Self-Study of Teaching and Teacher Education Practices 12

Shawn M. Bullock
Tom Russell *Editors*

Self-Studies of Science Teacher Education Practices

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Rebecca Cooper is a science educator in the Faculty of Education, Monash University, Australia. She works with preservice and inservice science teachers and her research interests include considering how science teachers and science teacher educators develop pedagogical knowledge throughout their career, improving the quality of science teaching to increase student engagement, and working with teachers on promoting values in their science teaching in an effort to better understand the development of scientific literacy with students. Prior to working at Monash University, Rebecca taught physics, science, and mathematics in secondary schools for many years.

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Garry Hoban is an associate professor of education at the University of Wollongong, Australia. He spent the first 14 years of his professional life as a secondary science teacher, department head, and K-12 science consultant in schools before moving into universities as a teacher educator. His research interests focus on teachers' long-term professional learning and the use of animation for teaching educational concepts supported by ICT.

Stephen Keast is a science teacher educator working in the Faculty of Education at Monash University, Australia. His research interests include self-study, teachers researching their own practice, articulating teacher educators' pedagogical knowledge, quality science teaching, understanding teachers' views of scientific literacy, and values in science. As a science teacher educator, he focuses on researching his own practice in ways that inform his practice for the benefit of his preservice teachers. He is also interested in the professional learning of science teachers and works in professional development programs to improve science teaching in Australia using the knowledge gained from his research interests.

John Loughran is dean of education at Monash University, Australia. Well-known for his many contributions to science education and the self-study of teacher education practices, he is the editor of this series of Springer publications in self-study. His most recent book is *What Expert Teachers Do: Teachers' Professional Knowledge of Classroom Practice,* published by Routledge. He was a founding editor of the journal *Studying Teacher Education: A Journal of Self-Study of Teacher Education Practices.*

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Chapter 1
Exploring the Intersections of Self-Study, Science Teaching, and Science Teacher Education

Shawn Michael Bullock

The challenges associated with teaching science and teaching about teaching science might initially seem linked to problems of creating technical knowledge. After all, science is often associated with concepts such as truth, rigour, and objective knowledge. Self-study of teacher education practices, by contrast, might initially bring to mind the epistemological challenges of knowledge that is constructed from personal experience. Of what relevance, then, is self-study methodology to issues of science teaching and science teacher education? Part of the answer, of course, lies in the fact that the disciplines of science are about far more than knowledge production. The discipline of teaching, similarly, is about far more than applying particular strategies to everyday classroom situations. Science teaching and science teacher education are complex endeavours that demand far more than the assumptions underpinning what Schön called technical rationality (1983, p. 21). Self-study methodology offers one way to move beyond technical rationality toward a more productive understanding of professional knowledge, one that is inextricably grounded in socially constructed understandings. Historically, the disciplines of science have also made use of socially mediated ways of knowing. In this introductory chapter, I develop a perspective from the history of science that helps to understand how self-study methodology relates to science education.

In science classrooms all over the world, students are asked to learn Boyle's law, which states that for a fixed amount of an ideal gas at constant temperature, the pressure and volume of a gas are inversely proportional. Many a chemistry student has dutifully memorized the formulae associated with Boyle's law and done countless mathematical questions ostensibly designed to demonstrate their understanding. Soon enough, perhaps even during the same lesson, students leave behind Boyle's

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law in favour of Charles' law (which describes the relationship between the volume of a gas and its temperature), the law of pressure-temperature, and Avogadro's law (which states that the number of molecules is the same in equal volumes of gases at the same temperature and pressure). In many classrooms, the point of introducing Boyle's law is to get to the ideal gas law equation.

Unfortunately, focusing solely on the mathematical formulation of Boyle's law as a means to examine the ideal gas law robs us of the opportunity to consider Boyle's insight. In the mid-seventeenth century, a revolution was underway in the United Kingdom. The newly formed Royal Society consisted of a group of scientists devoted to pursuing scientific knowledge through experiments. Although it might now seem self-evident that experimentation plays a large part in the construction of scientific knowledge, most of the natural philosophers of the day came from a Scholastic tradition that favoured natural observations over the idea of setting up an experiment, which by definition is contrived and thus unnatural. Shapin and Schaffer (1985) outlined the tensions between the new approaches to experimentation in science and the old approaches to natural philosophy by considering social dimensions of constructing scientific knowledge in the seventeenth century through two protagonists, Thomas Hobbes and Robert Boyle.

Perhaps better known today for his political philosophy in *Leviathan* than for his interest in physics and chemistry, Thomas Hobbes was one of the chief proponents of creating scientific knowledge through logic and natural philosophy as opposed to experimentation. One of Robert Boyle's early experimental projects involved the construction of an air pump—a device with which he could pump air out of a glass chamber in hopes of demonstrating the existence of a vacuum. The idea of a vacuum was horrifying to many Scholastic natural philosophers, including Thomas Hobbes, who went so far as to characterize Boyle's project with the air pump, as well as the process of experimentation that Boyle advocated at the Royal Society, as incorrect, irresponsible, and dangerous (Shapin & Schaffer, 1985).

Shapin and Schaffer (1985, p. 25) argued that Boyle employed three distinct technologies with his new approach to experimentation in science:

1. Material technology: "Embedded in the construction and operation of the air pump."
2. Literary technology: "By means of which the phenomena produced by the pump were made known to those who were not direct witnesses."
3. Social technology: "Incorporated the conventions experimental philosophers should use in dealing with each other and considering knowledge claims."

Hobbes was particularly put off by the idea that experimentation should be subject to social processes. Boyle, on the other hand, understood that knowledge production was possible not only through considering the physical, material technologies of experiment, but also through the ways in which experimental results were reported on (literary technologies) and the ways in which experimentalists engaged in discourse about their work with one another and with the general public (social technologies) (Shapin & Schaffer, 1985).

Of course, scientific experiments had been conduced countless times before Robert Boyle began working on his air pump. Medieval alchemists, for example, were frequent experimenters in their search for the transmutation of metals (Newman, 2006). Boyle's insight, however, was to recognize the importance of literary and social technologies to his work as an experimentalist. Boyle felt that it was important to debate and critique his work in public (Shapin & Schaffer, 1985).

Boyle's method of scientific experimentation clearly triumphed over the Scholastic philosophical traditions espoused by Hobbes and many of his contemporaries, yet both the natural and social scientific communities continue to debate what counts as evidence in experimentation and the validity of making knowledge claims from particular sources of data. In the 20 years since the original AERA symposium that was the catalyst for the self-study research movement (Loughran, 2004), the self-study of teacher education practices (S-STEP) research community has grown in both the scope of interests of its members and its impact on the educational research community as a whole. After the founding of the S-STEP Special Interest Group (SIG) of the American Educational Research Association (AERA) in the early 1990s, one of the early signals that S-STEP had arrived as a research methodology occurred when Zeichner used his 1998 Division K Vice-Presidential address to highlight "the new scholarship in teacher education" (Zeichner, 1999, p. 4). Beginning with the premise that "the new scholarship in teacher education is a much richer and more varied body of inquiry than that which existed 20 years ago" (p. 8), Zeichner went on to highlight five major categories of research in teacher education that had emerged since the late 1970s: survey research, case studies of teacher education programs, conceptual and historical research, studies of learning to teach, and examinations of the nature and impact of teacher education. Zeichner correctly pointed out the importance of teacher educators studying their own practices in much the same way that teacher educators expect their students to analyse their experiences in field placements. In particular, he noted:

> The disciplined and systematic inquiry into one's own teaching practice provides a model for prospective teachers and for teachers of the kind of inquiry that more and more teacher educators are hoping their students employ. These studies represent a whole new genre of work by practitioners that we will be hearing a lot more about in the years to come. (p. 11)

Zeichner was correct; the early part of the twenty-first century has indeed seen a proliferation of self-study research presented in a variety of top-tier journals, the publication of a two-volume international handbook (Loughran, Hamilton, LaBoskey, & Russell, 2004), and the founding of an academic journal, *Studying Teacher Education*, in 2005.

There has not, however, been a concurrent increase in the use of self-study methodology for articles published in science education journals such as the *Journal of Research in Science Teaching* and *Science Education*. At first consideration, the disconnect between the rise of self-study methodology and its concurrent use in the broader science education literature seems strange, particularly given that many members of the S-STEP SIG and research community began their careers as science teachers (including many of the authors in this book). Perhaps many self-study

researchers with an orientation toward science education prefer to focus on broader issues in pre-service teacher education than on particular approaches to working with future science teachers. In my own work, for example, I use self-study methodology as a "basis-for-knowing" (Bullock, 2009, p. 269) about how particularly pedagogical approaches have caused me to think about my practice in different ways. A recent study of how I attempted to incorporate digital technologies into my pedagogy of teacher education focused on big picture issues in teacher education, such as how Web 2.0 tools might be used productively to foster relationships with teacher candidates that enable critical analysis of practice (Bullock, 2011). The fact that participants in the research were pre-service science teachers was almost inconsequential.

The recent *World of Science Education* series (Roth & Tobin, 2009) also sheds light on the role of self-study methodology within the broad science education research community. In the first volume of their series (*Handbook of Research in North America*), Roth and Tobin gather a community of well-known science education scholars to discuss issues such as science literacy, equity in science education, and technology to support science education. No mention is made of self-study methodology in the chapter devoted to qualitative research methods. The chapter entitled *Exploring Science Teacher Education: Research in the Community* (Luft, 2009) begins with this statement:

> Educational researchers now more readily recognize the complex process of teacher education, in which the teacher is part of a dynamic system. This has resulted in science teacher education research that focuses on the teacher as learner in the classroom, professional learning communities that are composed of teachers, the interactions of teachers and students in the learning process, and the cognitive side of teaching. (pp. 547–548)

Although Luft (2009) acknowledges that science teachers "have important experiences and understandings to share with the research community," she goes on to admonish the research community for being "negligent in giving teachers the voice they deserve in the research process" (p. 563). Yet one might level the same criticism at her chapter devoted to science teacher education. Given her thesis that teachers construct professional knowledge that is worthy of analysis, interpretation, and dissemination, it follows that teacher educators—those who teach future science teachers—should also have a voice in research on science teacher education. Throughout her chapter and the rest of the book, however, science teacher educators are framed as those who are doing research on the practice of *other* science teachers, both pre-service and in-service. No attention is paid to the ways in which science teacher educators teach their own pre-service students.

If we return to the three technologies (physical, literary, and social) used by Robert Boyle to usher in his experimental approach to science, we begin to see some of the problems associated with excluding, by accident or design, the voices of science teacher educators as *practitioners* of science teacher education pedagogy. Boyle's physical apparatus—the air pump—has as a modern analogue the physical data collected via quantitative and qualitative research traditions. The literary technologies are alive and well in the academy in the form of scientific journals, books, conference papers, and technical reports. It is the social technology, however, that is of particular relevance to this discussion.

Academic discourse clearly has a set of social norms and patterns that encourage the analysis of research findings and construction of scientific knowledge. Until the self-study of teacher education practices movement, however, the voices of teacher educators, those who teach future teachers, were largely silent on important issues such as the way they enacted particular pedagogical approaches, the tensions they felt as they attempted to live particular values in practice, and the development of professional knowledge of teacher educators. From its beginnings as a Special Interest Group at AERA, S-STEP researchers have sought to use a variety of social technologies to make their practice and research findings available for public consideration and scrutiny. One of the most important social technologies is the biennial "Castle Conference," first held in 1996 at the International Study Centre of Queen's University, Canada, at Herstmonceux Castle, UK. The relatively small number of conference participants (100) combined with on-site accommodation creates a unique environment in which conversations about research findings and shared interests can continue after a presentation and into a meal or a late night at the castle pub. The SIG also prides itself on organizing atypical paper presentations at AERA. A key feature of these sessions is a reduced amount of time for traditional presentations projected on a screen and an increased amount of time for small-group discussions between presenters and participants. The focus on making research available for discussion is a critical feature of self-study methodology, as self-study requires the researcher to "formalize our work and make it available to our professional community for deliberation, further testing, and judgment" (LaBoskey, 2004, p. 860).

The unique social technologies of the S-STEP SIG are also manifest in discussions around validity, quality, and rigour in self-study research. Bullough and Pinnegar (2001, p. 14) asserted that "to study practice is simultaneously to study self: a study of self-in-relation to other." The authors also provided guidelines for quality in self-study (pp. 16–20) that are frequently cited by other researchers; some of the most relevant to our discussion include "autobiographical self-studies should ring true and enable connection" (p. 16) and "biographical and autobiographical self-studies in teacher education are about the problems and issues that make someone an educator" (p. 17). More recently, Pinnegar and Hamilton (2009) made a case that the traditional notions of validity and quality that arise during traditional research are grounded in old traditions of epistemology and claims about knowing. Specifically, the authors report: "Most recently we have realized that fundamentally establishing self-study as a methodology centres on a look toward ontology. The basic question is actually more about what is than about claims to know" (p. 2).

> An ontological stance when developing a study better situates researchers in self-study methodology. Here we stipulate ontology to mean a focus on what is real, constructed from our place within that experience with a commitment to shaping what is real to conform more closely with what we value. (p. 5)

Self-study methodology has much to offer science education research, particularly when one considers the powerful impact that the social technologies of the methodology can have on making the tacit knowledge of science educators and science teacher educators explicit. As LaBoskey (2004, p. 859) noted, the overall goal of self-study is self-improvement; it "looks for and requires evidence of the reframed thinking and transformed practice of the researcher."

The self-studies presented in the following chapters provide considerable evidence of the power and potential of self-study research methodology to engage with science education research. Each chapter presents an author, or group of authors, engaged in research that uses self-study methodology to inform their practice as science teacher educators and their research in science education. Before we became academics and teacher educators, each of us spent time in a profession that required specific conceptual understanding of scientific concepts. We were classroom science teachers, physical education teachers, and research scientists before becoming teacher educators. It would be foolish to ignore the fact that we each have a home discipline—the sciences—that forms a part of our identities and research agendas. We have each found self-study of teacher education practices methodology to be important for helping us to understand our work with pre-service teachers and with other teacher educators and academics. In particular, we are interested in exploring intersections between self-study literature, our own practices, and science education literature. There are several themes that might be drawn from the chapters in this book. In the final chapter, Tom Russell provides a discussion of the big ideas presented in this collection, but for now, it is useful to frame the book around three broad themes: becoming a science teacher educator, self-study and pedagogical content knowledge, and self-study as professional learning for science teacher educators.

There is considerable literature exploring the idea of becoming a teacher educator, with a particular focus on the tensions manifest in reconciling prior identities (as teachers, researchers, and graduate students) with developing identities as teacher educators. The concept of becoming a teacher educator is at the forefront of the ideas presented by Fletcher, Garbett, and Santau. Brown and Russell provide a unique glimpse into the challenges faced by a new science teacher who is trying to live his values in his teaching and by an experienced teacher educator who is trying to support a former student. Self-study methodology provided these five authors with the opportunity to understand teaching and learning in new ways. Fletcher, for example, came to understand why many elementary school teachers adopt a "custodial approach to teaching with aims to preserve its traditions and customs" as a result of teaching non-specialist teacher candidates a physical education methods course. Santau found that self-study provided her "with opportunities to bridge what her doctoral program could not prepare [her] for"—the complexities of teaching future science teachers. Garbett expressed a newfound appreciation for "no longer knowing exactly where the sessions are leading or what exactly [her] students are learning about teaching during [her] courses." Brown and Russell comment on the challenges inherent in creating learning environments that are different from the normal patterns of school: "Giving up control is far from simple; unless we teach very young children, expectations for the teaching-learning relationship have been shaped and constrained by many previous teachers. For the new teacher in particular, the process of constructing a new set of reflexes is both intellectually and emotionally demanding."

The construct of pedagogical content knowledge (PCK) has had a significant impact on research programs concerned with teachers' professional knowledge.

For Shulman, PCK "goes beyond knowledge of subject matter per se to the dimension of subject matter knowledge *for teaching*.... Pedagogical content knowledge also includes an understanding of what makes the learning of specific topics easy or difficult" (1987, p. 9). Berry, Loughran, and van Driel's (2008) review of science education research revealed that, despite intense effort from researchers around the globe, there has been little consensus around how to conduct research into and provide evidence of teachers' pedagogical content knowledge. Nilsson and Loughran's chapter takes on that challenge by providing insight into how (science) student teachers' PCK develops and how knowledge of that development matters for a teacher educator's teaching about teaching science. Their self-study emerges from the teacher educator's learning through a number of critical incidents she recognized when analysing her student teachers' learning experiences. Trumbull uses the case study of her teacher candidate—who went on to become a successful high school teacher focused more on success on the state examination than developing her PCK—to highlight the tension of idealism vs. realism for science teacher educators. Her self-study also reminds us of the tension between teaching about science teaching for educational reform, particularly with a focus on inquiry learning, and the demands of a high-stakes system of accountability that is very real to teacher candidates.

