning relationship is understood, recognized and developed in the educational enterprise is important. Two examples of how the complexity of pedagogy plays out in practice become starkly evident when considering pedagogical content knowledge and a pedagogy of teacher education. As this article explains, through a deep and rich understanding of pedagogical content knowledge and a pedagogy of teacher education, our understanding of pedagogy is substantially enhanced. The article concludes that pedagogy needs to be conceptualized as rich, complex and sophisticated, and in so doing, highlights why it must be viewed as much more than a synonym for teaching.

Pedagogy is a term that attracts much attention in the educational literature. For example, a simple ERIC search throws up 3,147 hits for the use of the term in the title of publication types (January 2012). Like many key terms and ideas in education, pedagogy has been interpreted, used and understood in a variety of ways. As such, because the term is widely used, it is important to grasp how it is being applied in a given situation to fully understand that which is intended and the subsequent implications of its use.

This article reviews the notion of pedagogy and argues that developing a deeper understanding of pedagogy is embedded in better recognizing and understanding the relationship between teaching and learning. The

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article therefore sets out to examine the nature of pedagogy and then to examine the importance of a deeper understanding of pedagogy through exploring two important constructs to which pedagogy is central: pedagogical content knowledge (PCK) and a pedagogy of teacher education. The article begins with an examination of pedagogy.

PEDAGOGY: RECONSIDERING TEACHING AND LEARNING

In *What Expert Teachers Do* (Loughran, 2010), the first section of the book concentrates in detail on unpacking pedagogy through a reconsideration of some of the important (and perhaps taken-for-granted) aspects of teaching and learning. In this first section of the article, two key ideas from the first section of *What Expert Teachers Do* that are crucial to understanding the nature of pedagogy are considered, they are that: 1) it is important to conceptualize teaching as being problematic, and 2) pedagogy is centred on the teaching–learning relationship.

Teaching, as so often characterized in the literature, tends to return to Lortie's (1975) Apprenticeship of Observation as a major shaping force. As a consequence, teaching is often cast as something that has been passively observed by students for a long time and therefore appears to many to be relatively straightforward and simple. The stereotypical impression created is that there is a set of routines that help to ensure the delivery of information in class, but that some teachers bring to bear an idiosyncratic edge to their practice that makes them stand out as being good teachers. In essence, then, to the casual observer, teaching looks easy. Russell (2007b) pushed this interpretation further when he stated that

> [i]n sharp contrast to the everyday views of teaching held by those who do not teach, most teachers have a sense that they are working quite hard, not just when planning lessons or assessing work, but also when actively engaged in a lesson. . . . Most teachers do not involve their students in activities that would indicate the complexity of teaching. Most teachers do not take the time to indicate the rationale for either a lesson's content or the way that it is taught . . . [therefore] much of what happens and how it happens in a classroom appears to be arbitrary, left to the teacher's personal or professional whim and certainly not requiring careful analysis. While teaching is definitely not easy, every member of a society who attends school is inadvertently and unintentionally taught several things about teaching:
>
> 1. Teaching is relatively easy.
> 2. Teaching involves a great deal of talk by the teacher.
> 3. Management of students has nothing to do with how they are being taught.
> 4. Schools must ensure that children meet standards, but how schools operate should be the same as one's own schooling; innovation and change are too risky. (p. 32)

So why does teaching look easy? As Russell intimates above, the thinking that underpins practice is rarely made explicit for others and so it is difficult

to see into the complex array of demands that a teacher must manage, that is, teacher thinking is not easily observed. As a consequence, "if little attention is paid to teacher thinking then much of that practice will remain tacit, elusive and difficult to define . . ." (Loughran, 2010, p. 13).

At the heart of this issue (i.e., what teaching might look like and what it really involves) is a disconnect because of two contradictory views of teaching. On the one hand there is the notion that teaching is about the delivery of information—a transmissive view of teaching or teaching as telling—and that this delivery is the major purpose of the experience. Barnes (1976) highlighted the limitations of this narrow view of teaching not only in terms of understanding practice but also in relation to understandings of student learning. Although these days, it is perhaps not often publicly stated, transmissive views of practice carry an assumption that learning is about the absorption of the information being delivered, and such views persist through the ways in which testing and assessment are portrayed in the public domain. As a consequence, transmissive views of teaching foster simplistic understandings of teaching and learning that are counterproductive to seeing teaching as complex and based on an evolving array of sophisticated skills and knowledge. In contrast, as research into teacher thinking has illustrated (see, for example, early work on teacher thinking captured by Clark & Lampert, 1986), teachers' active decision making and the reasoning that directs and informs their practice has a great deal to do with the ways in which teaching and learning experiences unfold in the practice setting. Hence, from a teacher thinking perspective, teaching is problematic. There is no one way to teach a subject and no one way that all students learn that subject. There are multiple decision points that need to be negotiated by both teacher and learner, hence teaching is problematic.

Teaching then is not bound by a script or set of routines, but depends on a teacher making informed decisions about practice. From this perspective, teaching is dynamic and demanding because it must be responsive to the varied learning demands inherent in the situation. Seeing practice in this way means it must be understood as problematic because narrow views of teaching and learning only serve to mask this complexity.

> Understanding teaching as problematic means that teaching is dilemma based and, because by definition dilemmas are situations that need to be managed (not necessarily solved), it means that we [teachers] are continually making judgements about what we consider to be appropriate actions in a given situation at a given time . . . it means that our personal professional judgement is paramount in responding to our students' needs and concerns. . . . (Loughran, 2010, pp. 13–14)

Mason (2002) was acutely aware of the complexity bound up in teaching. His research offered insights into understanding the problematic nature of practice. Mason suggested that teaching, far from being a simple linear form of transaction, involved serious consideration of not only what was to be taught, but also how it was to be taught, and crucially, how teachers' actions

and intentions were understood and interpreted by students. As a consequence of his delving into teaching as being complex and problematic, he introduced the idea of *noticing*: "noticing an opportunity to act appropriately . . . requires three things: being present and sensitive to the moment, having reason to act, and having a different act come to mind" (p. 1).