The final group of authors shed light on the ways in which self-study methodology fosters professional learning for academics. Hoban and his colleagues collected data from regular meetings of a professional learning community of academics and from journal entries of participants in the community after teaching the group how to engage in self-study. One member of the self-study professional learning community commented that "it's essential to self-study to uncover dilemmas and problems and we have to have a safe place to talk about them." Morrell and Schepige used design-based methods to enact a particular approach in their methods course, with the goal of thinking about how they teach pre-service teachers about analysing the field placement experience. By examining the coursework of their science teacher candidates, they were able to have a sustained professional learning dialogue about which research-based approaches to teaching science were most in need of attention during their coursework. Keast and Cooper engaged in another iteration of an ongoing, collaborative self-study in order to explore the differences between their pedagogy as science teachers and their pedagogy of science teacher education. They report the power of "learning more about ourselves, beginning to understand the values we promote and how our students perceive them" and conclude "that our often shared values manifest in different ways in our teaching."

Although the word *technology* might easily bring to mind electronic devices with integrated circuits, it is more productive to think of a technology as a craft or process that helps us to move forward in previously unimagined ways. At the beginning of this chapter, I mentioned the tension between Thomas Hobbes, the natural philosopher, and Robert Boyle, the experimental philosopher, at the beginning of the scientific revolution in the seventeenth century. Today, just as in Boyle's time, the key catalysts for thinking about new ways to construct knowledge are the new social technologies available to researchers. For Boyle, it was discussions with members

of the Royal Society and the general public. For science teacher educators who are interested in analysing their practice and subjecting the results of that analysis to public scrutiny and interpretation, the social technology is self-study of teacher education practices methodology. Self-study methodology can shed considerable light on science teaching and science teacher education. The intersections between self-study and the pedagogy used in science classrooms all over the world, be they elementary, secondary, or tertiary classrooms, have much to contribute to the science education research literature. This book helps to begin that discussion.

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Chapter 2
A Collaborative Self-Study of a Physics Teacher's First Two Years of Teaching

C. Liam Brown and Tom Russell

This chapter describes and interprets a beginning science teacher's electronic conversation over a period of 2 years with the teacher educator who helped to shape and extend that new teacher's strong instincts about how he wanted to teach. After an 8-month preservice teacher education program at Queen's University in which the two of us met and built an initial relationship, Liam taught for 2 years in Mexico while Tom continued teaching new physics teachers at Queen's. Teaching in Mexico was inspired by Liam's strong interest in travelling outside Canada.

Liam's self-study of his teaching practices began when he started to write to Tom, at first virtually every day, about the experiences, challenges, successes and frustrations of his first year of teaching. This became a collaborative self-study when Tom undertook to respond quickly to Liam's messages with a view to supporting Liam's commitment to the ideas we explored during his teacher education experiences. Liam entered teacher education with a strong sense of what good learning is, and he carried this into his first year of teaching. This self-study reveals how his most frustrating students led him to understand the importance of good relationships with individual students as well as with classes as a whole.

Liam's Introduction

When my studies at the Faculty of Education at Queen's University came to a close, Tom suggested that we maintain a correspondence as my teaching career got underway. I was glad he suggested this, because I was already feeling the

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panic of having to move from the comfortable waters of the university out into the raging rapids of my first teaching post, and I knew that I would be tempted to write him for advice.

As part of a class assignment, Tom had created blogs for each teacher candidate to use to discuss practicum experiences, and it seemed natural to continue to use mine to record our conversations. Much later, with my first 2 years of teaching completed and over 100,000 words written between the two of us, I was finally able to step back and read through the blog from beginning to end. By then, I had learned just how valuable this kind of conversation could be, as it made possible a kind of in-depth self-study of my teaching practices that I could carry out with the guidance of a mentor who had years of experience as both a physics teacher and a teacher educator. The blog had become the perfect forum for me to express my professional successes and frustrations, and it pushed me to examine all aspects of my teaching in detail. It had given me a chance to ask for help during my most challenging times as a teacher, and Tom's constant interest, advice and encouragement gave me the impetus to continue to try to improve my teaching and helped me to survive stressful periods. The three major themes of my 2 years of teaching that played out on the blog were (1) managing the relationships in my classroom, (2) dealing with lowered academic expectations, and (3) continuing to develop a full and holistic pedagogical approach.

Starting the Conversation

What I learned about teaching and learning during my 8-month bachelor of education program made me more eager to walk into my own classroom than I had expected. Although each of my professors had something to pass on to me, it was in my Physics Education class that I encountered a way of thinking about teaching that felt complete and important. I came to refer to the set of ideas and techniques that Tom led us towards as active learning, and I myself was engaged in active learning from our first class together.

One of the first things Tom introduced us to was the POE (Predict, Observe, Explain, see Baird & Northfield, 1992) teaching procedure, a group activity that I found staggering in the variety of positive effects it can have on students. By observing a physical phenomenon and working together in an open and low-risk manner to try to explain what they observe, students gain the confidence to try to explore physical explanations on their own before hearing answers from a teacher. POEs foster curiosity and interest in science, replicate the scientific process, build trust and teamwork skills in a group, and encourage students to examine their preconceptions and the ways those ideas can change after scientific investigation. In other words, a POE can completely engage students in their own learning.

It was this model that Tom exemplified during each class session. We teacher candidates were expected *not* to sit back and be told how to be good teachers. Instead, Tom encouraged us to work independently and with our peers, to question our ideas about teaching, and to pay careful attention to how we were learning how to teach. Just as in the POE process, Tom avoided the familiar role of teacher as the controlling dispenser of wisdom, choosing instead to guide and coach us in our learning. He listened carefully, asked a lot of questions, and challenged us to improve our work. It was clear that Tom took his role in our professional development very seriously and that he was committed not just to teaching active learning but to modelling it in his own classroom.

In this context, communicating with Tom in a blog format while I was away at my practice teaching sessions felt like a natural extension of our work on campus. In other assignments for other courses, I was sometimes asked to write about my experiences in a reflective essay answering a specific question; however necessary such work might be, it was not the organic and productive work of self-directed learning. In the blog, I was able to explore those topics that felt most pressing at the time. The writing happened at the end of the day while the events were still fresh in my mind, and Tom's prompt responses gave me a little push to go back and try again the next day. This process can be seen clearly in a series of posts about getting feedback from two groups that I was having trouble engaging. I had handed out an index card to each student at the end of my classes and asked the students to write anonymous comments on the cards about how the class was going.

When I looked over their responses, I realized again that asking a vague question yields little helpful information. I had assumed that my students were thinking as hard as I was about their learning in my classroom—a mistake I would continue to make in the months that followed. I was particularly disappointed in the results from my math students, and the blog seemed a good place to vent my frustrations and think about a way forward. The selections below, as in the rest of this chapter, are excerpts from longer posts and comments:

> The main question on my mind (and which I should have asked more specifically) was whether or not the students wanted the class to involve them more. The way I'm proceeding mostly involves me just standing at the board and telling them things. I've been taking this approach partly because I just don't know how to start teaching math any differently (as I've said), and partly because the overwhelming impression I get from these kids is that they don't like math, or school in general, and want to just show up, hear what I have to say, do a bit of work, and get their passing grade (maybe). And I was hoping to find out whether I was just giving up by not doing anything differently, or if I was in fact doing things in a way that would serve them best. (Liam, Feb. 26, 2008)

> Excellent reading, Liam, and more power to you. You've taken risks and found out more of what individual students are thinking than most teachers do. Have I mentioned that I have incredible confidence in such writing as one of the only ways to become the teacher you want to be?… If they don't change in one day, that's normal, VERY normal. Try again on Monday, perhaps telling them what math concept or procedure they will master if they do all their homework. (Tom, Feb. 26 & 28, 2008)

My First Month as a Teacher

I left Queen's feeling eager to apply my new teaching plans in my own classroom, starting on the first day of school. One thing I learned during my practice teaching sessions was that active learning is not a matter of one good 5-min activity. I could not expect my students to sit quietly through most of a lesson and then suddenly wake up and become metacognitive and see the overall point of the lesson. Any lesson plan that did not take this fact into account would be doomed to failure. The same rule applied from day to day, week to week and unit to unit. Learning how to learn well takes practice, and the only way to achieve this in a classroom is to engage students as soon as possible and work hard to maintain this kind of learning environment through every class over an entire year. My teaching philosophy was holistic: I wanted everything I did as a teacher to contribute towards my overall goal of achieving active learning.

Before I could even begin focusing on the quality of student learning, I had to prepare myself for my new job. I had accepted a position at an American school in Mexico, which meant moving to a new country and facing a number of complications. I wrote briefly on the blog that, although I had many last-minute teaching-related thoughts to share, I still did not have an internet connection in my new apartment and was generally busy, so I was not sure I would find time to write. Tom's answer was, 'Please do write! If the internet is down, write in Word, save it, and then copy and paste when it's back up, or just send an attached file!' So the next day, I wrote a long post in which I described having felt 'at sea for a lot of the last couple of weeks' and then proceeded with a bulleted list of tasks that were making me nervous: familiarizing myself with the campus and its resources, planning my courses, understanding how to handle an unfamiliar curriculum, determining a classroom management strategy, and filtering through all of the advice I had received from my administrators and fellow teachers. I was suddenly realizing that, with all of my teaching and learning experiences, there were a huge number of aspects of a teacher's life that were still completely unknown to me.

Instead of stressing me out even further, however, detailing the things that were worrying me actually gave me confidence. I was able to look each problem over in turn and recognize that there were, in fact, solutions to each one, or that I had already formed possible strategies to handle them. It turned a host of anxieties into known unknowns; as I continued to list new items only to describe ways they might be dealt with, I was forced to write the following comment:

> It's funny to read this over and see that it seems as if I've got almost everything figured out… I still have the feeling that when I stand at the front of the class I'm going to get a handful of questions I can't answer or that there's going to be some classroom management issue I wasn't expecting and can't solve… But somehow I also have the general idea that things will work out in the end. (Liam, Aug. 18, 2008)

I was eager to read Tom's response, and it did indeed reassure me in many ways. Aside from a list of other useful ideas and comments, Tom suggested I be sensitive to the culture in my new workplace: 'You are working in a foreign culture with

students who will necessarily react differently at times than Canadian students would'. This remark would later prove to be prescient.

From the moment I began my first practicum placement, one of my most common experiences in teaching has been the realization that I finally understood something that I had already been told. Education is such a personal activity that there is a significant difference between the conceptual understanding of ideas and the fully internalized understanding that can only come from practical experience. Tom's warning about cultural differences was a perfect example of this phenomenon: I read it and understood, but it seemed almost an obvious point. Of course I would be watching for cultural differences. What I could not know then was the magnitude of the effects this issue would have on my 2 years at the school. Not only did I have to contend with differences between Mexican and Canadian culture, but also I had to navigate through a plethora of other factors: the culture of a small, private American school; the mindsets of young people whose families were, on average, far wealthier than most people I had ever met; and a school system in which physics is, essentially, a required course (as opposed to an upper-year science elective, as is the case in Ontario). Unfortunately, it would be months before I would completely understand any of these factors.

Managing Relationships in the Classroom

My first taste of future disappointments appeared by the end of my second week of teaching. On August 26, I wrote that a group of male students was causing trouble, nothing more than the usual talking and being inattentive. One student in particular, who was given the alias 'Julian', was starting to display what would become his typically disruptive behaviour. I had done a POE that failed in his class because too many people had been talking rather than focusing on the activity. This was the most surprising and frustrating event of all, because until then I had never done a POE that had been anything less than highly successful.

In general, all of my students chatted with each other and lost focus far more often than I liked or was used to. I was always glad when this energy was directed towards the lesson, but most of the time, it was extremely disruptive. Almost any time a student or I was talking during a lesson, other students would begin a separate discussion unrelated to the subject. When the students were working in smaller groups, they could never keep their attention on the subject at hand because they would quickly start chatting about other things. In almost every classroom I had been in before Mexico, either as a student or as a teacher, this kind of talking was not a problem. During my practicum placements in Ontario, I taught classes with students who had serious behaviour problems, and even in those classes, there were only a few students who talked while I or another student was talking. If asked, such a student would usually stop talking for at least 5 or 10 min. In Mexico, however, the culture was quite different; the majority of my students found it hard to stay quiet for more than a minute. At first, I blamed myself, thinking that my seating

plans were poorly chosen or that I was not enforcing adequate consequences. Over the course of the year, however, I gradually realized that this problem was school-wide, influenced by a confluence of the Mexican culture of verbosity, a faculty that tolerated a constant, low level of unhelpful behaviour in exchange for a more amiable school environment, and wealthy students who seemed unaccustomed to serious discipline either at school or at home.

The other side of the cultural issue, of course, was the positive one. The students I encountered at my school had an intense respect for teachers. It was extremely rare to find any student anywhere in the school intentionally acting against a teacher. In other words, even the most frustrating students tended to do no more than talk with each other or refuse to do their homework. At the school where I had completed my practicum, I had frequently witnessed students verbally abusing their teachers and administrators, almost to the point of violence. Here such serious issues were virtually non-existent; it was only the smaller problems that seemed amplified.

At this stage, I was writing long posts every day; articulating my problems was still proving to be very helpful. As I wrote, I made decisions to tackle various problems; I would make up my mind to rearrange my seating plan, speak to a student after class the next day, or change the structure of my lesson plans. Tom continued to respond promptly to my posts. He seemed to find it exciting to watch a former student start out in the world of teaching, especially one with whom the ideas from his course had really resonated. He would often ask questions rather than tell me what to do next: 'Have you thought about asking them to tell you what it was like to do the assignment, how good they thought their learning was, what resources would have helped, etc.?' He also pushed me to consider the big picture, as he is fond of saying, even after my first few days of teaching:

> You've reminded me that I had a wonderful year of teaching saying as often as I could that I cared most about what they would remember about physics 5 YEARS from now, not on the next test. (Tom, Aug. 21, 2008)

> I can't help but wonder if you have thought about metacognition—getting the kids to think about how you are teaching them. I really think that they need to know that you are aware that you have views that are outside those of most teachers and that you are working hard to think through various issues of how you teach them. Something like, "It's only been 3 days but have you noticed any things I do differently than other teachers, or that you didn't expect me to do?" (Tom, Aug. 22, 2008)

I responded to the latter comment by saying that I had already done some work to try to get my students thinking about their own learning and seemed to be having some success. This technique had even come in handy when doing a lesson about my required format for writing out solutions: instead of saying, 'You have to do it this way', I showed the class my preferred techniques and then asked why each one would be useful to them and to me. The answers we developed together gave them good reasons for copying notes on the subject of solution formatting, so that they were not just blindly following instructions.

Later, I described a day that had gone badly. I admitted that it was partly my fault, because I had planned a fairly boring lesson. Tom picked up on this idea and asked, 'Did you tell them in advance it was going to be a less-than-exciting day?'

This small piece of advice turned out to be one of the most helpful. I always tried to plan engaging lessons, but on those days when I knew my class was going to be less exciting for them, I found that I could mitigate a lot of the damage by warning my students in advance, describing my reasons for doing what I wanted to do and asking for their cooperation.

Tom also asked, in the same post, 'Do the kids know you want to be respectful rather than intimidating?' This was an issue with which I was already struggling and one that would only intensify over time. Tom and I had begun to discuss ways to maintain a positive learning environment without my having to act contrary to my principles. I entered the teaching profession feeling serious concern about the role a teacher plays in the lives of his students. My greatest fear about starting this job was that I would be expected to act as an authoritarian. I do not mean to say that I was afraid to wield authority; rather, I felt (and still feel) that the rigid hierarchy of most modern school systems is hugely damaging both to students' learning and to their personal development. The world always needs more people to stand up for their beliefs, to work interdependently with their peers to achieve progress, and to summon the courage to challenge existing power structures, yet most young people spend 15 years in a system in which they have no voice and no agency. Furthermore, all of my experiences with education had shown me that true learning only occurs when the learner takes control of the process; this is certain to be a rare event when a student does not even have control over when they are allowed to go to the toilet.

The blog emerged as a prime forum for me to continue to articulate my thoughts on this issue, and Tom continued to work with me on becoming the kind of teacher I wanted to be. After Tom asked the question on August 22, I returned to the classroom the next day and tried explaining my approach to classroom management. From then on, I often took opportunities to remind my students that I was making a conscious effort to put aside the authoritarian tools at my disposal in order to treat them respectfully, as adults rather than as children, and that the only way we would succeed together would be if they responded with equal amounts of respect. Even reading those words brings out the high school student in me, and I feel ready to roll my eyes and dismiss them as coming from a weak teacher who can be taken advantage of. Such was, indeed, the response of some of my students, especially in my first year, before I had learned to navigate the teacher-student relationship. It would still be some time before I learned the importance of nurturing those relationships in order to achieve my goals of a new classroom structure.