In essence, Mason's idea of noticing highlighted how a teacher needed to be conscious of the interactions between teaching and learning in the real time of classroom practice. It also meant that through noticing, teachers were doing more than looking into their teaching; they were actually beginning to be aware of, and responsive to the overall pedagogical experience, not only as it was conceptualized in planning but also as it was unfolding in practice. Mason therefore highlighted the importance of understanding the teaching–learning relationship and in so doing focused serious attention on the nature of pedagogy.

Mason was of the view that to see into the teaching–learning relationship, to really understand pedagogy, requires disciplined enquiry. He suggested that *noticing* offered teachers ways of becoming increasingly informed about their practice, and more able to articulate their thinking (Mason, 2009). Hence, how teaching is constructed in response to learning offers a window into the complexity of practice. For example, one common view of learning—constructivism—which is widely cited as a foundation for learning in curriculum documents and the ways in which classroom activities are organized and conducted, illustrates how complex the teaching–learning relationship is and how sophisticated noticing is as a practice.

Although constructivism is a theory of learning, it is not uncommon to hear talk of constructivist teaching. The implication being that to encourage student learning in a way that is shaped by constructivist principles, then the nature of teaching must be such as to build those conditions for learning and actively encourage such learning through practice. Constructivist learning principles such as learning by doing, regulating one's own learning, building individual meaning in a situation or experience, and learning with and from others are clearly more easily achieved if the practice setting is organized, developed and enacted in ways that support those principles. Teachers who actively structure classroom experiences around such principles and seek to ensure that teaching and learning are dynamic and responsive to one another are creating ways of better seeing into the teaching–learning relationship. Thus, they are developing their knowledge and practice of pedagogy, not just their teaching skills. Therefore, understanding pedagogy as more than just teaching is important.

In countries such as the United Kingdom, United States, Canada, Australia and New Zealand, pedagogy is often used as a synonym for teaching, thus reducing its saliency. So much so that Simon (1981) lamented "Why no pedagogy in England?" van Manen (1999) responded to Simon's lament drawing on the European roots of pedagogy because he too was concerned that a lack of understanding of pedagogy meant that teaching and learning

were too often being viewed separately and therefore inadvertently reinforced narrow views of teaching. Van Manen saw great value in conceiving of teaching and learning not as separate and distinct but as being in relationship.

What Simon and van Manen therefore highlighted was the importance of pedagogy and that the traditional definition of it is as the art and science of educating children really matters. In so doing, pedagogy can be seen as bringing into sharper focus the need to better understand "the interplay between teaching and learning *and* learning and teaching . . . [which] means that the two exist together. The fact that teaching influences learning and learning influences teaching, and the way this is done, offers insights into the science of educating" (Loughran, 2010, p. 36).

Inherent in a European conceptualization of pedagogy is the point that teaching *purposefully* influences learning, and the same applies for learning to teaching. As is clear then when looking into pedagogy in this relational manner, exploring the "science of education" demands attention to the reasoning that underpins practice; the issues, ideas, concerns and knowledge that shape the interplay between teaching and learning. Korthagen (2001b) pushed this relational view of pedagogy further when he focused attention on the importance of self-understanding and connectedness. Again, like van Manen, Korthagen also drew on the European roots of pedagogy through the work of Kohnstamm (1929). Kohnstamm paid careful attention to learning experiences derived of the I–you relationship (as is the case between teacher and student). In considering student-teacher encounters inherent in teaching and learning situations, Kohnstamm suggested that greater contact was created with the inner-self. Thus, through educational experiences, all learners (students and teachers) are confronted by their own identities, actions, and practices, all of which inevitably shape the nature of their pedagogical experiences. However, in educational experiences, as van Manen, Korthagen and Kohnstamm (amongst myriad others) illustrate, the teaching–learning relationship is also influenced by other relationships such as those between teacher and student, student and student, learner and subject matter, and context and content. Therefore, it is not hard to see that the bedrock on which pedagogical practices are formed, supported and are actively constructed, is that of relationships.

As relationships are dynamic, it stands to reason that viewing practice as being problematic extends understandings of pedagogy. Pedagogy is complex and as teachers' learning about practice is enhanced through noticing, then pedagogy becomes both generative and informing as a consequence of an active and ongoing process. Dewey (1929) encapsulated the importance of the relationship between knowledge and practice in the process of pedagogical development when he stated that building a science of education depends on educational practices being the source of the problems to be investigated. (Mason can be seen as echoing this view

through his ideas about *noticing* as a disciplined endeavour.) Dewey saw the need for teachers to continually be examining practice to build deeper understandings of pedagogy. If pedagogy is understood in terms of the perspective outlined above, then Dewey's notion of the science of education being based on educational practices as the source of inquiry means that better understanding pedagogy in the work of teachers matters.

As the next sections of this article explain, developing richer understandings of pedagogy is important in conceptualizing two related constructs: Pedagogical Content Knowledge and a Pedagogy of Teacher Education.

PEDAGOGICAL CONTENT KNOWLEDGE IN SCIENCE EDUCATION: VALUING SUBJECT-SPECIFIC TEACHING EXPERTISE

The previous section of this article argues that pedagogy is concerned with the teaching–learning relationship. Pedagogical experiences are not "content free." Schooling is organized around fields of study and so how pedagogy is shaped by content is important. It was through a consideration of that perspective that Pedagogical Content Knowledge (PCK) first burst onto the educational scene.

When Shulman (1986) introduced the notion of PCK he described it as including "the most powerful analogies, illustrations, examples, explanations, and demonstrations—in a word, the ways of representing and formulating the subject that makes it comprehensible for others" (p. 9). In so doing, he focused the spotlight on the relationship between teaching, learning and subject matter knowledge in ways that created great debate about that which teachers "need to know and are able to do." Because he conceptualized PCK as "the category [of teacher knowledge] most likely to distinguish the understanding of the content specialist" (Shulman, 1987, p. 8), he placed on the public record the need to better understand and value the specialist skills, knowledge and ability of teachers. In so doing, he challenged technicist views of teaching and highlighted yet again the importance of moving beyond simplistic views of "teaching as telling" and "learning as listening." Shulman asserted that teachers needed strong PCK to be the best possible teachers and his ideas sparked a great deal of interest about pedagogy within specific content domains, with much discussion about how, and to what extent, that subject matter influences the nature of pedagogical experiences (Geddis, Onslow, Beynon, & Oesch, 1993; Lytle & Cochran-Smith, 1991; Smith & Neale, 1989; Tamir, 1988).

Not unlike pedagogy, PCK has similarly been interpreted, defined and used in various ways. As a case in point, Abell (2008) described her frustration with the situation when she noted that

> [i]n my recent review of science teacher knowledge research (Abell, 2007), I deplored the inconsistent and oftentimes vague application of the PCK construct in

science education research, and encouraged researchers to use PCK more explicitly and coherently to frame their studies. (p. 1407)

Abell, along with numerous other researchers in science education (see, for example, Appleton, 2006; Gess-Newsome & Lederman, 1999; Lederman & Gess-Newsome, 1992; Padilla, Ponce-de-Leon, Rembado, & Garritz, 2008; Rollnick, Bennett, Rhemtula, Dharsey, & Ndlovu, 2008; van Driel, Beijaard, & Verloop, 2001; Veal, Tippins, & Bell, 1999) devoted a great deal of time and effort to understanding PCK.

Although PCK has been debated, interpreted and applied in diverse ways, an important aspect central to its conceptualization is often overlooked. Just as teaching–learning relationships are crucial to deeper understandings of pedagogy, so the notion of transformation is fundamental to richer understandings of PCK. PCK is concerned with how subject matter knowledge can be transformed through pedagogical situations so that the particular subject matter under consideration is better understood by students. Therefore, PCK is evident when subject matter knowledge is reconstructed through learning, first by the teacher in considering how to teach the content as more than propositional knowledge, and secondly by the student when that subject matter knowledge becomes meaningful and useable—especially in new and different contexts.

Gess-Newsome (1999) mused over the notion of transformation by considering two different models of PCK and imagining them along a continuum. At one end she suggested there could be an "integrated" model, and at the other end, a "transformative" model: "The distinction between these two models are subtle—the integration of knowledge versus the transformation of knowledge" (Gess-Newsome, 1999, p. 11). The strength of her idea about PCK is thoughtfully portrayed through the analogy she created to describe the difference in the two ends of her continuum. As she explained, "when two materials are mixed together they can form a mixture or a compound. In a mixture, the original elements remain chemically distinct. . . . In contrast . . . a compound is a new substance, distinct from its original ingredients, with chemical and physical properties that distinguish it from all other materials" (p. 11).

The integrative model suggests that that PCK is made up of separate entities, each of which can be drawn upon in different ways by a teacher in practice. Using this model, an experienced teacher may appear to make seamless shifts from one entity to another as each element is used and placed together in different ways. However, the mixing of these entities does not change them; they simply fit together in different ways.

The transformative model illustrates that it involves the creation of something new. The transformative model means that something new is synthesized through the melding of the elements, thus transforming knowledge in new and meaningful ways to enhance student understanding. Although Gess-Newsome described the difference as subtle, her argument

illustrates that PCK is complex and sophisticated and that the dynamic nature of teaching—learning relationships leads to the creation of something new. For example, in school science students learn about the particle model, that is, if we break up substances, the smallest "bits" we can get are particles—atoms and molecules. However, students consistently struggle to understand that air has mass and thus is made up of particles, because although students appear to know that a mixture of particles make up air (e.g., oxygen, nitrogen, etc.), when questioned, they often state that there is no difference in weight between a balloon that is empty and one that is blown up (full of air). They carry that view because they cannot see air and so demonstrate that they only know the particle model as an abstract concept. For a science teacher to be able to teach the particle model in such a way as to help students understand it concretely—so that they confidently predict that the blown-up balloon will weigh more than an empty balloon—is dramatically different from the students acquiring the information as discrete propositions. Therefore, the transformative model of PCK suggests that the specific content knowledge being taught will be understood by students in ways that allow them to apply it in different contexts and different situations in a scientifically correct manner. The particle model is also used to help explain "states of matter"—solids, liquids and gases. Teaching about states of matter in ways that help students understand that glass is an amorphous solid—a state somewhere between two states of matter—requires a transformation in understanding.

Just as it is important to go back to the roots of pedagogy to fully understand what it means and might look like in different contexts, so too the same applies to PCK because

> [a]lthough Shulman originally fashioned a definition [of PCK], individuals within any group of educational stakeholders, researchers, teacher educators, teachers or others, are likely to interpret the nature of PCK differently thus engendering a variety of meanings. Beyond the issues of interpretation, the high level of specificity of PCK with respect to instructional variables such as students' characteristics, subject matter, contexts, and pedagogy . . . makes the task of defining PCK more challenging. Consequently, the amorphic nature of PCK causes difficulty in its explicit use as a conceptual tool. . . . In other words, it has been difficult to portray a clear picture . . . of how to scaffold PCK development in teachers. . . . (Park & Oliver, 2008, p. 262)

One example of PCK based on a 9-year longitudinal research project into science teachers' PCK is fully explicated through the book *Understanding and Developing Science Teachers' Pedagogical Content Knowledge* (Loughran, Berry, & Mulhall, 2006, 2012). In that book, the complexity of the teaching–learning relationship and how it is influenced by teachers' and students' thinking about particular subject matter domains (e.g., electricity, chemical reactions, forces), is examined in detail. What becomes immediately apparent through that examination is how difficult teachers found it to talk about

their teaching and their students' learning beyond general observations and descriptions of activities. Their ability to articulate their knowledge of practice was somewhat limited. However, as the research project developed over time, the ability of participants to offer insights into the teaching–learning relationship using the scaffolding of PCK (described below) changed not only what they were able to talk about, but also the level of sophistication with which they were able to engage with their pedagogical experiences, their knowledge of practice and their understanding of their students' learning of science.