My first major event of disruptive student behaviour came a month after school began. I was teaching two physics courses: Honors and College Prep (CP). College Prep was the school's chosen term for courses for the less academic students, and it was in these classes that I had the greatest difficulty. On this particular day, four of my CP students were talking incessantly throughout the period. In addition to asking two to stay after class to speak with me, I tried the new tactic of telling the other two to wait for me in the vice-principal's office. This was something I had been hoping to avoid. Because I wanted to nurture the working relationship between me and my students, I did not want to resort to outside authority to solve my problems; however, I was already becoming nervous about these students' chatty tendencies

and decided to take my department head's advice to show the class that I was serious about discipline. The result was a minor disaster: the two boys reported briefly to the office but left before I arrived, and I left for the weekend feeling frustrated and angry. After describing the entire incident on the blog, I ended with this note:

> I'm lucky that I genuinely like the vast majority of my students, and a class that I find fun to work with came after the bad one today, so at least that was a good way to end the week. But I'm now leaving that junk behind, because this is a 4-day weekend and I'm headed to the beach with some friends for a few days. So you won't hear from me, and I'm going to try not to think about the four dudes who ruined my otherwise very good day. (Liam, Sept. 12, 2008)

These four students consumed much of my attention during my first year, but I learned some valuable lessons from them. José turned out to be a thoughtful and sensitive person, and I soon had a meeting with him after class to enlist his cooperation in dealing with his friends. Although it did not solve the problem, it was certainly an improvement to have someone in the group who understood my perspective and wanted to help. Callo surprised me as well; after months of difficulty, our struggles with each other finally found their resolution after a bitter argument about a mark I gave him on an essay. With the help of another teacher he had turned to for advice, I finally discovered that he had been convinced, from the beginning of the year, that I disliked him and treated him unfairly. With one conversation, I was able to dispel these ideas, and he became a different student in my class. Guillermo, I later learned, was emotionally finished with high school and spent most of his classes in either a disruptive or a disengaged state. I made something of a pact with him: I agreed not to hassle him as long as he was not disrupting other people's learning. This was only a partial success, of course, but it still improved the situation.

Julian was my biggest challenge, for he combined high intelligence with a strong personality and a difficult family background, meaning that he was an expert at frustrating me in my work as a teacher. I frequently met with him after class and tried almost every tactic I could think of, with no success. My last resort was to hold a meeting with him and the principal in which we discussed removing him from my classes. It was only in this meeting that Julian began to understand why his behaviour frustrated me. The most important point I made in speaking with him was that I did not want control of the class for control's sake, but in order to achieve good learning in my classroom.

In each case, the only technique that actually got through to these students was one that Tom and I had discussed many times on the blog and that seemed to be the answer to almost every problem a teacher has: *listen to the students*. When these boys were in my class, all I saw were four people who seemed to enjoy driving me insane. Once I had spoken with them individually and achieved honest dialogue with them, I learned that each one had his own particular reasons for his actions and that the only way I could solve our problems was by addressing those reasons specifically. I continued to experience days in which I wished the boys had never enrolled in physics in the first place, but, in general, their behaviour in my class had changed significantly by the end of the year. If they did not behave more productively, they at least treated me with much less antagonism.

Classroom Management as a Special Case of Building Relationships

As I dealt with the four male students, I was also watching the more general behaviour problems in my CP classes escalate. My attempts at building an atmosphere of mutual respect seemed to be failing. I described my intentions on the blog:

> I have an opportunity every day to try my best to model a different kind of authority… Maybe what some of them will take away from my class, even if it's only subconsciously, is that there is a different way to treat the people around you, and that some very positive things can come out of treating other people with serious and self-conscious respect. (Liam, Nov. 5, 2008)

At the same time, however, I was quick to recognize the limitations of my strategy. Just as I had to battle with the culture of the school when trying to achieve good learning, I was also facing the fact that these students had spent their entire school careers under the thumbs of authoritative teachers:

> If you have been living your whole life being told what to do, you get used to that. And when someone comes along who tries to treat you with respect and assumes that you'll act with respect, it seems like a lot of people will have little choice but to take that as a sign of weakness and to disregard any deeper meaning behind it. (Liam, Nov. 5, 2008)

This became even clearer to me when I analysed the difference between my Honors students and my CP students. The Honors students handled freedom well, using their time in productive ways and constantly displaying eagerness to continue learning. In conversations with other teachers, it was obvious that these students had always been treated more as adults and given more freedoms and responsibilities in their classes from an early age. The CP students, in their role as the less academic students, had always been viewed as the troublesome students and thus had been subject to stronger discipline. This seemed, in fact, to be a sort of self-sealing loop: the CP students were less interested in their subjects to begin with, which caused them to be more distracted more often, which caused their teachers to use discipline to try to get them back on track, which further restricted the students' freedom and thus further limited their interest in school.

Tom's suggestions to me in this area were of a familiar theme: he insisted that the more students and teachers understood each other, the more productive the classroom would become:

> I'm convinced that culture is a significant player here. Your reflexes don't match theirs, and the non-authoritarian stance probably has them baffled, particularly if you never talk about it, which keeps it buried beneath the surface. Do they have ANY sense of the turmoil you are feeling?… For those who don't want to learn, much of the only fun available to them involves attacking the organization in whatever way they feel like. You don't rise to most of the bait, and all they know to do is to keep trying. (Tom, Jan. 12, 2009)

Throughout my frustrations, I realized through my work on the blog that I was still learning, even if it was, perhaps, learning what *not* to do. In February, I received the results of the students' annual anonymous teacher feedback forms, and I discussed the

results with all of my classes shortly afterwards. After thanking them sincerely for their responses, I went on to discuss the comments from students who were frustrated with their fellow classmates' behaviour and with what they perceived as my lack of authority. After explaining my approach to authority and discipline more explicitly than I had ever done before, I finished with the following remarks:

> If you're one of the people who do feel frustrated, know that I certainly have never ignored the problem, but that it's on my mind too. And if you're one of the people who may be helping to cause the frustration, you should know that you're acting that way in that context, in a group of people who come in here looking to do something productive, and that you're hindering their ability to make that happen. (Liam, Feb. 13, 2009)

When I asked if anyone had comments or questions, Julian said, 'We appreciate that you would take the time to pay attention to what we have to say', and the rest of the class nodded and started clapping.

By the end of my first year, I found that adhering to my principles and continuing to put thoughtful effort into relationship building had indeed achieved at least some small success. Although the amount of effort they were putting into their school work had dwindled to almost nothing, they developed what I referred to on the blog as a charitable attitude towards me and the class, which was not very productive but which did make my job slightly easier.

> I think that this has at least something to do with how I've been teaching, both this week and the whole year; it's not just because the year is ending. It seems like now that they're almost out from under my thumb, they're realizing that I'm a pretty O.K. guy who's just trying to help them learn something. (Liam, May 21, 2009)

My relationships with my students during my second year were very different. I had gained some confidence in my role as a teacher; I had learned that the students expected teachers to be friendly and would react poorly to a teacher who tried to maintain the kind of professional distance that is required in schools in Ontario. I had also learned that the standards of behaviour at the school were very different from what I had expected, and that it was quite possible to overreact to behaviour that in other classrooms might have seemed normal. I tried to continue to listen to my students as often as possible and found more modest successes with this approach. Early in the year, I had a conversation with two students after class that went much more smoothly than my earlier attempts:

> I approached them both without anger and made it clear that I was simply frustrated with their behaviour and needed it to stop. When one of them gave me a fake apology, I told him I didn't need an apology and that I hadn't taken anything personally, but that all three of us were probably a bit frustrated with the situation and I needed them to tell me what we could do to fix things. (Liam, Sept. 16, 2009)

For part of the year, I found classroom management quite easy, thanks mostly to the positive relationships I had with my students. Because we trusted each other, I was able to control the class environment through brief discussions and explanations rather than threats. I had also gained new tools to use when those strategies failed: certain students became used to the idea of being asked to 'take a walk' when they were being too disruptive; in my most difficult class, I occasionally stopped teaching and assigned independent reading when all other strategies failed.

Later in the year, it began to feel as though I had made very little progress in maintaining focused, productive learning environments. Although I had avoided antagonistic relationships, I experienced the same feeling that these students were simply not ready for the kind of responsibilities for their own learning that I wanted them to accept. They had had years of experience feeling disenchanted with their education; because of those years of experience, the only time they behaved productively was when they were forced to do so.

Classroom Management and Building Relationships: Tom's Summary

Every beginning teacher struggles with building relationships, both with individual students and with entire classes, and those relationships continue to evolve over the entire time they work together. Liam was no exception. Practicum experiences are simply not the same because the teacher-in-training usually arrives after the course has begun, stays a relatively short time, and never has complete responsibility. Discussion of these issues, perhaps including role-playing, in education classes can never generate the learning that comes with personal experience. Each new teacher is unique in his or her approach to these issues; Liam's approach was particularly interesting because of his strong personal conviction that he did not want to command students' learning. In his words, 'true learning only occurs when the learner takes control of the process'.

I am intrigued that my comments to Liam seem to have been helpful. I have worked to be more explicit in my own classes about what I am doing and why I am doing it as I teach. When Liam's messages appeared, I responded quickly, perhaps guided intuitively by an awareness of how strongly Liam valued what he terms active learning. The suggestion that he be more explicit seemed to help him. There were obvious cultural issues in Liam's efforts to establish productive individual and group relationships; he had not attended school in a context of constant talking by students. My attention to the cross-cultural issues he experienced was guided in part by my personal experiences more than 40 years ago when I taught for 2 years in Nigeria as an untrained volunteer teacher.

'Listen to the students' jumped off the page at me when Liam described this as an almost universal solution to the challenges he faced. His examples of how listening reshaped his relationships with four unusually difficult boys are powerful illustrations of how listening can help a teacher. As Liam mentioned, my approach that he characterized as active learning included several specific strategies for listening to him and his classmates. This experience of blogging with Liam through his first 2 years of experience as a teacher is truly unique in my more than 30 years as a teacher educator. Writing his many blog entries appears to have been a powerful metacognitive and self-study strategy for Liam as he worked to find ways to enact his personal values in a school context that had many unfamiliar features. Analysing my responses on the blog is a similarly productive self-study strategy for me.

Lowering My Academic Expectations

My most significant professional issue during my 2 years in Mexico was that my students consistently performed below my academic expectations. One of the first posts on the blog about this issue came once I had completed my first few weeks and settled into some kind of pattern:

> There are so many little things that they either haven't learned about or don't remember; for example, they are supposed to know a lot of math, but they seem to have no idea how to show it. I get these answers that are just scratches all over the page; here and there I recognize some of the numbers I'm looking for, but they've just appeared out of nowhere, or you get something like $\cos(45) = x/300 = 212 = x$. (Liam, Sept. 8, 2008)

This was only a hint of what was, once again, a much bigger problem than I realized initially. The difference in math skills between Canadian students and students at my new school was profound and had a number of causes. Like many international schools, this one had a high turnover rate, which made it extremely difficult to establish or adopt an official curriculum. Teachers arrived, taught whatever they thought was necessary, and often left soon afterwards. My students routinely said that they had not learned a given mathematical technique because they had had Mr. So-and-so a few years ago and he had not taught them anything. The problem of standards was further compounded by the influence of the Mexican education system (our school was accredited by both the Mexican and American education systems). In a conversation with one math teacher, I learned that the school had consistently high scores in the statewide standardized math tests; this was a misleading statistic because of the low standards in the public system there.

One feature of this problem was the gap between the two academic streams at the school. The division into Honors and College Prep classes was similar to what I had experienced as both a student and a teacher in Ontario. However, the difference between the two groups of students at my new school was enormous. In the Honors groups, I encountered students who were performing far above almost all of the students I had ever known. Many of the students in the CP classes, meanwhile, struggled with math, language and a host of other skills. The math problem was the most significant academic issue in my CP physics classes. When I first mentioned this problem in the blog post above, Tom offered a novel suggestion:

> I really fear that if you can't get them to talk about their strategies (or lack of), you'll never be able to help them improve. What about giving them one problem in two columns and, for every step they do on the left, they have to write on the right what and why they did it? (Tom, Sept. 8, 2008)

Although I did have some success with this strategy, I was still faced with a dilemma that will seem familiar to any teacher: should I spend time teaching skills they were supposed to have learned in previous classes at the expense of my own subject, or should I keep moving on in physics and leave it up to the students to work on their math skills independently?

I was also learning quickly that, aside from math, my students' more general academic skills were much lower than what I had come to expect in Canada. Students

seemed to be expert at doing the absolute minimum required of them for any type of assignment or activity. This too will sound familiar to many teachers, but it was nevertheless a more pronounced problem than I had ever experienced. For example, I eventually learned that, when I described assignments, I had to cover in excruciating detail the required format, length and so on, or risk receiving something scribbled on a piece of paper torn out of a notebook.

The causes for this phenomenon were complex and interlinked. The influence of the Mexican education system and the overall learning environment of the school certainly affected my students' motivation, but there seemed to be a more specific problem regarding student and teacher attitudes towards grade 12. I taught CP physics to students who were in their last year of high school, by which time they had spent up to 16 years at the same institution. Midway through the year, most students had accepted either jobs or offers to attend post-secondary schools, making it difficult for them to see the point of working hard when their fates were sealed. Because grade 12 students were essentially required to take the physics course (there was another science course they could take, but it had limited enrolment and required a written application), few of them had any personal interest or investment in the subject of physics.

Over time, a number of teachers had faced the same situation, and one longstanding physics teacher who had retired 2 years before I arrived had responded by spending most of his class time on long-term construction projects. The room was still filled with drawers full of tools, electrical equipment, disassembled speakers and scraps of wood, and it did not have much working physics equipment. Physics had gained a reputation as being a fun class where students got to shoot off rockets and build things out of wood, which meant that from my very first day I had been asking them to do something much less exciting than what they had hoped for. Although practical, project-based learning can be very successful, I had never found construction projects to be fun or rewarding either as a teacher or as a student, so I struggled to resist the temptation to go that route.

Tom and I began to discuss my options on the blog. The most reasonable path to take seemed to be to reduce the math content in the course and focus on concepts; we both believed that doing too many construction projects would represent my giving up on what I believed physics class should be. Even reducing the math content was something I did not feel comfortable doing, as I have always felt that a purely conceptual understanding of the subject, while crucial, falls short of capturing the fundamental mathematical structure of physics as a model for making sense of the world. In addition, I had no experience with either teaching or studying in a purely conceptual physics class and was unsure of how I would proceed. For example, the textbook provided thousands of useful math problems to help students practice and explore concepts; where could I find replacements that involved no math?

After weeks of frustration, I decided to try a small project with the class to see how they would handle it and also to give myself a break from the difficulty of trying to keep them focused on more traditional learning. The project I chose involved students building contraptions to protect an egg when it is thrown from a certain height. I was at once impressed and disappointed with the results; although there

was some productive work done, many students seemed to be using it as an excuse *not* to work.

With mixed feelings about this trial, I moved back to the more rigorous math I was used to teaching and learning. Unfortunately, when I tried to work through the difficult questions at the end of the unit on Newton's laws, I began to understand how far below my expectations the students were performing. The questions involved objects sliding down ramps, and they incorporated almost all of the concepts we had discussed up to that point and involved some difficult math and geometry. However, I knew from experience that it was reasonable to expect students at that level to be able to do them, and I knew that I had taught everything they needed to know to understand the solutions. Instead, I became so exasperated with their performance that I wrote the following in a blog post:

This is a list of specific ways in which they're frustrating me:

- Forgetting formulas and concepts we've covered within the past 1 or 2 weeks.
- Forgetting that these formulas even exist in the first place.
- Never, ever, ever going through their notes or textbooks to try to find hints about what to do next when working on problems.
- Pretty much refusing to ever try the next step without me telling them what it is, explicitly.
- After looking in their notes because I'm standing there telling them to do so, acting as if they were reading some foreign-language novel they'd never even seen before.
- Never trying to see how the new problems we're working on relate to the old things we've already learned; never even considering that they might be able to do something new with old skills.
- Listening patiently while I explain instructions and then ignoring them, unless I repeat these instructions five or six times.
- Taking terrible notes from what I write on the board.
- Appearing to be on a mission to always do the minimum amount of work possible to please me and get good marks.
- Approaching this subject not as something to understand but as a series of bizarre pronouncements made by a teacher, which they are expected to write out later on a quiz or test.
- Assuming, despite all the evidence that I've presented to the contrary, that if they get the right number at the end of a word problem, they're succeeding in my class.
- Getting frustrated in class because they don't understand, but making no effort to understand anything when they're not in class (e.g., by staying for extra help, posting on the class website, etc.). (Liam, Oct. 20, 2008)

As Tom and I discussed the issue, we both became convinced that, whatever I might be doing poorly as a teacher, I was facing a deeper systematic problem:

> You've listed perfectly the PEEL [Project for Enhancing Effective Learning; http://peelweb.org] list of Poor Learning Tendencies, and what you seem to have in these CP groups are students who have very effectively learned *passive* learning behaviours. No one has ever been willing to show them how to think about what they are learning and so they cannot, much as you want them to. (Tom, Oct. 21, 2008)

After each of my first few quizzes, I had been surprised to find that the marks were always lower than I expected. By the time of writing these posts, I had changed my assessment strategy significantly. I have always thought of physics less as a body of knowledge and more as a set of concepts and problem-solving techniques. In the past (during my practicum sessions, for example), the tests and quizzes I created had always challenged my students to synthesize what they had learned in class and to apply their skills and knowledge to new types of problems. My favourite kinds of questions involved things we had never discussed in class but which the students could fairly be expected to figure out based on other knowledge; this seemed to be the most accurate way of judging whether they had achieved a deep conceptual understanding rather than merely memorizing facts. However, at this school I consistently saw the majority of my students failing at these types of questions, and so more and more of the problems on my assessments were simple math problems or basic questions about lesson content. When I saw that my students still had difficulty with questions that were like their homework problems but required solving for a different variable, I began to resort to questions copied directly from their textbooks, using different numbers.

A significant example of the ways in which my students had been trained to be passive rather than active learners occurred just before the Christmas break, when students were preparing for exams; I was asked to prepare review packages for each of my classes. If a teacher had ever prepared a review package for me while I was in school, I would have been impressed; here it was expected of me, and my students were even upset when I refused to turn it into an easy fill-in-the-blanks type of assignment for extra credit. I joked with the students that I would bet them 100 pesos each that, if they created their own review packages without first looking at mine, they would get As on their exams. None of them took me up on that bet.

As I finished my first semester and felt at a loss as to how to proceed when my students were performing at such a low level, Tom offered the following advice:

> What are the remaining units? What about a qualitative approach to electricity – get them to give you their REAL questions about electricity, get them into places like the howthingswork website? (Tom, Nov. 6, 2008)

I took this advice at the beginning of the second semester, and I had some luck with it. My students seemed much more engaged when we left the math behind and moved on to subjects that interested them. We also did more project work, building cars with electric motors, which involved very little physics and a lot of working with various tools.

My real turning point with some of my classes was the moment I decided to drop all of my expectations for my CP students, both for behaviour and for academic performance. I tried hard to focus my teaching on those students in my class who were still active learners, even if they were the minority, and I was no longer surprised by low test scores or poorly done assignments. It was frustrating to watch my goals as a teacher fall lower and lower and to watch myself abandoning the kind of classroom I wanted for the one I could achieve, but the blog remained a place for the two of us to continue to focus on ways to work with what I had.

Lowering Academic Expectations: Tom's Summary

Liam has created an intriguing account of why he had to lower his academic expectations; it is important to remember that he is writing mainly about the so-called College Prep classes, not the Honors classes. Here we can glimpse Liam's very strong sense of physics as a discipline, for he appreciates both its conceptual structure and its mathematical structure. The students in his CP classes appear to have had marginal math skills at best; conceptually, it appears that the students simply did not expect what they were taught to make sense. The October 20, 2008 list of ways in which Liam felt frustrated by these students will ring true to many teachers of students who are not doing well in school. In my response to Liam the next day, I mentioned the Project for Enhancing Effective Learning (PEEL), a project now based at Monash University in Melbourne that began in 1986 as one school's collective effort to address students' poor learning tendencies. This aspect of Liam's self-study illustrates the essential nature of experience for the first-year teacher. Only by working day after day to identify and understand his own students' approaches to learning and the skills they had developed or not developed in previous courses could he begin to find ways to modify his initial hopes and expectations that were inevitably based on his own experiences as a student over many years of school and university.

Developing My Pedagogical Approach

All of these experiences did more than just teach me how to cope with poor student performance; they also kept me constantly thinking about how to engage students in their learning. My work in the Honors classes quickly reached a level of easy consistency, because the students in those classes were eager to learn or at least eager to succeed. I could do the most pedagogically weak lesson with them, and they would still learn. I rarely felt compelled to stop and question my practices in those classes, especially when the CP groups were demanding so much of my energy and attention. In my CP classes, however, I had no choice but to re-evaluate my practice constantly. By the end of my 2 years, I had tried every teaching strategy I could think of in order to try to engage those students in active learning.

In retrospect, my struggles to develop teaching-learning strategies closely parallel my efforts to establish positive relationships with my students. I saw my big-picture strategy as one unified approach; fostering a respectful classroom environment was one necessary step in achieving my most important goal of quality student learning. I knew that active learning can only occur when students wilfully engage themselves in the experience (or, in the words of the poster I taped above my whiteboard, 'Learning is not something done *to* you'). Thus, I attempted to create an environment in which students were not dominated by an authority figure, but instead participated in the productive functioning of the class. Similarly, the activities

I experimented with in my CP classes were generally designed to transfer some measure of control from the teacher to the students.

When I recorded on the blog my efforts to translate my first project, the egg drop, into good physics learning Tom offered the following comment:

> That will take a lifetime! We all "know" that activities are better but we fall back on lecturing so we can focus on how much we have "covered" – that was the priority for most of our own teachers. (Tom, Sept. 23, 2008)

In reply, I recorded my view of the two extremes of full teacher control and full student interest, neither of which offered a way forward in developing my personal pedagogical approach:

> It's true, there does seem to be this catch-22: if you stand up and lecture, you can control exactly what is heading towards their ears and make sure that what they hear is correct, but they won't really learn it. If you let them go nuts with something that interests them, they'll be more open to learning, but you won't really know *what* they're learning. (Liam, Sept. 24, 2008)

I quickly learned that giving up control is far more complex than I thought it would be, particularly when the students you want to give control to seem to have very little intellectual curiosity or passion for learning. When I did get my students interested in the subject with a strategy such as Predict, Observe, Explain, I often found it difficult to follow through with good learning. POEs challenge students to come to new understandings as a group, independent of the teacher's direction, but because these students had so little experience of independent learning, I always found myself having to simply give out the answers when we were finished.

In my practicum, I had come to understand that active learning is not something that can be turned on for brief moments; it has to be sustained throughout the entire class period. I also learned that achieving such a feat would take years of practice as a teacher. I continued to improve in this area during my 2 years in Mexico, but I still had much more work to do when I finished. In the meantime, I had discovered that active learning takes years of practice for the students as well and could not be turned on for one period at a time during their last year of high school. Even so, I did experience a number of successes, and these held as many lessons for my teaching as did my frustrations and failures. My most effective activities and strategies were ones that drew students into their learning in as many ways as possible.

To illustrate, after assigning one or two essays to my CP classes in order to try to convince them of the fascinating conceptual side of the subject of physics, I was feeling disappointed by their apparent lack of understanding about what I would be looking for in their writing. The next time I wanted to assign an essay, we did a practice activity in class. They wrote short essays answering simpler questions (choosing from a list of possible questions, with each question based on presentations they and their classmates had done earlier in the week), and then handed the anonymous essays back to me. I distributed them randomly back to the class, and they marked each other's work based on a simple marking scheme. I also asked the markers to leave specific comments about things the writer did well and things the writer could improve on. We passed the essays around for one more anonymous

marking and then I returned them to their owners. I wrote on the blog at the time that I liked the activity for a number of reasons: it gave students quick feedback; it gave them insight into the work their fellow classmates were doing; and it forced them to think from a teacher's perspective.

I also worked to capture my students' interest in the subject. The combination of mathematics, esoteric terminology and a new perspective on the world we live in has frightened high school students away from physics for decades, and my students were not immune to this combination. Whenever I came across a new topic that I thought might interest my students or saw a face light up at a passing remark about black holes or quantum theory, I tried to seize the opportunity to talk about something they might find interesting enough to remember. For example, I started each class with an Image of the Day, courtesy of the NASA website (http://www.nasa.gov), giving us ample opportunity to discuss interesting astronomical phenomena. One of my favourite teaching days occurred when I threw out my lesson at the last minute in order to spend a class chatting with them about antimatter; it was my most frustrating students who had requested it of me.

However, I could not do that every day. Having a mandated curriculum meant that I would sometimes have to teach subjects that my students did not find inherently interesting. In my first year, I noticed a vast difference between my success with a math-heavy, highly technical unit on forces and vectors and my later unit on waves. In the waves unit, I focused on conceptual understanding for a number of class periods before introducing any formulas. I used almost 100 different animations and videos that I found online to illustrate wave phenomena, and I was able to take my students outside for a number of hands-on activities. From anonymous survey results and test scores, it was quite clear that the accessibility of the waves unit was what made it a success; in other words, it was not that the content was more or less interesting, but that I was able to get them interested and engaged in their learning, Tom, as always, was encouraging:

> You really did avoid giving up. The resonance lesson by the pool is surely one you are going to remember. Referencing Real-Life Things—that's real physics teaching, isn't it? The concepts are empty words unless they connect to their version of real life. When you say you knew all along that you could better capture interest by grounding your teaching in real-life, tangible things, perhaps it's the case that you knew it intellectually but now you really know it in a way that is grounded in the real life of teaching! (Tom, May 22, 2009)

In my second year, I tried starting the CP course with the waves unit to draw students in and get them interested; after only a few weeks, I heard from a number of them that physics was their favourite class.

Pedagogical Approach: Tom's Summary

Is there something significant in the way that Liam has organized his self-study? He began with building relationships and classroom management, then considered how he had to lower expectations, and finally discussed the development of his

pedagogical approach. In my classes with him, where he experienced a pedagogical approach that he characterized as active learning, my focus was on developing the ability to identify how a teaching procedure influences the quality of students' learning. Since my 2007–2008 class that included Liam, I have continued this focus, but I have given greater emphasis to building my professional relationship with each student in my class, and that helps me adjust my expectations and shape my pedagogical approach accordingly.

As he begins his teaching career and I approach the end of mine, Liam and I share the idea that learning is not something done to or for you by someone else but something we do for ourselves. In school, a teacher typically creates the environment in which we hope learning will occur. As Liam points out, giving up control is far from simple; unless we teach very young children, expectations for the teaching-learning relationship have been shaped and constrained by many previous teachers. For the new teacher in particular, the process of constructing a new set of reflexes is both intellectually and emotionally demanding. Liam's CP students seemed to be so unable to judge the quality of their own learning that they provided him with a unique opportunity for self-study as he worked to construct a pedagogical approach that would engage them.

Liam's Conclusions

The blog posts reveal some distinctive patterns. I used the blog to articulate my thoughts, clarify my thinking and track my progress. Tom's open ear and experienced-based advice provided much-needed emotional support; in looking over our posts, it is clear that he was effective in helping me keep my own professional goals in mind as I battled through the day-to-day challenges of teaching. Although classroom management was a constant struggle for me and although they consistently performed below my expectations, I learned important lessons about forging positive and respectful relationships with my students. My struggle to teach students who presented so many obstacles to their own learning reinforced my pedagogical ideas and challenged me to find many new strategies to encourage active learning in a physics classroom.

The most important realization I arrived at during my time in Mexico involves a deep understanding about what I wanted people to take from my class. Tom and I often discussed the idea of focusing on what students will remember 5 years later. In his words, it is not *what* you teach but *how* you teach that is most likely to be remembered. In his education class, that meant modelling the kind of teaching and learning he hoped we would try to achieve in our classrooms. In my physics class, that meant modelling the kind of respectful relationships, intellectual curiosity and active learning that I hoped my students would continue to pursue throughout their lives. I could not have achieved my successes as a teacher, nor could I have analysed and improved my own work, had it not been for this collaborative self-study of my first 2 years of teaching.

Tom's Conclusions

Is there a teacher anywhere who does not want to be remembered positively by his students? Is there a teacher educator anywhere who does not want to influence and follow how his students begin their teaching careers? Liam's messages recorded in a blog were a unique, unusual, unexpected and intriguing opportunity to follow his progress as a beginning teacher. His working in a different culture offered an intriguing parallel to my own initial teaching experiences, working as an untrained volunteer teacher in Nigeria 40-odd years ago, with no teacher educator as a model and with no internet to permit quick and easy communication with someone back home. When his messages suddenly appeared just before he started to teach and then came on an almost daily basis, I knew something important was happening. We have never discussed just why he connected so thoroughly to the way I was teaching his physics methods course, but that shared experience clearly created the mutual trust that made it so easy and so important to keep the blog going.

It did not immediately occur to me that Liam was using the blog for self-study purposes, and I did not immediately realize how my collaboration by responding to most of his messages was also an opportunity for me to engage in self-study. My own introduction to self-study of teaching practices occurred just before the Self-Study of Teacher Education Practices special interest group was formed within the American Educational Research Association in 1993. For 5 months in 1991 and again in 1992, after 14 years in the teacher education classroom, I took myself back to the physics classroom by accepting full responsibility for one class a day in a local secondary school. In the second year, I managed to record in a computer file a daily analysis of my teaching and the students' responses; although I was only conversing with myself in that file, I quickly realized the contribution that my writing was making to improving the quality of my teaching and my ability to listen to my students' learning, in both the physics classroom and the teacher education classroom (Russell, 1995a, 1995b). Perhaps that experience, years earlier, helped me realize from the outset the importance of my responses to Liam's messages, as a way to encourage him to continue his writing and as a way to support his commitment to active learning that had begun in my physics methods classroom.

In my own contributions to this chapter, I have attempted to call attention to Liam's *learning from experience*, learning that could only happen in his own classroom. Personal experience has an authority that is uniquely different from the authority of reason (as in other people's writing about how to teach science) and the authority of position (as in the statements of mentor teachers' comments to a teacher candidate about how to teach science). Munby and Russell (1994) developed the idea of the authority of experience from data that I collected while listening to my teacher education students in 1992–1993, the year that was also the second year of my return to the secondary school.

The blog itself, to which Liam contributed far more than I did, proved to be an excellent way to store the self-study data as it accumulated. Inspired by the quality of the professional learning that Liam revealed through his writing about his teaching,

I have since encouraged students to set up a private blog with me during their preservice program. Keeping up with 30 or more blogs at a time can be challenging. While I do not always meet my goal of responding promptly, I still believe the practice is a promising one for new teachers for at least two reasons. As Liam explains, the blog was a powerful element in his professional learning; the blog also became a permanent record that we could revisit at any time to make sense of the overall impact of our many exchanges that ultimately proved to be self-study experiences for both of us. Coincidentally, the year that Liam and I worked together in my physics methods course was the same year that Shawn Bullock (2011) studied what five of my students were learning in relation to their learning from practicum experiences. These two self-study experiences sealed my commitment to continuous self-study of my teacher education practices.

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Chapter 3
The Transformation from Expert Science Teacher to Science Teacher Educator

Dawn Garbett

This chapter documents my journey from science teacher to science teacher educator. I had been a successful science teacher in a secondary school for more than 10 years before my appointment to a Teacher Education College. In my new position, I relished my role and status as an expert science teacher. I was beguiled by the relative ease with which I could make learning science engaging and interesting for my student teachers. I joined them at the water trough to demonstrate comparative buoyancies of different materials and showed them how to diagnose their children's understanding of why boats float and coins sink. We made sherbet and ice cream; we put together simple electrical circuits and pulled apart torches; we planted seeds and charted their growth. The experiences were rich and varied, and the learning was fun. As many other teacher educators have realized, however, teaching about teaching is more complex than teaching a subject itself.

I have come to this realization through self-study research, which has given me the following insights into my practice. Firstly, science education is only a vehicle through which I can engage my students in learning about teaching. I use my subject knowledge and my experience in the classroom to contextualize teaching about teaching. Secondly, expertise in teacher education comes from understanding the complexities of teaching about teaching and in being able to articulate and demonstrate those complexities in meaningful ways. So while my science education experience is important to what I teach, it is how I am as a teacher and how I unpack the teaching decisions that underpin my teacher education practices that are the subject knowledge of teacher education.

I explore my journey of transformation from science teacher to teacher educator through two projects that I have been involved in over the past 7 years. The catalyst

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for the first self-study involved my introducing peer teaching as an approach to engage primary and secondary student teachers in teaching science. The second self-study emerged when a colleague and I took a team approach to science education. To begin, I outline why I believe science education is a particularly difficult curriculum area in which to be a teacher educator, as a way of contextualizing my research. Then I discuss why I am so committed to self-study research and how I undertake this form of scholarship. A synopsis of the two projects follows, to show how they combined to lead me forward and make those insights apparent.