The particular approach to capturing, articulating and portraying PCK outlined in this book is based around two key elements that are considered to exist in a dynamic relationship, a CoRe (Content Representation) and PaP-eRs (Pedagogical and Professional-experience Repertoires):

> . . . the CoRe (Content Representation) framework [emerged] as a consequence of thinking much more deeply about the nature of science content knowledge for teaching. Big Science Ideas emerged as an important way of reconsidering what matters most in conceptualizing science topics for teaching. . . . PaP-eRs (Pedagogical and Professional-experience Repertoires) were developed as a natural consequence of the need to dig deeper into the myriad aspects of the CoRe in order to capture the essence of teachers' pedagogical reasoning and purpose; to make the tacit explicit.
>
> The synergies between CoRes and PaP-eRs were immediately obvious to us . . . [together they illustrated what] Shulman so eloquently described as pedagogical content knowledge. . . . (Loughran et al., 2012, p. ix)

Comprehending the purpose of CoRes and PaP-eRs (explained in detail below) is vital. They can too easily be misinterpreted as distinct and separate entities. Such an interpretation would, however, be regrettable because the foundation on which PCK is conceptualized is that of a coherent whole, the amalgam of content and pedagogy. The reality of CoRes and PaP-eRs is that they are designed to highlight, and meaningfully reflect, the complexity of PCK as an entity in its own right by explicating the particular features of the specific science content knowledge for teaching in concert with the pedagogical reasoning underpinning the teaching and learning experiences being portrayed.

CoRes (see Appendix 1 for an abbreviated example: Loughran et al., 2012, pp. 26–31) begin to unpack the complexity of PCK through a consideration of what it means to conceptualize Big Science Teaching Ideas (the top row of Appendix 1), and what it means to "unpack" those Big Ideas through the prompts that appear in the left-hand column. The prompts in a CoRe (i.e., What do you intend students to learn?; Why is it important for student to know this?; What knowledge do you have about students' thinking that influences your teaching of this idea; and so on), help to draw out teachers' informed understandings of the particular subject matter knowledge. These prompts were developed and refined through the research

project in response to attempting to access very particular aspects of teacher thinking that consistently arose when experienced science teachers explained key components of practice that they considered important in influencing the teaching–learning relationships in their practice. As a consequence, when these prompts were used as ways of inquiring into the thinking of less experienced science teachers, they proved to be very effective (i.e., participants were better able to explain the ways in which they understood their teaching and their students' learning as a consequence of the prompts).

> . . . CoRes offer the means of gaining a unique insight into teachers' practices relating to specific science topics. CoRes are working documents that can be changed at will, so can actively reflect development of PCK, thus avoiding the image of a static, unalterable body of knowledge. Training novice teachers in writing CoRes would prove valuable in helping develop their ability to reflect on practice and consider the 'real world' of a professional science teacher. (Kind, 2009, p. 199)

CoRes then offer a "way in" to the complexity of PCK through the lens of "subject matter content"—as illustrated in the abbreviated CoRe in Appendix 1. For example, in considering the prompt "Knowledge about students' thinking which influences your teaching of this idea," under the Big Idea "there is empty space between particles," the prompt highlights recognition that the notion of "space" is very difficult to think about, so much so that most students propose other "stuff" to exist between particles. Therefore, for a teacher to both uncover this thinking in students and then create pedagogical experiences that can help to reconcile these contradictory views is clearly demanding and requires a level of sophistication that goes well beyond simply stating the information. Despite the inherent complexity in that which is uncovered and articulated through a CoRe, it is important to be reminded that subject matter knowledge alone is not PCK; pedagogical practice matters. Shedding light on, and creating insight into, the teaching–learning relationship (the heart of pedagogy) occurs through PaP-eRs as the CoRe is brought to life through these windows into pedagogy.

PaP-eRs are designed to make clear how particular aspects of subject-specific practice might be exemplified, and therefore contribute to a teacher's PCK. PaP-eRs are linked to a particular element of the CoRe to see into the pedagogical experience through an action lens. Appendix 2 offers an example of a PaP-eR titled "Playdough Balls: Concrete Models of Abstract Ideas" (Loughran et al., 2012, pp. 42–44). This PaP-eR (designed in two parts) explores how a teacher works with the Big Ideas of "Particles are in constant motion" and "There are different types of small bits of substances" from the CoRe (Appendix 1). The PaP-eR shows the teacher thinking underpinning practice and how the dynamic nature of the teaching–learning relationship is both acknowledged and worked with to enhance student understanding of these concepts. The extent of pedagogical reasoning inherent in this PaP-eR focuses attention on the sophisticated

thinking necessary to transform propositional knowledge into useable and meaningful conceptual development both in terms of a teacher's practice but also in relation to students' learning.

PaP-eRs also reflect that which Gudmunsdottir (1995) described as the deep narrative nature of PCK. Making sense of PCK requires accessing and understanding that narrative nature because it

> . . . highlights a particular piece, or aspect, of science content to be taught. . . . A PaP-eR is designed to purposefully unpack a teacher's thinking about a particular aspect of PCK in that given content, and so is largely based around classroom practice. PaP-eRs are intended to represent the teacher's reasoning; that is, the thinking and actions of a successful science teacher in teaching specific aspects of science content.
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> As narrative accounts, PaP-eRs are meant to elaborate and give insight into the interacting elements of the teacher's PCK in ways that are meaningful and accessible to the reader . . . some PaPeRs are drawn from a student's perspective, others from that of the teacher, some take the form of an interview, others a classroom observation or the thinking inherent in a teacher reflecting on the problematic nature of a given concept . . . a PaP-eR is responsive to the type of situation it is attempting to portray. . . . PaP-eRs bring the CoRe to life and offer one way of capturing the holistic nature and complexity of PCK in ways that are not possible in the CoRe alone. (Loughran et al., 2012, p. 19)

Through the conceptualization of CoRes and PaP-eRs (outlined above), content and pedagogy can be seen to combine and interact in meaningful ways in teaching and learning situations. As a consequence they also illustrate how a teacher is increasingly confronted by dilemmas, issues and concerns that need to be managed in practice which draws attention to the sophisticated knowledge of teaching and learning underpinning practice and how that is further complicated through important aspects of subject matter knowledge that influence both teaching and learning. As a consequence of conceptualizing PCK through CoRes and PaP-eRs, the research illustrates that sophisticated views of practice emerge as teachers learn about pedagogy and refine their understandings through experiences of teaching of subject specific content—and that process is the heart and soul of PCK. CoRes and PaP-eRs are therefore insights into those constituent parts.