Research Context

Science education is a difficult curriculum area in which to be a teacher educator. In New Zealand elementary schools, teachers are expected to be generalists and to teach all curriculum areas to children aged between 5 and 12. The goals of science education are built upon a constructivist approach that sees the learner is an active participant, involved in the interpretation of meaning, the reorganization of experience and the reconstruction of experience to become more knowing. This is based on the pioneering work of Osborne and Freyberg (1985) and Driver, Guesne, and Tiberghien (1985). Effective teaching in science depends on teachers recognizing how learners are making sense of science ideas. Unfortunately, teachers often lack the rich subject-matter knowledge required to be responsive to students' thinking and to foster learning with understanding (Appleton & Kindt, 2002). Misconceptions are often reinforced by teachers asking where the Sun goes when it is dark (Garbett, 2007a) or suggesting that a plant gets nutrition through its roots. Many teachers avoid teaching science altogether or present it as a book-based subject because it is easier to maintain control in a classroom if children are kept seated and working quietly (Baker & Jones, 2005; Education Review Office, 2004). Thus, the science education practices student teachers see on practicum (and are encouraged to emulate) when they are in elementary classes are not exemplary, if, indeed, they see science being taught at all (Garbett, 2011a).

The problems I face as a teacher educator teaching science to student teachers in this sector are manifest. Prior to my self-study research, I modeled what I believed to be exemplary science education pedagogy. My approach was to diagnose my students' prior science understanding and then challenge those commonly held misconceptions by providing engaging, activity-based sessions. My course evaluations indicated that students enjoyed my classes and graduated enthusiastic about having learned science. Despite these evaluations, I had misgivings about my impact as a teacher educator and whether my students would actually teach science in their classrooms.

As I sought ways to be more effective in fostering my students' confidence and competence to teach science, I introduced peer teaching as an approach and then set up a research project to study its effectiveness (Garbett, 2011b). This project evolved into a self-study that drew my attention to the first insight that science education is merely a vehicle through which I could engage my students in learning about teaching.

I started questioning my emphasis on science content knowledge and what my role was, if it was not to model exemplary practice for my students to copy. The second self-study, developed in the same context of teaching an elementary science education methods course, enabled me to explore a new role for myself as a teacher educator. Teaching alongside a trusted colleague brought other questions to the fore as we discussed and made public our implicit practices. I gained a deeper understanding of how complex teacher education should be when it is the focus of study.

Self-Study Methodology

Both self-studies were underpinned by common methodological features. They were self-initiated and focused, improvement-aimed and transformative (LaBoskey, 2004, pp. 842–849). Furthermore, self-study is typically a collaborative endeavor, and research is shared with critical friends who can question assumptions and provoke new perspectives throughout the project. Making the results of my study available to my peers for critique and review turned scholarly, reflective practice into research. When I consider reflecting in and on my practice as a self-study researcher, I remind myself of Hans Christian Andersen's story of *The Emperor's New Clothes*. The Emperor was fooled into wearing an invisible suit. He looked at himself from every angle in the mirror and pronounced to his stunned court that he looked very fine indeed! No one was prepared to question the absurdity of the situation lest they be seen as fools.

In much the same way, it is also possible to perceive of reflective practice as an illusionary device to reflect what the viewer wants to see or as a carefully scripted exercise, portraying an image that has no real substance. As Bolton (2005) writes: "The metaphor it embodies is limited: a mirror reflection is merely the image of an object directly in front of it—faithfully reproduced back to front" (p. 4). Reflecting is not overly helpful in advancing understanding of practice, generating new knowledge or disrupting the status quo unless there is some means of gaining a new angle to enable a new line of sight. The collaborative nature of self-study enabled me to be more than a passive recipient of my supposed mirror image. Students and colleagues gave me new perspectives to consider. The Emperor may have been oblivious to the obvious, but I did not want to be. Self-study is a way of looking through the mirror, rather than at the reflection.

Ham and Kane (2004) write of self-study as "that self-conscious attempt to validate one's own data, and to see one's participant self through alternative lenses" (p. 129). They suggest that the questions that should be addressed in self-study are:

> Have you viewed your own experience with fresh eyes, seen your practices as others might, and have you tried to make the richness of your own experience of relevance and significance not only to you but also to your critical peers? (p. 130)

Thus, self-study is a transparent and systematic research process in which multiple methods are used to generate and gather data. Narrative and autobiographical

forms of inquiry and reflective practice have had a strong influence on self-study research as teacher educators have put their own practices under the microscope (Mitchell & Weber, 2005). Analysis of data in self-study is typically a non-linear process or "a hermeneutic spiral of questioning, discovery, challenge, framing, reframing and revisiting" (Samaras, 2011, p. 81).

The unique identifier of self-study is the focus on "self in the act of teaching" and the understanding we bring of ourselves as practitioners to the research. Maintaining this focus requires a disciplined and conscious effort. As Trumbull (2004) states:

> All of us work to ensure that the data gathered are not mere fictions, even as we acknowledge that our own views will affect how we see the world. We work to capture the fleeting complex interactions and musings that characterize teacher education. Doing so is not an easy task, and it is one we consciously attend to in our work. We strive to look at our data systematically, to ensure that we do not attend only to the findings that support our hopes and wishes. (pp. 1225–1226)

One of the main sources of data in my self-studies was my electronic journal entries. This professional-personal e-journal was a diary of practice and experience. Using the guidelines outlined by Holly (1989) and Bolton (2005), I recorded my impressions and descriptions of events, circumstances, experiences, discussions and reflections. I wrote as close as possible to each of my teaching sessions in order to capture the detail that such closeness can bring. At other times, I wrote journal entries to revise, elaborate, and reflect on triggering incidents and emerging themes. Writing in my e-journal was an opportunity to not only capture descriptions of events and situations I encountered, but also to enrich and expand this data set as I analysed and reconstructed what had taken place in my teaching sessions, my conversations and interviews with students and colleagues and my responses to them.

In order to gain a different perspective and enable me to see my teaching through my students' eyes, I sought their comments and feedback. For example, to ascertain the effectiveness of peer teaching, I designed questionnaires using Likert scales and open-ended questions to be given at the start of their program of teacher education, at the start of their science education course (midyear) and at the end of the course and program. Questions included: "Rate your confidence in your subject knowledge," "What are your expectations of the science education course?" and in the end-of-course evaluation, "How have you learnt the most important things in the science education methods course, and what are they?" The number of students enrolled in the 1-year Graduate Diploma of Teaching (Primary) program varied between 80 and 120 with response rates to the questionnaires consistently better than 80%.

A second source of student-generated data in my peer-teaching study was the written feedback to one another evaluating each other's teaching. There was no compunction for students to share their feedback with me, but the interaction rate was consistently above 50% for each of the four peer-teaching sessions. I copied the peer evaluation guides in order to analyse the comments more carefully later. I also presented a preliminary analysis of these data sets to the students as a summative form of member checking. Furthermore, I invited any student to participate in informal focus-group interviews to discuss my findings. Fifteen graduating students participated in these interviews at the conclusion of their teacher education program.

Questions were open-ended, and I encouraged the participants to talk at length, as suggested by Smith, Flowers, and Larkin (2009) when conducting interviews. The students commented candidly on the relative merits of peer teaching and the course structure and content. I asked them specifically to tell me how they thought the course could be improved for future cohorts. This became a third data set generated from the students' perspective that informed my understanding of how my pedagogical practices had influenced student teachers through peer teaching.

In the team-teaching project, my colleague and I kept individual electronic journals, but during the session, when in the role of the participant observer, we also kept a shared log of observations, questions, and ideas that we wanted to draw to the students' attention during the session, as well as additional comments that we wanted to share with one another after the session. We surveyed our students formally by asking for anonymous written responses to our team-teaching approach at the midpoint and end point of each semester. We also regularly used less formal ways of gathering feedback from the students, such as Brookfield's (1995, pp. 114–139) critical incident questionnaire. These provided further data for analysis. Students also responded verbally during class discussions, and their comments were recorded in the log or our electronic journals.

We collected our thoughts about whether we wanted to continue using team-teaching as an approach by writing a survival advice memo adapted from Brookfield (1995, pp. 78–79). Individually, we wrote answers to questions such as "What do I see as the advantages/disadvantages of team-teaching for students and for teacher educators?" and "What would I leave in a survival memo for someone else who was coming to work here for the first time as a teacher educator and thought they wanted to team teach?" Through reading and discussing each other's survival memos, themes emerged that we used to reconstruct our understanding of the roles we had taken in team-teaching (Garbett & Heap, 2011).

My focus when analysing these collective and expanding data sets was to make sense of this information as a teacher educator simultaneously immersed in teaching and researching that teaching. Ideas skipped between projects as I jotted notes to myself in my e-journal of issues, reactions, similarities, contrasts and reflections (Samaras, 2011). As I considered these newly generated entries, I recognized emergent themes that crossed over between projects. Searching for connections and patterns across them and sharing my interpretations in regular discussion with critical friends and collaborators became a further step in my analysis. Critical friends provided constructive feedback beyond technical advice and challenged me to clarify my interpretations. Sometimes the meetings were an informal but focused way of discussing our joint experiences. Critical friends provided practical support for implementing the approaches and the opportunity to reframe what was being learnt. Articulating our developing understanding, disseminating our research and responding to critique enabled us to sense how our changing practice resonated with others (Garbett & Ovens, 2010; Ovens & Garbett, 2008). Finally, as recommended by Lankshear and Knobel (2004), I revisited the data to look for particular instances to support the themes that had emerged, and I considered my analysis in the wider context of the research literature. The end result was a far greater awareness and understanding of the efficacy of my pedagogy.

Project 1: Peer Teaching

In 2004, I introduced peer teaching as a formal requirement in the Graduate Diploma of Teaching (Primary) science methods course, never expecting that it would have a profound impact on my teaching (Garbett, 2007b). The approach shifted the organization and structure of those sessions away from being teacher-centered and oriented towards modeling exemplary practice to situate students' learning in the act of teaching. I set aside between 20 and 30 min in four sessions for each student teacher to teach peers in small groups based on the jigsaw approach (Aronsen, 2000). Having students teach their peers was artificial in many ways (e.g., limited time was available, they taught small groups of peers, resources were made available and their choice of topics was very narrow), but, nonetheless, it provided a rich learning opportunity for both the student who was teaching and for the peers. The teaching-student had to make the sorts of decisions that they might be expected to make in a classroom situation while in the supportive context of the science education course. As a means of enhancing efficacy, research suggested that observing others who overcame difficulties and coped through effort and persistence was more effective than observing those who appeared to complete the task with comparative ease (Palmer, 2006) or watching experts model exemplary practice (Long & Stuart, 2004). Learning from their peers' teaching efforts as well as their own was theoretically sound.

While the student teachers were engaged in peer teaching, I formatively assessed the situation by wandering through the teaching spaces, eaves-dropping on conversations, monitoring participation and checking on preparation. Sometimes I joined in with a group for a short while to examine the snail or to study the effects of a magnet. From this superficial scanning of the sessions, it appeared as though there was considerable learning and teaching taking place, but I felt that I was losing my expert status in my students' eyes. In my journal after one session I wrote:

> One of the women commented that it was the clearest explanation of day and night she had ever had and that no-one had explained like that before. She said I was a very good teacher and asked why had I stopped teaching science? (Journal entry, August 2004)

My teaching was suffering as I tried to teach the same amount of content in less time. I had not taken into account the practicalities of sharing teaching time:

> I had organized too many activities for the POE [predict, observe, explain] phase of the session. They hardly had time to think about what they were doing or seeing … The whole session was too rushed. It was just like "show and tell" rather than engaging them in any actual learning or understanding of the concept. (Journal entry, September 2004)

As I considered the potential for the student teachers to learn about teaching science, I wrote:

> It really has made me aware that I am trying to be a better teacher educator rather than a science teacher. I have to give up the quest to be "the expert teacher" and acknowledge that, if I am committed to my belief that the students need to be confident and able to teach science with enthusiasm, then I need to let them experiment in this role where they are safe. (Journal entry, September 2004)

Later I wrote about my doubts about the effectiveness of peer teaching:

> They are teaching one another. This may not be as effective a way to transmit content knowledge as lecturing to the students. I suspect that I would do a better job of explaining concepts in many cases. (Journal entry, September 2004)

It was evident from my concerns that I still believed in the importance of having confidence in science content knowledge. From my perspective, science was the most difficult area of the curriculum to teach well with limited background knowledge, and my job was to make sure that student teachers had a good grasp of the basic knowledge of the discipline. A lifetime of experiences had shaped my perceptions. My undergraduate degree was a bachelor of science, with a zoology major, although I failed physics, botany and mathematics in my first year. I went on to complete my qualification and teaching certification concurrently. My teacher training program was fitted around my university studies. Any timetable clashes were taken as an opportunity to negotiate individual and independent courses of study at the training college. Academic knowledge was foregrounded in my enculturation into the teaching profession. Lecturers at the training college considered it more important that I complete university work than professional studies. The importance of a sound subject knowledge base was thus reified. "A teacher needs to know a subject in order to be able to teach it" was the message I took from both institutions. The legacy of my own educational experiences was that I perceive science in general, particularly physics and chemistry, as a more difficult subject to understand and teach.

Compounding my focus on subject knowledge was my complete lack of experience in teaching in primary schools. Ten years' experience of teaching science in secondary schools gave me credibility and confidence in the secondary teacher education courses. Although I doubted my qualifications to teach science in the primary teacher education program, the institution thought it was well within my capabilities. The implication was quite clear: my subject knowledge of science was more highly valued than my experience in the classroom. However, I still felt inadequate compared to those with primary classroom experience. What did I know of primary teaching? How transferable were my experiences as a secondary school teacher?

These doubts led me to emphasize subject knowledge as important in developing student teachers' confidence and competence. My approach was based largely on how important science content knowledge was to my perceived confidence and competence to teach teachers. I confidently modeled being a knowledgeable, enthusiastic science teacher, and I used my extensive subject knowledge to compensate for my lack of understanding about teaching in a primary school. Among Myers' (2002) reasons why telling, showing and guided practice might be standard practice in many teacher education practices, his second point resonated strongly:

> Study of one's own practice makes one vulnerable. Many teacher educators are not secure and courageous enough to question what they do, to experiment. They choose to view teaching as doing what they do "the right way," rather than a continuous process of experimentation, reflection, analysis and learning from experience. They seem to think that teaching in ways that are not 'the right way' is, in effect, poor teaching. They cannot risk being thought of as poor teachers. Teacher educators cannot be poor teachers. (p. 137)

Teacher educators can find themselves unsupported by their colleagues and the students they teach when they try to adopt new roles. Challenging the status quo can lead to uncertainty and confusion. Even with a growing awareness of the self-study in teacher education practices literature as a positive means of developing professionally and confident in my role as an expert science teacher, I was wary of trying new ideas. I was increasingly mindful that modeling how to teach science might not foster student teachers' confidence and competence to the extent I had hoped.

Student teachers learn content knowledge and, at the same time, must learn about teaching that content knowledge to others. The teacher educator's role is to marry these dual purposes in such a way that student teachers develop the skills, confidence and competence to teach learners with different needs and abilities. Analysing my journal entries and recalling discussions with my colleagues, I realised that we all struggled to articulate this dual process. It was easier to describe *what* we did in terms of subject knowledge or lesson planning techniques than it was to justify *why* we considered these to be important to our practice. I willingly shared stories with my colleagues about how I taught student teachers a basic understanding of phases of the moon or how to diagnose students' misconceptions about dissolving. As I listened to myself telling those stories, I realised that I was speaking as a science teacher. When I attempted to describe what I intended for student teachers to learn about teaching, I had no stories. My confidence and competence to discuss the problematic nature of teacher education with my students and colleagues was limited. My view of myself changed from a very competent science teacher to a less confident teacher educator. In my journal I wrote:

> It really has made me aware that I am trying to be a better teacher-teacher rather than a science teacher. My sessions are nowhere near as perfectly planned as I would like; I don't accomplish what I expected to. I want to believe in my expertise in the teaching role. I am struggling with giving them the power to teach about my subject area because I know that it defines me in part. I am a great science teacher—I am not so sure that I am a great teacher-teacher. (Journal entry, September 2004)

Perhaps the Emperor and I had more in common than I thought. My students did not want to disrupt that image of me as the expert science teacher. From their responses to the questionnaires, it was apparent that they wanted to engage as learners of science not as teachers of science. They expected me to deliver tricks and tips, practical activities and experiments, units of work and lesson plans that would stand them in good stead in the following years. It should not have come as a surprise to me that my attempts to renegotiate our relative positions could be met with half-hearted enthusiasm, passive resistance and even disapproval.

It was through peer teaching that I realised that there was a lot more learning taking place that I was not responsible for and could not instigate by maintaining the authoritative mantle of expert teacher. The student teachers began to explore their own identities as teachers of science. They practiced skills of teaching: being enthusiastic, knowledgeable guides, prepared to listen to their learners and develop their understanding through presenting stimulating ideas and activities, questioning and explaining and redirecting the learning towards more scientifically accepted ideas. I stepped aside from the teacher's role to ensure that the student teacher "experts"

experienced teaching science for themselves. In doing this, I was creating avenues for the student teachers to access participation in a community of practice which had as its focus science teaching rather than science learning. While I stayed center stage as the expert science teacher, I was denying the student teachers access to this role and, in effect, gatekeeping. Student teachers need to practice and develop those skills necessary to be competent in their new role as teachers.