> The concept of pedagogical content knowledge . . . buttressed the claim that teaching, like research, was domain specific. This implied that teaching as "the transformation of understanding" rested on depth, quality and flexibility of content knowledge and on the capacity to generate powerful representations and reflections on that knowledge. (Shulman, 1999, p. xi)

Overall, then, PCK is important in further illustrating the dynamic nature of the teaching–learning relationship in interaction with subject matter knowledge.

The importance of understanding the complex nature of pedagogy is also illustrated through a consideration of the work of teacher educators.

As the next section of this article will highlight, a pedagogy of teacher education requires sophisticated understandings of, and actions in, the context of teacher education.

A PEDAGOGY OF TEACHER EDUCATION

Because teacher education is a beginning point in a teaching career it seems reasonable to expect that students of teaching should be introduced to, and come to understand, the notion of pedagogy. It seems equally fair to assert that teacher educators should be leaders in that endeavour.

Northfield and Gunstone (1997) were two teacher educators who were more than aware of the importance of a rich understanding of pedagogy in teacher education. They argued that "a coherent pedagogy of teacher education . . . requires considering how teachers learn about teaching and what it means to know and understand teaching and learning" (p. 55). As Northfield and Gunstone made clear, that which happens in teaching and learning is fundamental to understanding pedagogy, not just for students of teaching, but also for the teachers of teaching. So once again, pedagogy and the centrality of the teaching–learning relationship comes to the fore. In this case, it does so in what should be the home of pedagogy, in teacher education.

A pedagogy of teacher education can be viewed as the theory and practice of teaching and learning about teaching. As with all forms of pedagogy, the foundations of a pedagogy of teacher education can be found in the teaching–learning relationship, in this case in the *teaching* about teaching and the *learning* about teaching relationship. Korthagen (2001a) considered the foundations of a pedagogy of teacher education to be based on principles which he described as

1. The teacher educator should help the student teacher to become aware of his or her own learning.
2. The teacher educator should help the student teacher in finding useful experiences.
3. The teacher educator should help the student teacher to reflect on those experiences in detail. (p. 72)

Although not explicitly stated, Korthagen's principles have ramifications not only for students of teaching but also for their teachers of teaching. The teaching–learning relationship is key to a pedagogy of teacher education because both students of teaching and their teacher educators are involved in shared teaching and learning experiences. Korthagen's principles could therefore be recast to state that in learning about pedagogy, teacher education should be such that it creates conditions in which teachers *and* students:

1) become aware of their own/others' learning;

2) expect to be engaged in meaningful learning experiences; and,
3) reflect on those experiences in detail.

Just as there is reciprocity in teaching and learning, so too, in a pedagogy of teacher education the same applies to students and teachers of teaching. In *Developing a Pedagogy of Teacher Education* (Loughran, 2006), this reciprocity is unpacked in detail by highlighting not only the *teaching* of teaching but also the *learning* of teaching. In so doing, a pedagogy of teacher education is conceptualized around both teaching and learning with the specific aim of building deeper understandings of pedagogy and how that influences teaching *and* learning about teaching.

From a teaching about teaching perspective, an often overlooked, or superficially understood phenomenon, is the shift inherent in the transition from being a school teacher to a teacher educator. That shift has implications for what it means to be a teacher educator because underpinning this shift is the need to see beyond "doing teaching" in a school setting and teaching about teaching where the ability to articulate and explain pedagogical reasoning and to make clear for students of teaching the complexity of practice is fundamental to the role. Therefore, being a teacher educator

> [r]equires an understanding of teaching that goes beyond being a good teacher. There is a need to be able to theorize practice in such a way as to know and be able to articulate the what, how and why of teaching and to do so through the very experiences of teaching and learning about teaching [with students of teaching]. This matters because students of teaching need to be able to see into practice in ways that go beyond their initial expectations of learning the script, or developing a recipe, for how to teach. It also matters in terms of the expectations of the work of academia (creating, researching, disseminating and using new knowledge). (Loughran, 2006, p. 14)

Central to this view of moving beyond "doing teaching" is the importance of understanding teaching as problematic (as described earlier in this article) which requires a teacher educator to make the pedagogical reasoning underpinning practice visible for students of teaching (not unlike that illustrated in the PaP-eR in Appendix 2). In so doing, a teacher educator needs to be capable of, and actively pursue, making the tacit nature of practice explicit so that the teaching–learning relationship is able to be seen, experienced and inquired into rather than superficially viewed as a simple set of routines and/or procedures. In that way, a pedagogy of teacher education is being enacted and as such creates conditions through which students and teachers of teaching can begin to "pay more attention to the process of learning to teach . . . to be aware of the complexity of learning to teach in order to facilitate better learning and to consider more critically the tasks in teacher education" (Loughran, 2006, pp. 66–67).

The importance of a pedagogy of teacher education becomes increasingly apparent when thinking about context. For example, in school teach-

ing there is a major reliance on the sharing of teaching procedures and other "activities that work" (Appleton, 2002), which account for "doing teaching." However, in teacher education, understanding and sharing the pedagogical reasoning underpinning practice is crucial as it helps to make clear the nature of pedagogy and shines a light on myriad aspects of practice (e.g., how context impacts learning, student motivation, teacher planning, listening to students, considering difficulties that students encounter with specific content/concepts, etc.) that impact teaching *and* learning about teaching. To do so though requires a language of practice—a way of describing and unpacking pedagogy—so that it might be shared, critiqued and ultimately, more comprehensively understood. Different approaches to developing and sharing a language of teaching and learning about teaching are evident in the literature. Each of these approaches (briefly outlined below), illustrate different ways of conveying important ideas about teaching *and* learning about teaching. Importantly, as the literature demonstrates, when other teacher educators "tap into" and work with the ideas encapsulated (below) they begin to work with the complexity of pedagogy in their teacher education settings in ways that explicate that complexity for themselves and their students of teaching. The following examples (and brief explanations) illustrate not only what a shared language might look like, but also what it means for understanding pedagogy.

- **Program principles** (see, for example, Kroll, 2004; Kroll et al., 2005; Northfield & Gunstone, 1997). One program principle that Northfield and Gunstone argue is important in conceptualizing a teacher education program is "that the student-teacher has needs and prior experiences which must be considered in planning and implementing the teacher preparation program. And, the nature and intensity of these should shift throughout the program" (p. 50). In accepting and applying such a principle a teacher educator must therefore not only know about, but be able to respond to such needs and experiences which means the principle is not so much a matter of propositional knowledge. Rather, it means that teaching and learning must be responsive to changing demands and expectations within pedagogical experiences. It also means that another of Northfield and Gunstone's principles that "teacher education should model the teaching and learning approaches being advocated in the program" creates an expectation that teacher educators practice what they preach, that what they advocate for their students of teaching as practitioners, they do themselves. As these principles suggest, it is not only the wording but also the intent inherent in them that demonstrates how the notion of a shared language can impact approaches to a pedagogy of teacher education. The same applies to the work of Kroll as, for example, her principles of "teaching is a moral act invoking an ethic of care" and "teaching is reflective and requires an inquiry stance,"

illustrate how the language creates an expectation for practice but does not define the scripts and rules for so doing. There is not one correct way of responding to the principles; there are multiple possibilities.

- **Paradox** (see, for example, Palmer, 1998; Wilkes, 1998). Palmer's use of paradox also illustrates how important language is in conveying understanding for others. His paradoxes of a need to "invite the voice of the individual and the voice of the group" and "welcome both silence and speech" conjures up a sense of what it means to try to create different teaching and learning conditions almost simultaneously, thus highlighting again the complex and sophisticated nature of pedagogy. Paradoxes then create strong images of what is needed in creating pedagogical experiences and Palmer's use of paradox as a language to convey meaning illustrates the value of invitations to thinking about pedagogy that are simple to access—but are far from simplistic to develop or apply.
- **Tensions** (Berry, 2004, 2007). As the literature illustrates, Berry's tensions have been widely used as a conceptual tool for examining a pedagogy of teacher education. For example, her tension between "Telling and Growth" offers insights into the difficulty that teacher educators face in *informing* students of teaching while simultaneously *creating* opportunities for them to reflect and self-direct, or to acknowledge their needs and concerns whilst also challenging them to grow. Her language of tensions works to highlight the problematic and shed light on how teacher educators' decision making is crucial to the ways in which pedagogical experiences might be planned and unfold. The same is evident in her tension between "Discomfort and Challenge" through which she describes the need to create constructive learning experiences as well as uncomfortable learning experiences. Because these two are in tension, the underlying message is that they exist together but need to be well managed as discomfort could easily counteract the expectations hoped for through a challenging pedagogical experience. Again, the language of tensions portrays a way of conceptualizing practice but does not attempt to limit how that practice might be conducted.
- **Axioms** (Senese, 2002). Senese's three axioms, "Go slow to go fast," "Be tight to be loose" and "Relinquish control in order to gain influence," further illustrate how ideas about pedagogy are able to be conveyed through a particular approach to language. Rather than requiring extensive elaboration, these axioms convey meaning in ways that again capture the essence of the problematic nature of teaching and the complexity of pedagogy as teacher educators identify with the ideas underpinning each. For example, "Go slow to go fast" is a reminder of how by initially working on ideas in depth there can be major gains in the extent of learning in the long run, thus helping

> teacher educators to pay more attention to conceptual development rather than only focusing on curriculum coverage.

One reason why a shared language matters and is important in thinking about a pedagogy of teacher education hinges on the ability to "speak" with students of teaching (as well as colleagues and peers) in ways that help to make clear shaping factors in pedagogical relationships. A pedagogy of teacher education therefore is not about defining how to act, but is more about creating conditions through which students of teaching can learn more about practice. That means a pedagogy of teacher education must involve helping students of teaching to see into pedagogy and facilitate their ability to grasp more than "the how," but to also be engaged in unpacking "the why" of their rich learning about teaching experiences. As noted earlier, that examination will be much stronger when embedded in the shared experiences of the teaching–learning relationships in which students and teachers of teaching are engaged in together. An example of that shared engagement is in the work of Brandenburg in which her use of assumptions (another form of a shared language) offers ways of seeing into the complexity of pedagogy and how, as a teacher educator, she engages her students of teaching in seeing into pedagogy in informed and sophisticated ways.

In her book *Powerful Pedagogy*, Brandenburg (2008) illustrated how both the teaching and learning about teaching are central to her pedagogy of teacher education. She used assumptions as a lens through which she could focus attention on teaching *and* learning about teaching because

> [u]nderstanding assumptions and the powerful ways in which they influence our practices as teacher educators and learners, through teaching, is a difficult process. In essence expressions of assumptions represent "who we are." . . . It is no surprise then that as we come to "hunt" (Brookfield, 1995) identify and examine our assumptions . . . I [had] to dig deeply . . . to uncover as it were, what had previously remained implicit . . . to "own up" to the assumptions and taken for granted aspects of practice that quietly lurk in the depths of our sub-conscious. (p. 10)

Brandenburg was able to work within the relationship of teaching and learning to become better informed about the nature of the shared pedagogical experiences she created in her teacher education classes to better understand pedagogy. Her study made clear how important it is for teacher educators to actively pursue the development of their pedagogy of teacher education. Her research helped her see into the episodes and experiences she created for her students of teaching not only from her perspective as their teacher but also from their perspective as her students of teaching. As a consequence, she was able to see beyond her own personal practice and to look outward to what her learning meant for the teacher education community more generally. She sought to "examine and share ways of coming to know as a teacher educator rather than ways of doing teacher

education" (p. 169). She purposefully took the learning from her own inquiries with her students of teaching and questioned what that meant for the teaching and learning of others.