This initial self-study provided a rare opportunity to effect change in my understanding and practice of pedagogy and to recognize these insights as meaningful learning. After a career of fathoming how to teach science, self-study drew my attention to how to teach teaching. Being more conscious of teaching about teaching, I discussed a second project with a colleague. We shared a common desire to explore, making our teaching decisions more explicit to our students. Fortuitously, two small classes were timetabled in the same section, and we had the opportunity to combine them and teach the classes together. We have written and discussed this self-study project in several articles (Garbett & Heap, 2009, 2010, 2011). What I learnt from this second self-study project is described below.

Project 2: Team-Teaching

My colleague Rena Heap and I approached team-teaching with mixed feelings. I was apprehensive about teaching with a colleague who had considerably more experience of teaching in an elementary classroom. Her credibility with the students and ability to integrate actual day-to-day experiences was far greater than mine. Given my penchant to rely on subject-matter knowledge to compensate for my lack of knowledge about teaching young children, I knew that I would feel insecure. Unbeknownst to me, Rena also felt insecure in her status as a relative newcomer to the institution. She had strong content knowledge with an undergraduate science degree and was an accomplished elementary teacher, but she considered that I was far more experienced as a teacher educator and practitioner-researcher. We entered the team-teaching project with a strong desire to improve our practices and both thinking that we had much to learn from each other:

> We are both apprehensive. We are both very good at what we do, which is to teach behind closed doors. Forming those relationships with a group of student teachers is easier when you can ….what? Relax? Be yourself? Teaching in front of a peer is an added strain and comes at a personal cost. (Journal entry, March, 2009)

Through team-teaching, we wanted to make the tacit knowledge that underpinned every day teaching decisions more explicit to the student teachers. Science content knowledge and science education theory remained the foci for the students and us. However, the subtext of learning about teaching was given more prominence through unpacking teaching decisions that we made intuitively and non-consciously throughout each session:

> Your instructions for Draw-a-scientist included—quick sketch; not an artistic representation; stick figures are O.K.; put some clothes on it; we want detail. They hardly have any time to

> draw… we are racing through this to make up time. This is too fast. What can we ditch… where did we lose it? (Shared log, March, 2009)

Critiquing one another's practice in front of the students drew their attention to the complex and challenging dilemmas that we resolved when teaching. It moved our teaching actions beyond what could have been described as a formulaic performance towards a pedagogy which was more attuned to our students' needs to learn about teaching. This was challenging for both of us.

> In the debrief Rena drew the students' attention to a couple of things that I had done that I thought would just pass everyone by. But no—Rena had spotted the fact that I had got everyone's attention and then been sidetracked and had lost everyone's attention again. Then I had started to introduce an experiment out of sequence and had stopped myself in mid-sentence. The students were surprised that they hadn't noticed the false starts, mistakes and repetitions. Rena asked them how they thought I felt when things didn't go as I had anticipated. How would they feel? I admitted that I make those decisions on the fly and that it was absolutely typical! (Journal entry, March 2009)

In practical terms, we planned, prepared, taught and then debriefed after each session as a team. We anticipated that there would be two distinct roles but that we would switch between them, either on a session-by-session basis or within a single session. One of us would "teach" the science content and science education as had been our standard practice. We would demonstrate various ways to diagnose learners' prior understanding about a science topic, model ways to orchestrate rich learning experiences that would challenge those learners to construct new understandings about that science concept and then evaluate whether learners had understood what had been taught. The other person would act as the critical participant observer in the class, keeping a running log of thoughts, observations, questions, and ideas for discussion with the students during the session. As our confidence in each other increased over the semesters that we team-taught, our ability to step into and out of each role became more practiced. Several students made comments about team-teaching being a supportive and collegial way to operate in a classroom. One wrote, "You two seem to work well together and I like the team environment. It creates an excellent learning environment. Please don't change it." (Student feedback, May 2009).

We also debriefed as soon as possible after each session and continued to record and analyse our actions in our journals:

> Instead of latching on to the students with the right answers it was important to probe students' answers—right or wrong to find out what they really meant. For example, when Nathan went on about the salt having sodium in it that ate into the ice, Rena wasn't in a space to let him explain himself further. I tried to make the point [in debriefing with the students] that teaching was more than gathering the right answers and moving on as though that were sufficient evidence that the learners had understood. (Journal entry, April 2009)

Having these discussions in front of the students, either during that debriefing or the following session, enabled them to hear how we had articulated our thoughts and responses to one another, reflecting in action and on action (Schön, 1995).

However, in order to make more time available to discuss teaching matters, we had to pare back the science content that we taught. We omitted a number of content-based activities in favor of drawing the students' attention to teaching

decisions. We were conscious that the students did not necessarily appreciate our intent, even though many appreciated the pragmatic benefits of having two teachers in the class. Comments from the students' evaluation (2009) included that team-teaching made the sessions "disjointed," "led to wasted time," that "it was confusing," and "distracting," but there were also many positive comments: "better, deeper discussions," "different perspectives," "more accessible," "learning about teaching decisions."

When I was in the role of provocateur, the challenge to see behind Rena's skillful teaching act sharpened my appreciation of how effortless teaching seemed when we were acting the role of expert science teacher. I recognized that this was my default position—to be the expert knowledgeable science teacher—so when Rena made public things that I did unconsciously, it was illuminating for me as well as the students.

I thought about the roles Rena and I played when teaching as a team. I had felt inadequate initially because she had a wealth of practical experience to draw on while I had none. By the same token, neither of us had much experience as the provocateur. I wrote that "I was secretly glad that I was teaching because the debriefing side of things is more foreign to us both. Will we spot anything worth drawing to the students' attention?" (Journal entry, March 1, 2009)

When asked for feedback about how they saw our roles at a midpoint in the course, many students commented that we "shared the role and responsibilities equally" and "used our strengths." However, some students saw me as being the "dominant," "intimidating," or "authoritative" one in the team-teaching partnership who "probed for understanding" and saw Rena as the more "approachable one who does most of the teaching" (Student feedback, March, 2009). I did take a different role to Rena because, in the absence of experience teaching science in a primary classroom, I compensated by being more focused on teacher education:

> I don't think I over powered Rena or upstaged her in any way. I am very conscious of the fact that the students normally adore her and that I am seen as a bit more distant. I don't score as highly on the accessibility stakes, Rena is more approachable and knows more than me about the reality of teaching in a primary school. (Journal entry, March 2009)

Instead of modeling exemplary science teaching, I focused on modeling being an inquiring teacher who was intent on improving her learners' experiences. I wanted my students to appreciate that when we cease to explore ways to improve our practice, it becomes routine and formulaic (Clarke & Erickson, 2004). As I wrote in the survival memo, I was learning as much about teacher education as I hoped the students were:

> There is merit in them seeing us wanting to improve our practice and if we can make them recognise that we are doing it as much, if not more, for ourselves as for their benefit, then it might be even more beneficial for the students. (Survival memo, April, 2008)

Team-teaching gave me another lens through which to view my growth as a teacher educator. I learnt about the importance of teaching about teaching rather than science education. The impact of this transformation in my practice carried through to all the other classes that I taught, whether or not I taught in a team-teaching situation or used peer teaching.

Conclusion

My mission is far more complex than I anticipated when, as an experienced and successful science teacher, I set out to become a science teacher educator. I am now resigned to no longer knowing exactly where the sessions are leading or what exactly my students are learning about teaching during my courses. Even though I am confident in my uncertainty, I am cautious when explaining this uncertainty to my students. When I admit to not knowing exactly what I am doing, I know that the more apprehensive or critical student teachers will be quick to criticize that my sessions are not carefully planned or that my learning intentions are not always stated. However, when they question whether they have covered what they perceive as necessary science content, I am more adept at justifying my changed pedagogy. Likewise, with my peers, I challenge whether delivering science education content is what our student teachers need if they are to be confident and competent about teaching science in their own classrooms. Unsurprisingly, not everyone is convinced by my argument, or perhaps they are not yet prepared to give up their hard-won expertise.

I can blame self-study for destabilizing my sense that the role of a science teacher educator should be grounded on teaching science concepts, or I can thank self-study for providing liberating opportunities to develop a new vision of myself as a teacher educator. I am confident that the image I see reflected in the mirror that I hold up to my practice is a true image, not one that is deceptively flattering. I am no longer cocksure like the Emperor, as I was when dressed in my imaginary finery as a science teacher. With the cloak of self-study research firmly around my shoulders, I can now engage in conversations about teaching teachers with my student teachers and peers. I hope that those who read this chapter are similarly inspired and challenged to problematise teaching about teaching.

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Chapter 4
Bridging the Gap Between a Science Laboratory Past and a Science Teacher Educator Present: Rethinking the Doctoral Program in Science Education

Alexandra O. Santau

The lack of clarity surrounding the general purpose of the Ph.D. can be exacerbated by several personal, contextual factors, particularly in a discipline as diverse as education. The focus of this chapter is the tension between what I was being prepared for during my doctoral studies and what was awaiting me in an academic appointment. Bringing the additional baggage of a nontraditional doctoral student in science education from Europe, for whom English is a third language and who only knew the world of science laboratories and not the world of classrooms, my journey ended with the same outcome as those with more traditional backgrounds: A Ph.D. in teaching and learning with an emphasis in science education.

Although the term *science education* implies that both science *and* education are integral to our field, most science teacher educators have only a background in classroom science teaching, so most of their experiences are grounded in the classroom and school context (Dinkelman, Margolis, & Sikkenga, 2006; Labaree, 2004). Future teacher educators generally begin their professional development as classroom teachers, progress through their doctoral preparation, and proceed into the professoriate, with the assumption that a good teacher will also make a good teacher educator (Abell, Park Rogers, Hanuscin, Lee, & Gagnon, 2009; Korthagen, Loughran, & Lunenberg, 2005). However, even those who possess classroom teaching experience often find themselves struggling with what to teach their students about teaching, having had no formal preparation and not necessarily being able to draw upon their classroom experience in their roles as teachers of teachers (Berry, 2008). In a self-study on continuing to improve herself as a teacher educator, Mueller (2003, p. 68) courageously but accurately stated:

> It is widely assumed that if you are a classroom teacher, then you can also be a teacher educator. However, the expectations and demands of the profession are neither well

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> understood nor adequately documented. The pedagogy of teacher educators is very different from that of a classroom teacher. No specific training exists for teacher educators. In general, you simply are "stamped" teacher educator if you get the job.

Despite the lack of explicit attention to teacher educator preparation, "a permanent appointment in a university teacher education program usually requires a doctoral level qualification in education, with successful classroom experience deemed an asset" (Russell, 2007, p. 1204).

Another reality is that few science teacher educators have a background in the science laboratory as working scientists. Because science teacher educators need to be experts in both science content and pedagogy, ready to teach for scientific understanding (Romberg, Carpenter, & Dremock, 2005), it stands to reason that experiences in both the science laboratory *and* the classroom context of some science discipline may be beneficial for a science teacher educator's teaching practice. But to what extent do doctoral programs in science education mold their graduate students to become science teacher educators with such knowledge and skills? Do they effectively account for the myriad of backgrounds doctoral candidates bring into their studies? Moreover, should doctoral programs in science education strive to fill in the gaps based on what is specifically missing among their candidates' experiences?

Although considerable attention has been paid to teacher preparation during the past two decades, little attention has been paid to the preparation of those who prepare teachers (Cochran-Smith, 2003). The wide-ranging challenges of teacher education reform set in universities are very similar to the challenges of educational reform set in schools (Russell, 2007). Just like teachers, what our teaching as teacher educators looks like in practice must be worked out by ourselves, as it is not explicitly taught to us (Feiman-Nemser, 2001). The required backgrounds for teaching in a teacher education context show little to no attention to the "unique differences between teaching a subject to children and teaching professional perspectives on teaching practice to adults preparing for a career in teaching" (Russell, 2007, p. 1204).

It seems quite daunting to configure quality doctoral programs that prepare teacher educators, particularly due to the complex nature of teaching and teacher education, as Labaree (2004) argued:

> Teaching… lacks a valid and reliable technology of instruction, a set of norms of defining acceptable professional practice, clear goals for instruction, clear goals of measuring pedagogical effects, or even a clear definition of the clientele to be served. As a result, there is arguably no realm of professional education that faces a challenge more daunting than the challenge presented to teacher educators. (p. 12)

In addition, there is no commonly agreed sense of the purpose of doctoral studies:

> The composition or "essence" of the Ph.D. needs to be defined. Some members of this sector believe that the Ph.D. is a selective, specialized degree with the singular focus of producing a creative, self-initiating, independent scholar and researcher for academia. Others believe that the degree should produce graduates who can consider an array of options in terms of careers and contribute to society in many ways outside the academy. (Nyquist & Woodford, 2000, p. 8)

In the case of science education, the *Professional Knowledge Standards for Science Teacher Educators* include expectations that teacher educators have a strong science knowledge base; understand science pedagogy, curriculum, instruction, and assessment; and know about learning and cognition, preparation for research, and professional development (Lederman et al., 1997).

The research literature indicates an uneasy relationship between expectations and the lived reality of many novice science teacher educators (Abell et al., 2009; Fagen & Niebur, 2000; Nyquist & Woodford, 2000). Through surveys of doctoral students in different fields, Fagen and Niebur found that respondents felt their doctoral programs to overemphasize research but to insufficiently prepare them for teaching and other demands related to academic appointments. Similarly, Brown, Davis, Fagen, Niebur and Wells (2001) found that respondents to their survey felt they had received insufficient preparation as teaching assistants and lacked mentoring to improve their teaching. Despite doctoral programs generally expecting their graduates to be able to teach methods courses and supervise student teachers, few require their students to be involved in specific courses or activities related to teacher education (Jablon, 2002). Furthermore, according to Jablon:

> Even though 100% of the doctoral program heads expected their graduates to be able to teach methods courses and supervise student teaching (96% expected proficiency at inservice workshops), only 34% required their graduates to be involved in a mentored teaching of a methods course, student teaching, or inservice workshops. Forty two percent said the students could do this as an elective and 24% said their graduates had no opportunity to be mentored in any of these skills. (p. 17)

These reactions are not unanticipated when considering that the standards for science teacher educators do not address "a critical aspect of what science teacher educators should know: how to teach future science teachers" (Abell et al., 2009, p. 78).

The "Whats" and "Hows" of Science Teaching

It would be ambitious to assert that the whats and hows of science teaching can be portrayed succinctly but accurately, and without compromising important elements. Nonetheless, a degree of consensus has been reached within the science education policy, research, and teaching community. In a nutshell, those who have gone through a doctoral program in science education, written a dissertation in science education, or have tried their luck as scholars in science education have likely internalized the modern fundamentals of science teaching. In the United States, we are aware of national and state standards and countless publications, unanimously emphasizing science content knowledge, scientific inquiry and understanding, and nature of science (NOS) (American Association for the Advancement of Science, 1989, 1993; Blanchard et al., 2010; Kennedy, 1998; National Research Council, 1996, 2000, 2007; Romberg et al., 2005). In the aftermath of a science reform movement, we generally believe that science

should be taught as an inquiry approach to achieve scientific understanding, employing minds-on and hands-on approaches, conveying deep and complex understandings of science concepts, connecting science topics while thinking like scientists, and applying science concepts to explain natural phenomena, all while moving away from traditional habits of presenting science as a collection of unrelated facts, deposited into students' minds through repetition and recitation (Abrams, Southerland & Evans, 2007; Gess-Newsome, Southerland, Johnston, & Woodbury, 2003; Kennedy, 1998; Lee, Luykx, Buxton & Shaver, 2007). In other words, we have a general idea of *what* to teach.

The challenging part for science teacher educators is that we are expected to teach teacher candidates *how* to teach science to students of various ages, levels, and linguistic and cultural backgrounds. The construct of pedagogical content knowledge (PCK), defined as the "knowledge of the representations, analogies, and strategies useful for teaching a particular topic, as well as knowledge of students' ideas about a topic"(Lee & Luft, 2008; Shulman, 1986), can theoretically come to the rescue during the *how* struggle of science teaching. Its development and implementation, however, are often nebulous to science teacher educators, especially in cases where we were never quite shown how to "do it" during our doctoral training.