As her study demonstrates, at the core of her pedagogy of teacher education is her imperative to be better informed about teaching and learning, to be able to articulate that which she came to better know and understand about pedagogy as she tested her interpretations of her teaching against her students' perceptions of their learning through those experiences. In so doing, she created in her teacher education classrooms something akin to that which Schön (1987) described as a "Hall of Mirrors" in which both her teaching and her students' learning reflected on each other to create richer meaning of situations. Her pedagogy of teacher education was based on her concern to create conditions through which reciprocity between her teaching and her students' learning might be the norm:

> Understanding my developing pedagogy of teacher education . . . evolved from the inside-out. By systematically researching a reconceptualised approach to learning and teaching . . . more has been exposed about how examining the ordinary can lead to extra-ordinary insights . . . if teaching is problematised and learners' assumptions identified and examined, then possibilities for meaningful, systematic and sustainable educational change might well be enhanced. (p. 179)

Teacher education is clearly an important site for the development of deeper understandings of pedagogy and so brings into sharp focus the work of teacher educators as inquirers of pedagogy. Through a pedagogy of teacher education, teaching *and* learning about teaching is placed at the centre of the work that matters for challenging understandings about, and actions inherent in, pedagogical experiences.

> Enacting a deliberate pedagogy of teacher education does not come naturally to anyone. Our experiences of many years as students in school and university, our own pre-service teacher education experiences, and our experiences as teachers and teacher educators have inadvertently but successfully taught us to focus on what we teach. Enacting a pedagogy of teacher education challenges us to create classroom environments in which it is safe, appropriate and necessary to consider how we learn as well as what we learn. (Russell, 2007a, pp. 190–191)

That teacher education should be the home of serious inquiry into, and informed practice of, pedagogy, seems a fair expectation. If the next generation of teachers is to have deeper understandings of the nature of pedagogy, then it must begin in their initial formal learning about teaching. Teacher educators therefore need to not only be conscious of the "how and why" of their teaching but to also take seriously, and actively respond to, what they learn about what their practice means for their students of teaching. As Brandenburg demonstrated, working with the experiences created in teacher educators' own classes so that the teaching–learning relationship can be examined through those shared pedagogical experiences, opens up

for all involved, ways of seeing into, and seriously learning about, the nature of pedagogy.

Conclusion

In understanding pedagogy as complex, teachers' knowledge skills and abilities (as portrayed through such things as pedagogical content knowledge and a pedagogy of teacher education) begin to highlight why it is that teaching itself needs to be more highly valued and prized. Managing and responding to the interactions of teaching and learning and learning and teaching is where pedagogical purpose and reasoning is open to scrutiny in ways not so obvious when considered from the more common view drawn from an Apprenticeship of Observation.

It seems reasonable to assert that teacher education should be the place where understanding pedagogy is prescient. It is a context in which the teaching–learning relationship should always be to the fore and should be understood, unpacked and examined in ways that opens up that learning to scrutiny with students of teaching on a regular basis. As Brandenburg illustrated, when teacher educators make concerted efforts to develop, portray and disseminate their pedagogical insights, teacher education can be a springboard for action and a source of knowledge to support educational change and to initiate what Dewey described as a Science of Education.

The argument at the core of this article is that pedagogy needs to be understood in ways that go way beyond being cast as a synonym for teaching. Pedagogy is about the teaching–learning relationship. Choosing to pursue deeper understandings of the teaching–learning relationship or, as Mason (2002) described it, *noticing* pedagogy through disciplined inquiry, focuses attention on ways of thinking about teaching that are broad and informative rather than narrow and superficial. In so doing, practice is able to be more fully understood as problematic and the richness of pedagogical experiences is able to be appreciated so that rich learning through those experiences is enhanced.

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APPENDIX 1: ABBREVIATED CoRe (LOUGHRAN ET AL., 2012, pp. 26–31)

This CoRe is designed for students in Lower Secondary School, i.e., Years 7–9.	***IMPORTANT SCIENCE***		
	A: Matter is made up of small bits that are called particles.	**B: There is empty space between particles.**	**C: Particles are in constant motion.**
What you intend the students to learn about this idea.	If we break up substances, the smallest bit of substance we can get is a particle.	The relative distances between particles differs in solids, liquids and gases.	Particles of matter are always moving. The speed of particles can be changed (by heating/cooling, pressure change) . . .
Why it is important for students to know this.	Because it helps to explain the behaviour of everyday things e.g., diffusion.	Because it explains the ability to compress things and helps to explain events such as expansion and dissolving.	Because it explains what happens in phase changes, e.g., the need to contain gases is evidence the particles are moving.
What else you know about this idea (that you do not intend students to know yet).	At this stage "particles" is used in a general sense without discriminating between atoms and molecules. Subatomic structure. Chemical reactions. Ions. More complex properties of materials. . . .		
Difficulties/ limitations connected with teaching this idea.	The use of particular science models is not necessary to comprehend science in everyday life . . .	There is a big difference between macro (seen) and micro (unseen) levels . . .	That macro properties are a result of micro arrangements is hard to understand. . . .
Knowledge about students' thinking which influences your teaching of this idea.	Many students will use a continuous model (despite former teaching).	The notion of "space" is very difficult to think about—most students propose there is other "stuff" between the particles . . .	Students have commonly encountered "states of matter" but do not understand the ideas in terms of particle movement . . .
Other factors that influence your teaching of this idea.	Maturity—stage of psychological development, readiness to grapple with abstract ideas. Dealing with many different student conceptions at once. Knowledge of context (students' and teacher's). Using the term "phase" suggests the idea of a continuum . . .		
Teaching procedures (and particular reasons for using these to engage with this idea).	**Probes of student understanding:** e.g., students draw a flask containing air, then re-draw the same flask with some of the air removed. Probes promote student thinking . . .	**POE (Predict-Observe-Explain:** e.g., squashing syringe of air (ask students to predict the outcome based on different models of matter . . .	**Translation activities:** e.g., role-play, modelling, drawing. For example, my life as a Carbon Atom; or, write about what you would see if you were inside a particle of water . . .
Specific ways of ascertaining students' understanding or confusion around this idea (include likely range of responses)	. . . Explaining thinking and defending views. Making predictions about new situations. Tracking one's own learning, e.g., "I used to think . . ." Asking questions such as, "What is something that has been bothering you from yesterday's lesson?" . . .		