When considering how to prepare science teacher educators, Abell et al. (2009) contend it is necessary for doctoral programs to address a parallel form of PCK in order to teach future science teacher educators the "hows" of science teaching within the context of preservice teacher preparation. While this seems obvious, doctoral programs apparently ignore that "science teacher educator's PCK includes his or her knowledge about curriculum, instruction, and assessment for teaching science methods courses and supervising field experience, as well as his/her knowledge about preservice teachers and orientations to teaching science teachers" (Abell et al., 2009, p. 79). Like preservice teachers, teacher educators undergo a professional continuum that progresses through the doctoral preparation and continues through their academic appointments. With this in mind, the authors propose that doctoral students move through phases of their career and participate in five learner roles as they progress in their professional continuum, which define a trajectory in developing PCK for teaching teachers. From the beginning through the end of the doctoral program, a student moves through the stages of observer, apprentice, and partner. Since not all students enter a Ph.D. program with the same background, it is important for them to observe veteran teacher educators teaching methods courses. Doctoral students need experiences beyond observation; they need to have apprenticeship experience in order to learn and study their practice with the help of a veteran science teacher educator. Through a partnership with a veteran teacher educator, the student and the mentor can together develop aspects of PCK as a team. Whether still in the doctoral program or as a new faculty member, the next phase is to assume the role of an independent instructor of a science methods course. Upon entering the professoriate, the final step is to mentor new doctoral students who will in turn enter the continuum.

Issues Being Addressed

Beyond the wide-ranging issues identified in the literature, this chapter was motivated by my own experiences seeking out a tenure-track position upon graduating with my Ph.D. in teaching and learning with emphasis in science education. It seemed to be tacitly presumed—and sometimes explicitly required—that applicants had prior experience as classroom science teachers. I lacked this experience and became troubled that I might not meet the needs of science framed by the social and cultural context of elementary and secondary schooling (Appleton, 2007). Unlike Ritter (2007), an early-career teacher educator who described his need to reinvent himself as a teacher educator by drawing back to his classroom teacher identity as a source of expertise, I did not have anything other than my doctoral program, my limited experience as a biology instructor, and my laboratory experience to draw upon contexts that I briefly describe later. These uncertainties raised questions about the extent to which my doctoral program prepared me to be a science teacher educator: Was I doomed because I did not have classroom experience, or did my doctoral program help bridge the gap between my laboratory past and my science teacher educator present? Would I agree with Abell et al. (2009), who claimed that doctoral programs do not teach Ph.D. students how to teach science teachers? Specifically, this chapter is organized around the following three questions:

1. How did my doctoral program prepare me to be a science teacher educator?
2. How did my doctoral program prepare me to be a researcher/scholar?
3. How can self-study contribute to my continuing professional development as a science teacher educator?

To gain insights into the degree and quality of preparation of my doctoral program, I frame this chapter around autobiographical accounts of two main components: my doctoral course work and my responsibilities as a graduate research assistant. In describing and interpreting my recollections related to my doctoral preparation, I focus on five of nine guidelines that help foster the quality of an autobiographical self-study, as suggested by Bullough and Pinnegar (2001). First, I hope to connect with others by "ringing true and enabling connections" (p. 16). Second, this self-study "promotes insight and interpretation" (p. 16), as I describe and interpret "nodal moments" that I consider significant in providing answers to my questions. Third, I "engage history forthrightly and take an honest stand" (p. 16). Fourth, this self-study focuses on "the problems and issues that make someone an educator" (p. 17). Finally, I "have an ineluctable obligation to improve the learning situation not only for the self but for the other" (p. 17). I then connect my experiences as a graduate student with my teaching and research as a junior faculty member and reconsider to what extent my doctoral preparation compensated for the apparent shortcomings in my background. Lastly, I discuss how I can continue to analyze my teaching practices and improve them by engaging in self-study.

Cultural and Educational Background

Born in Romania to middle-class European parents, I attended kindergarten and elementary school in the Romanian school system. Romanian is my native language. At the age of 10, my family and I moved to Germany, where I attended school from fifth through thirteenth grade. I learned German through complete immersion, along with taking English and French throughout middle and secondary school. Following secondary school, I moved to the USA and completed a bachelor's degree in microbiology, a master's degree in biology, and a Ph.D. in science education.

Upon completing my master's degree in the biological sciences, I worked as a research associate in a cancer research laboratory at a Midwestern medical school. Once I realized I would rather spend time with people than microorganisms, I took an opportunity to teach introductory anatomy, physiology, and biology courses at postsecondary institutions. To my surprise, teaching felt like the clichéd "calling" that I now intended to make a permanent part of my professional life. Teaching without any formal training in education also raised a plethora of questions concerning how people learn science, why sciences are perceived as difficult subjects, and why there are so many misconceptions about science. I was determined to connect my old passion for science with my newfound passion for education and to pursue answers to these questions. Luckily, I found exactly what I thought I was looking for: a marriage of the two through a discipline called science education. With mixed emotions to swap my world of "hard and pure" knowledge for one that is "particularly soft and applied" (Labaree, 2004), my new interests pushed me toward a Ph.D. program in science education. I must admit that, beyond hoping to find answers to the questions stated above, I did not have prior knowledge of the actual structure of the program, nor of the faculty involved, and I knew even less about what would follow upon completion. I was accepted and recruited as a graduate assistant by a highly regarded professor, researcher, and scholar who was the principal investigator of a multiyear, government-funded research project involving teacher professional development focusing on promoting science to English language learners in urban elementary schools. I blindly accepted the offer and was thrilled to be admitted into the program, although it took rather a long time before I internalized what I had "signed up for."

Doctoral Program in Teaching and Learning with Emphasis in Science Education

The entire program, yielding a Ph.D. in teaching and learning with emphasis in science education, took 4 years to complete. My coursework consisted mainly of research statistics courses, methods courses, and courses focusing on teaching and learning, curriculum, and assessment, which is consistent with most doctoral programs in education (Jablon, 2002). The first 2 years were comprised of coursework, followed by qualifying exams. Throughout the program, candidates

were involved in research activities that were part of a graduate assistantship. A graduate assistant (GA) was expected to conduct 20 h of research a week in order to be exempt from university tuition and to get compensated for GA duties. I did not have a teaching assignment as a teaching assistant, I did not co-teach any undergraduate or graduate courses, and I was not involved with teacher candidates' field or student teaching experiences. Essentially, I had no contact with undergraduate or graduate teacher candidates throughout this program. Since advisors tailored programs of study to reflect the individual needs of each doctoral student, the rationale for my lack of teaching assignment was that I had already taught science at postsecondary institutions. My advisors agreed that additional teaching would not benefit me any further—a conclusion that was supported by my former favorable teaching evaluations as a biology instructor—but that immersing me in what I lacked—educational research experience—was central in preparing me as a future faculty member in science education.

Coursework

There were three central foci of the coursework, as depicted in Table 4.1: (a) teaching and teacher education (such as teaching and learning, curriculum, and assessment in mathematics and science), (b) research (such as quantitative and qualitative research methods courses), and (c) statistics. Other courses, although not as numerous, focused on general teacher education, diversity, or science content. In the total of 87 credits, 12 were dissertation credits.

The format of the courses differed based on their nature.

> If conventional models emphasize teaching as telling and learning as listening, reform-oriented models call for teachers to do more listening as they elicit student thinking and assess their understanding and for students to do more asking and explaining as they investigate authentic problems and share their solutions. (Feiman-Nemser, 2001, p. 1015)

Consistent with this statement, courses within my major were taught by education faculty in mathematics and science education and were therefore taught following reform-oriented methods, including projects, discussions, and critiques of scholarly papers. Assignments comprised mainly reflection papers, with a final project usually involving a comprehensive literature review on a chosen topic. Research methods and statistics courses were generally taught following conventional lecture formats, with assessments in the form of summative (mostly open-ended) midterm and final exams. The courses in diversity included students from a variety of majors, not just education. They also focused on group discussions, presentations, and literature review assignments. I was required to take one graduate-level science content course, which I was able to select based on my preference. Although it seemed that one science course would not be significant in my program of study, I presume that my advisors suggested it in order to make more explicit the focus on science education as opposed to mathematics education.

Table 4.1 Courses comprising the doctoral program

Courses in major	Courses in teacher education	Courses in research	Courses in discipline	Courses in diversity	Doctoral dissertation
Teaching and Learning in Mathematics and Science	The Teacher in American Society	Introduction to Research Methods	Neuroscience I	Social Analysis and Race Relations	Dissertation
Mathematics and Science Curriculum	Pro-Seminar	Program Evaluation		Class Structure and Society Stratification	
Assessment in Mathematics and Science		ANOVA		Issues and Trends in Multicultural Education	
Research Seminar in Mathematics and Science		Regression			
		Qualitative Methods I			

Qualifying Exams

Once I completed my coursework, I had to take qualifying exams, as in most doctoral program. However, the format of my qualifying exams was atypical. I had the choice between traditional exams involving a half-day of answering questions written by faculty who had taught me up to that point and completing a portfolio reflecting my activities as a graduate assistant in the research project I worked on. I recall the rationale for offering this choice being that because my professors tried to support reform-oriented teaching practices, they also wished for those practices to be reflected in what was asked in qualifying exams. I chose the second option, the portfolio. While I do not know the specific nature of my fellow doctoral students' portfolios, my advisors explained that each student's portfolio questions were individually tailored to each student's involvement in the research project. In my case, there were three major areas I was asked to complete based on my activity as a graduate assistant on the project:

1. Explicate the conceptual framework underlying the project curriculum and teacher professional development through providing relevant literature, reflect on your insights, and provide examples to support your claims. Address issues of student diversity. Based on relevant literature, critique the project in terms of strengths, limitations, trade-offs in the decisions being made, and suggestions for improvement.
2. Explain the construction of science assessment instruments for the project. Describe the process involved in the construction of the instruments, field-testing, revision, and scoring of student responses. Provide relevant literature and examples to support your claims. Address issues of student diversity.
3. Review a manuscript that is submitted for publication consideration in a science education journal, such as the *Journal of Research in Science Teaching* or *Science Education.* Your academic advisor will contact the editor(s) of one of the journals to obtain a manuscript for your review.

Research

Being approached by my major professor to be part of her research project turned out to be a lucky and uncommon event that was to shape entirely my years as a doctoral student. Given that the program took place at a research-intensive institution, the key commitments of my supervisor and other committee members were to research and scholarship. Consequently, being in this position made my experience as a doctoral student an intensely research-driven one, as is often the case with doctoral programs (Abell et al., 2009; Fagen & Niebur, 2000; Jablon, 2002). In addition to taking courses, I worked 20 h each week on the research project. During the summer semesters, when I was not taking courses, my major professor hired me full-time to maintain a continuum between the research tasks during the semesters and to take full advantage of time to conduct data analysis. Through my graduate assistant assignment, I cultivated a wide range of practical research skills that led to leadership

roles in test and curriculum development, data collection, and teacher professional development, which ultimately translated into coauthoring a journal article and a book chapter, in addition to serving as data sources for my dissertation:

- The first opportunity to take leadership involved the invitation to be a coauthor of the life science portion of the fourth grade curriculum unit used as part of the research project, called "Processes of Life." I helped write inquiry activities, science content, and assessments for the student booklet and teachers' guide. This work included organizing science supplies for the unit activities. Additionally, I was involved in the revision of two other fourth grade curriculum units.
- A second major opportunity to take leadership involved conducting workshops with fourth grade teachers across all fourth grade curriculum units (in addition to "Processes of Life," there were also "energy" and "force and motion" units). Although I did not have an official teaching assignment, I had the opportunity to teach the content and pedagogy of these units to inservice elementary teachers who participated in the project as part of their professional development. After about 1 year on the project, I was given the freedom to plan and organize all workshops for fourth grade teachers.
- A third major opportunity to take leadership involved taking primary responsibility for data collection and analysis with fourth grade teachers (and some with third and fifth grade teachers), including classroom observations, postobservation interviews with teachers, and reasoning interviews with teachers and students. An important aspect of my involvement with data collection was that I gained exposure to urban elementary schools with linguistically and culturally diverse student populations and witnessed the underpinnings of school life in the USA. I interacted with American principals, teachers, students, and school support staff for the first time in my life.
- A fourth major opportunity to take leadership involved playing key roles in science assessments (pre-/posttest) of fourth and fifth grade students, including the development, field-testing, revision, and scoring. I also participated in the development of fourth grade students' reasoning interview instrument, another branch of the project. Additionally, for some time, I was responsible for pulling data from the district office, which to some extent exposed me to the "behind the scenes" of educational administration.
- Finally, all of the above activities led to invitations by my major professor to coauthor a manuscript on teacher professional development and a book chapter on student assessment. Both manuscripts were under review for publication while I was a doctoral student. My leadership with fourth grade prompted my advisor to grant me access to data I had collected and to write about it as I wished, which extended well into my first 2 years as a faculty member.

Dissertation

My dissertation topic, *Elementary Teachers' Knowledge and Practices in Teaching Science to English Language Learners*, emerged from interests motivated by my

involvement in the research project. I used data I collected through classroom observations, postobservation interviews, and surveys that grew into a cohesive document employing quantitative and qualitative methodology to gain insights into the topic of interest. My committee members and my major professor showed remarkable support and guidance in preparing me for all steps involved in the dissertation process, and especially for my dissertation proposal defense and my final dissertation defense. With the amount of support I received, I passed it without requiring any revisions to the final document. The entire dissertation process took about four semesters to complete.

How Did My Doctoral Program Prepare Me to Be a Science Teacher Educator?

As a new doctoral student, I brought my experiences acquired in the past: my science content knowledge from my undergraduate and graduate studies in the "hard sciences," my connection to the scientific research world from working in a science laboratory, and my teaching experience as a biology instructor. It might seem as though I had adequate science content knowledge, although doubts enter my mind when I reflect on how I was taught science. Prior to the reform movement in science education, it is safe to assume that most of us were taught science by traditional, noninquiry-based methods and thus by educators who were not familiar with inquiry methodology and PCK. We received science content through the conventional view of its transmission as propositional knowledge (Loughran, 2007). Prior to my doctoral program, my professors were scientists and not educators. Considering Abell et al.'s (2009, p. 79) point that "knowing science is a necessary but not sufficient condition for teaching" it is a worrisome but logical conclusion that we, now considered content experts who according to Lederman et al. (1997) theoretically meet an important professional standard, might not have in fact learned scientific content either. We might have been taught "incorrectly."

Coursework

The wide variety of coursework provided a strong theoretical foundation for me as a science teacher educator, especially since I had commenced my doctoral study lacking any background in education. Reading many scholarly articles, book chapters, and books helped me gain an understanding of the required topics and to develop a sense of associating prominent scholars with their particular areas of expertise. Most of my courses were taught by experienced educators who employed reform-based teaching methods, so I see now that being in their classes aided me in developing my own PCK through the perspective of a master/apprentice relationship (Abell et al., 2009). Through my professors' different discussion strategies of the assigned readings (e.g., students discussing in small groups before presenting to

the whole class, creating outlines, or debating topics), I also gained a unique perspective from which to observe their instructional strategies in these courses. Through the lens of course preparation, my doctoral program equipped me with the theoretical underpinnings of educational theory and practice relevant to teaching and learning, curriculum, assessment, and research.

Teaching

As I, like many other doctoral students, did not have a teaching assignment of any kind, I did not have an opportunity to develop PCK through these means. I was not involved in co-teaching or teaching a science methods course, did not have an opportunity to observe professors who taught science methods courses to preservice teachers, and was not involved with preservice teachers' field or student teaching experiences. My mentors did not share with me the strategies of planning science methods courses. Once I was invited as a guest speaker to teach a session on life sciences as part of a methods course taught by my advisor, and I was allowed to plan the session on my own terms. This situation, while again common among doctoral programs (Jablon, 2002), raises a very important issue, as Nyquist and Woodford (2000) pointed out:

> Lack of pedagogical training means that new faculty are not prepared to teach today's students at these colleges and universities. The main preparation for new faculty has been teaching assistantships, so they are limited in their teaching repertoire by the nature of their particular assignment… often without supervision or adequate mentoring. (p. 10)

If I simply considered the lack of exposure to teaching, my doctoral program only minimally would have prepared me to be a science teacher educator. I did, however, have the opportunity to design, plan, and teach professional development workshops to experienced teachers several times a year. These experiences exposed me to interacting with adults who were already teachers and who indirectly shared their and their students' perspectives about science and science learning with me. I value this experience for its insights into the world of urban elementary schooling, as I became aware of the many challenges such teaching entails. Through exposure to teaching inservice teachers, my doctoral program did prepare me to be a science teacher educator in an alternative yet equally valuable way.

Involvement with Field/Student Teaching Experiences

To a degree, science teacher educators are responsible for establishing a connection between the theoretical aspects of teaching and learning discussed during methods courses and practical aspects of teaching and learning that emerge during teacher candidates' experiences in the field. Unfortunately, my doctoral program was not designed to involve me with field or student teaching experiences. This calls certain issues into question, as "the general structure of doctoral programs was even questioned by K-12

educators, who maintained that "few doctoral programs recognize how the "wisdom of practice" can inform theory" (Nyquist & Woodford, 2000, p. 12)."

I could easily interpret this lack of field involvement with being denied exposure to schools, especially since my cultural, linguistic, and educational background—being largely outside of the USA—required specifically that I became familiar with the American school system. My future profession—someone who would teach and mentor future science teachers—required that I understood the requirements and expectations of a future science teacher. At a closer look, however, I gained ample exposure to schools through my involvement in the research project. Through data collection activities in the form of classroom observations, teacher interviews, and student interviews, I was able to spend generous amounts of time in schools. I was able to interact with principals, teachers, and students perhaps in a different way than one would during field or student teaching experiences. Therefore, although through alternative ways, my doctoral program *did* expose me to school contexts I had not at all experienced prior to my involvement in the research project.