APPENDIX 1: *CONTINUED*

IDEAS/CONCEPTS			
D: Particles of different substances are different.	**E: There are different types of small bits of substances.**	**F: Atom particles don't disappear but their arrangements may be changed.**	**G: Models are used in science to help explain phenomena. All models have limitations.**
The characteristics of substances are related to the types of particles they contain.	There are two types of small bits of substance: • Atoms • Molecules. Molecules form when atoms combine.	Atoms don't change but molecules can. New atoms can't be made and atoms can't be destroyed (Conservation of matter).	Particle theory is an idea constructed by scientists to help us understand some aspects of the behaviour of matter . . .
Because it explains the observable behaviours of different substances.	Because it explains why there are a limited number of elements, but many different kinds of compounds.	Because in any reaction involving matter, all of that matter must be able to accounted for.	Because it helps students understand why the particle model is not is perfect and because it gives some insights into how science works.
(As per Big Ideas A, B & C.)	Details about ionic and molecular structures. Fission and fusion reactions.		
	Students can come to think that molecules "disassociate" in boiling water . . .	Atoms don't change . . .	
Students internalise textbook models showing circles of the same size . . .	Students use the terms "molecule" and "atom" without understanding the difference between these concepts . . .	Students believe that new stuff can appear and that stuff can disappear (e.g., when water evaporates).	It's hard for students to shift from thinking of science as "discovered" to "constructed".
(As per Big Ideas A, B & C.)			This is not traditionally addressed in science curricula.
Mixing activities: It can be helpful to model the mixing of different substances . . .	**POE (Predict-Observe-Explain)**: e.g., What is the vapour above boiling water? Students predict what happens to hydrogen and oxygen molecules when water is boiled . . .		**Historical research:** Students investigate history of ideas about atoms and atomic structure and how scientists observing nature came to different interpretations of it . . .
(As per Big Ideas A, B & C.)	Draw a picture to show what happens to water particles when water boils.		Listening for student questions, such as "Why doesn't wood melt?"

APPENDIX 2: AN EXAMPLE OF A PaP-eR (LOUGHRAN ET AL., 2012, pp. 42–44)

Playdough Balls: Concrete Models of Abstract Ideas

Many students in the early years of secondary school have difficulty grasping the abstract ideas of the Particle Model of matter. Providing students with concrete models which they can manipulate can be effective not only in promoting their understanding but also in enabling the teacher to diagnose possible sources of student misunderstanding. The parts that comprise this PaP-eR portrays how and why a teacher uses physical models with her class.

Part 1: The Particle Movement During Phase Changes Needs to Be Made Explicit to Students

While students may know how the particles are arranged in solids, liquids and gases, they do not necessarily make the link that there must be particle movement to achieve a phase change. Recognising her students' difficulties in understanding particle movement as matter changes phase, the teacher responds by asking the students to make and manipulate model particles.

As she went through the Year 8's homework about solids, liquids and gases, it became clear that many of the students didn't really understand what it was that we were representing. They could draw dots as they were arranged in each phase, but I didn't feel they had a sense of the change, the transition between the phases.

So we all rolled little balls of playdough (that I had ready for the next part of the lesson). On a piece of butcher's paper divided into three sections, each pair needed to be able to demonstrate how the balls, "particles", would be arranged in each phase. As I came around I asked them to show me what happened as the substance changed from a liquid to a gas, or from a liquid to a solid. Thinking in terms of the particle model is such an abstract exercise—I think it benefited several students to actually manipulate the "particles". They had to show how they move; how they move more as they are heated; and how this results in the particles breaking away from one another and moving further apart. It's like the roleplay that students often take part in, but here they worked through it themselves to gain a sense of the transition between the states they see represented in their textbooks.

Part 2: Distinguishing Between the Particles in Elements, Compounds and Mixtures Can Be Confusing for Students

This Part illustrates how one teacher's careful selection of an activity for her students that requires them to show the arrangement of particles in an everyday solution, using their playdough models, helps to serve as the basis for distinguishing

the important difference between fixed ratio arrangements of atoms in a molecule and compound and the loose ratio of compounds in a mixture.

I gave the class a definition of an element and some examples (hydrogen, oxygen, chlorine and sodium) with their chemical symbols. The main idea was that all of the "bits" in an element are the same as each other. Each pair of students used different coloured playdough balls to represent these elements.

Then I put the names and symbols for two compounds (water and sodium chloride (salt)) and a mixture (salty water) on the board and asked the students to use the playdough to work out models for these.

Different groups showed their representations and we used these to build up definitions for compound and mixture. Importantly, pairs had different proportions of salt and water in their salty water. So we could bring out that mixtures are not chemical arrangements and don't require fixed amounts of each particle.

The concepts of element and compound, represented using the playdough balls, required us to differentiate between atoms and molecules. The students then moved on to a worksheet that clarified these four concepts using nonsense examples and non-examples of each.

Three things I'd like to mention:

- I was not intending to make much of a link with the work on states of matter. It was interesting however that a number of students thought about whether the various substances were solids, liquids or gases, and tried to show this, as well as whether they were elements or compounds. On reflection I can see how using the same materials to represent the particles is a good way to reinforce that this model applies to all of the ways we ask them to think about matter.
- A few students had separated the sodium and chloride in their salty water. If they had also separated the hydrogen and oxygen then I knew that they didn't have the compound part right. If it was only the NaCl then I said something like: "You've shown what actually does happen to the salt in the water, but for now we want to keep the compounds together and show how the two compounds are mixed up." This is an example of where we teach misconceptions in order to get the concepts straight.
- Underlying all this is my belief that to grasp complex abstract ideas, students need to revisit them from different directions and manipulate them in different ways. If they just spout back the words that you give them—for example, just tell you back what an element is—then you can't be sure that they've learnt anything at all.