How Did My Doctoral Program Prepare Me to Be a Researcher/Scholar?

When I applied to the doctoral program, I did not anticipate the duties and tasks that awaited me as a graduate assistant. I was entirely in the dark as to what I would be doing, how much I would be doing, and how anything I would be doing might link to my final product, a Ph.D. in science education. This lack of realistic expectations ensued from two major aspects. First, I was transferring from the world of laboratory science that seemed utterly unrelated to the world of education. Even my teaching years in 2-year colleges seemed only marginally connected to elementary or secondary education and certainly to teacher education. Second, my precollege educational experience took place outside the United States, which rendered the world of American education foreign to me. Moreover, I also had little insight into the actual expectations of a university faculty member, and this also crystallized as a central concern among doctoral students in a survey about Ph.D. programs (Nyquist & Woodford, 2000). Thankfully, my advisors seemed to be well aware of the context they were preparing me for, as it is known that "in the case of a teacher educator holding tenure, training in educational research is essential" (Russell, 2007, p. 1204).

Coursework

Reading such a wide variety and number of scholarly research papers, although theoretical, laid an important foundation in understanding research and scholarship. The initial exposure to articles taught me the general formats of scholarly work.

The subsequent discussions and critiques of articles deepened my knowledge of research methodology and how to pinpoint strengths and weaknesses of research studies. With increased experience through taking research methodology courses, I gained practice in conducting my own research in the future. Practice in writing literature reviews did not seem essential at the time but proved important during the dissertation process and beyond. The seminar that expected us to have a publishable manuscript upon completion taught me the step-by-step process of writing a research article. My qualifying exams—reviewing a scholarly paper for a major journal—further added to acquiring a better sense of the publishing world, one that is quite foreign to an inexperienced doctoral student. All in all, the courses in my major, research methodology, and statistics, along with the research seminar, laid the essential groundwork for better understanding research and moving toward the world of scholarship.

Research

My doctoral program was intensely research-driven (a reality many doctoral programs are criticized for), but I am unsure about what the term *research-intensive* means when applied to doctoral programs. Is a research-intensive program one that involves a plethora of research courses? Or is it one that requires the doctoral students to be involved in actual research activities. My program met both criteria. Though my involvement on the research project, I performed a wide variety of data collection, analysis, instrument and curriculum development, workshop planning and teaching, and more. Getting to know the organization of a research project to such an intricate level has been invaluable in preparing me to be a researcher. Coauthoring a journal article and a book chapter was important in exposing me to the world of scholarship and publishing.

Mentoring/Advisor Support

Although it seems common for doctoral students to feel that there is a lack of quality in mentoring and support from their advisors (Nyquist & Woodford, 2000), I was fortunate to have an extremely close relationship with my major professor. She guided me through every phase of my doctoral program. Based on my performance and initiative, she gauged the degree to which she trusted me with leadership positions as part of her project. The more I was willing to accept leadership, the more opportunities to which she granted me access. Unlike many other doctoral students, I had explicit and concrete direction, consistent and frequent performance feedback through semester evaluations, as well as emotional support and encouragement. I certainly viewed, and still view, my major professor as an academic mother and an advisor regarding academic matters. My other committee members were also very

supportive and available if I needed their guidance. Many of them even attempted to offer me insights into the lives as faculty members, explaining to me the responsibilities that came with the territory upon graduation.

How Can Self-Study Contribute to My Continuing Professional Development as a Science Teacher Educator?

Had I had a clearer idea of what was ahead in my professional career, I would have already begun to reflect upon my experiences as a doctoral student. I failed to do so simply because I was unaware of the field of self-study and how engaging in it could help me to understand, enhance, and share my development as a science teacher educator, even early on. Upon graduating from my doctoral program, I felt confident and well prepared as a science teacher educator and scholar, which left me with few concerns about my new profession and its new contexts.

My false sense of security began to crumble when I, as a new tenure-track faculty member, was rather challenged by balancing new responsibilities, much like many others at the early professorial level (Bullock, 2007, 2009; Dinkelman et al. 2006; Ritter, 2007, 2009). Early in my professional career, I noticed elements of my job for which my doctoral program did not or could not have prepared me. Had I had enough opportunities to develop the PCK of a science teacher educator, which, according to Abell et al. (2009), is a parallel rather than identical form of the PCK of a science teacher? Did I possess a basic understanding of the structure of field experiences and student teaching? I slowly became uncertain to what extent my doctoral training prepared me to teach teachers, which is consistent with the general picture summarized by Wilson (2006, p. 315): "Not… many scholars of this new generation have opportunities to learn to teach teachers in structured and scholarly apprenticeships; instead they are thrown into the practice of teacher education." I also noticed that the responsibility of my teaching was up to me and was to remain that way, as neither new nor senior faculty received ongoing professional development support in teaching teachers beyond support to attend conferences (Zeichner, 2005).

I had to scramble for ways to take a careful look at my teaching, and I began to investigate aspects of my professional self. By discovering and engaging in self-study as a junior faculty member, I realized that my knowledge to teach teachers would continue to develop well beyond the doctoral program as I continue to analyze my teaching. It seemed that self-study was suitable for those who want not only to improve their teaching practices and views on these practices but also to develop them in the first place. Would self-study help me further teach myself how to teach? The following comments rang true to me:

> Learning from experience is particularly complex for teacher education, especially in establishing qualifications for those who teach new teachers… Schools and universities are inclined to present theory before experience and to assume that students will make connections between the two as they gain experience. (Russell, 2007 p. 1204)

Self-study revealed itself as an avenue to "yield knowledge about practice" (Dinkelman, 2003, p. 9). Unlike Russell (1997), who through his physics methods course aimed to make his knowledge and practices more accessible to his student teachers, I engaged in self-study to explore deeper insights into my personal views, knowledge, and teaching practices as a science teacher educator within the perspective of science teacher as a learner (Chin, 1997; Loughran, 2007). Self-study helped pave the way for me, as a science teacher educator, to develop professionally in ways that I could not have identified had I not made myself aware of my thoughts related to my teaching practices (Schön, 1983). It also became important to explore how, through the lens of self as researcher and researched, my vulnerabilities and tensions as a new science teacher educator played a role, both professionally and personally (Berry, 2008; Hamilton, 2004). Essentially, I chose self-study because "the role of self in a self-study project is less about looking at the self than it is about looking at what is going on between self and practice" (Tidwell & Fitzgerald, 2004, p. 75).

In my second year as a faculty member, I began collecting data through observations and analyses of an elementary science methods course. While not the focus of this chapter, my self-study that used classroom observations and reflections as data sources revealed that, while my cultural and educational insecurities did not explicitly crystallize in my observed instruction, I expressed concerns about my ability to guide teacher candidates because I still felt somewhat unfamiliar with the school system, despite my exposure during graduate school. The following is a brief illustration:

Data source: Self-reflection
Subject: Educational background
Date: November 15, 2009
At least those who went to school here know what school is like here, even if they've never been teachers. They went through it as students; they know how things work… I don't even have that experience. I don't know how things work here [in the U.S.], not well enough to be able to relate to it….Over and over again, I think that I really don't know the life a classroom teacher lives. I don't know the typical sequence of their day. I know the typical sequence of a teacher in Germany, but not here.

My doctoral program prepared me for many aspects of being a science teacher educator. Yet it was left to me to develop my identity as a teacher educator, especially given my unique personal and educational background and also the potential missing pieces of my doctoral program specifically concerned with the preparation of a science teacher educator. I have been using and will continue to use self-study for the ongoing development of this identity, as this quotation suggests:

> Self-study researchers seek to understand their practice settings… study research from other methodologies for insights into their current practice, thoughtfully consider their own background and contribution to this setting, and reflect on any combination of these avenues in their attempts to understand. (Pinnegar, 1998, p. 33)

Self-study will help me fortify my future practices not only through investigating my professional self but also through sharing vulnerabilities and uncertainties in my practices (Bullough & Pinnegar, 2001).

Conclusions and Future Considerations for Doctoral Programs

This chapter provides insights into how a doctoral program in science education prepared one individual to become a science teacher educator and a researcher/scholar, although it is by no means intended to generalize to other persons in the same or other doctoral programs. Self-study has been serving and will continue to serve as a professional development tool in developing my identity as a science teacher educator. From autobiographical accounts of nodal moments that occurred during the course of my doctoral program, I was able to identify four clusters of broad conclusions leading toward insights to the three questions posed at the beginning of this chapter.

1. My coursework and the associated projects theoretically enhanced my understanding of educational issues, although there was no explicit emphasis on learning about science teacher education. Due to the lack of a teaching assignment, I did not receive specific preparation in or mentoring of my teaching skills, consistent with studies conducted on this topic (Brown et al., 2001; Fagen & Niebur, 2000; Nyquist & Woodford, 2000). However, and more importantly, through alternative avenues such as conducting teacher workshops and collecting data in schools, I gained teaching experience and familiarity with the school systems.
2. Due to the intense involvement in and emphasis on research as a graduate research assistant, my program included many facets that were highly beneficial in preparing me for a university research position, although some might interpret this as an overemphasis on research and falling short of other important elements of an academic career.
3. Self-study can provide me with opportunities to bridge what my doctoral program could not prepare me for and what my faculty appointment requires and to continuously help me to improve my professional self as a learner through reflective practice (Chin, 1997; Loughran, 2007).
4. The nature of my doctoral program exposed me to the importance of cultural and linguistic diversity, an aspect that has been engrained in my consideration of issues in my teaching and research.

An important focus of this chapter has been the nature of my preparation for a Ph.D. in science education. Several questions arose in analyzing the conclusions that emerged: Are we as science teacher educators actively and purposefully taught how to teach future teachers? Are we truly qualified to be teachers of those whose main job will be to be teachers? Goodlad (1990, p. 265) stated: "Teachers teach as they observed and experienced teaching in schools, colleges, and universities during 16 or 17 years of attendance." Thus, I am someone whom teacher candidates may emulate once they have their own teaching assignments. Am I qualified to be emulated?

Although doctoral programs, whether in science education or other disciplines, vary in the nuances of preparation, research literature suggests that they often lack explicit attention to developing future teacher educators (Abell et al., 2009; Jablon, 2002). A series of assumptions appears to drive the path of a doctoral student who enters academia and who is, by default, expected to teach teacher candidates without

explicit attention to preparation for the role of teacher educator. Russell (2007, p. 1203) offered the following comments:

> For most, if not all [teacher educators], "teacher education" is a second and subsidiary discipline. In many instances, teacher education itself is not the primary research interest of individuals who teach preservice teachers. Many individuals who teach preservice teachers have prior, often highly successful, experience as teachers in primary and secondary schools. Preservice teacher candidates understandably credit recent, relevant, and successful experience as an important element of their professors' backgrounds. These assumptions about teacher educators remind us that it is easily taken for granted within the domain of teacher education that successful personal classroom experience is not just necessary but also sufficient preparation for the task of teaching pre-service teachers.

I suggest that the design of doctoral programs should pay close attention to the individual backgrounds of students—personal, educational, professional, cultural, and linguistic. Just as we do not consider science students to be blank slates but as individuals who bring prior knowledge that we seek to develop, so we should not consider doctoral students to be blank slates. Doctoral programs should not follow a one-size-fits-all model but should consider students' unique needs. In any type of doctoral program, students can augment their preparation by being active smiths of their own development as teachers or researchers by engaging in self-study, both during their studies and after completion. The insights of self-studies can serve as powerful tools, not only to inform oneself, but also to help others who might consider themselves in similar situations.

Explicit attention should be paid to guiding doctoral students toward awareness of their future practices, as it is often left to them to figure out their teaching as they go. There have been some suggestions for addressing this missing component of many doctoral programs, whether in general or in science education. In an effort to better prepare future science teacher educators, I concur with the conclusion of Abell et al. (2009) that including a parallel form of PCK for science teacher educators, grounded in Shulman's (1986) work, is an essential component of doctoral programs in science education and the *Professional Knowledge Standards for Science Teacher Educators* (Lederman et al., 1997). This should include opportunities to gain knowledge and experience of curriculum, instruction, and assessment related to teaching methods courses, as well as knowledge of science teachers' understanding of science and science teaching.

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Chapter 5
Articulating Our Values to Develop Our Pedagogy of Science Teacher Education

Stephen Keast and Rebecca Cooper

Self-study of teacher education practices has emerged in the past two decades as one way in which teacher educators can research the dilemmas, tensions, and contradictions in their own practice in order to develop deeper understandings of teaching and learning about teaching. Self-study offers an entry point for seeing one's own practice through the eyes of another (Loughran, 2004). Self-study is also about observing practice from another's perspective, as Brandenburg (2008) asserts that it requires the views, opinions, and perspectives of someone other than the self in order to question the tacit nature of practice and make it explicit. Often this includes sharing data with a significant critical friend. It is through the perspective of the other that the tacit knowledge of personal practices is scrutinized and professionally challenged (Loughran & Northfield, 1998).

The opportunity to make explicit the tacit ideas of teaching preservice science teachers and the values they take into their teaching, both for ourselves and our preservice teachers, is at the heart of the work presented in this chapter. Self-study provides a framework to move thinking beyond the technical considerations of teaching about teaching to the pedagogical reasoning underlying the teaching. These reasons lie at the core of the values of science teacher education pedagogy and the inevitable desire to improve teacher education practices (LaBoskey, 2004).

We have been fortunate to research our practice together for several years, leading to insights into our practice as well as that of the transition from teacher to teacher educator (Cooper & Keast, 2008). Our studies have helped us to better articulate our practice (Keast & Cooper, 2011) and to develop and refine our understanding of our pedagogy of teacher education. The study reported in this chapter is based on the self-study research of our shared teaching of the general science unit at Monash University during one semester of a preservice teacher preparation program.

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The general science unit is conducted in second semester as a common unit in both the 1-year Graduate Diploma of Education and the final year of the Bachelor of Science/Bachelor of Education double-degree program.

Preservice teachers enrolled in the unit have studied science at university and are preparing to teach secondary school science at junior high school level. There are two 3 hour classes of general science each week during semester 2 that take the form of a tutorial or a workshop. The classes are held in the morning and afternoon of the same day, and this study is based on our teaching of those classes. In the past, we each taught our own class while the other observed, although the observer would often contribute when an opportunity has emerged to add to the understanding of the preservice teachers. It seemed a natural transition to begin team teaching. Team teaching has meant that one teacher educator could observe the other teaching and then unpack the purposes of the teaching for the preservice teachers in the moment. This was done to make the teacher educator's thinking about teaching explicit to the preservice teachers.

When unable to properly explain his practice to a colleague, Mitchell (1999) became aware of his tacit knowledge of practice and how much it was taken for granted. By sharing the planning, teaching, and assessment associated with each class and by observing each other teach, we, like Mitchell, were confronted by the tacit nature of our knowledge of practice. Following on from what Loughran (2004) identified as the purpose of self-study of teacher education practices, our research into our own teaching was driven by a desire to better understand the relationship between teaching and researching practice and thus a better understanding of ourself, teaching, learning, and the development of knowledge of teaching about teaching. In a similar vein, Korthagen (1995) suggested that, for teacher educators, self-study brings together scientific research on education and the teacher educator's world of practice in a way that generates better understanding of practice, leading to improvements in preservice teachers' learning about teaching. Just as Brandenburg's (2008) purpose for her self-study was for preservice teachers to better learn about teaching through their experiences as both a learner and a teacher, so too we embarked on this shared adventure in learning about teaching. In contrast to Brandenburg and other self-study researchers such as Berry (2007), who worked on their own in their classrooms, we had the advantage of sharing all aspects of our practice together. While self-study is inherently about the study of one's own practices, it also requires an alternative perspective to challenge the tacit knowledge of the self. By working together, we were able to experience, intercede in, and create critical incidents (Tripp, 1993; Woods, 1993) that were the basis of many powerful learning experiences for our preservice teachers and us. In this way, the preservice teachers were able to make the most of the teachable moments (Loughran, 2002; van Manen, 1990) that arose in our teaching about science teaching and our preservice teachers' learning about science teaching.

This chapter is based on the research into our teaching together and the inherent values of science we were conveying to our preservice teachers through our practice. We were confronted by what Whitehead (1993) identified as "living contradictions" and chose to challenge the assumptions that stood out for us in our teaching of our general science classes. We found ourselves asking whether or not our preservice

teachers were identifying with the values we assumed we were espousing. To aid in that exploration, we were also able to draw on alternative perspectives on a range of pedagogical situations through the views of a critical friend (Schuck & Russell, 2005) who was a nonteaching participant observer for our classes.

This chapter outlines our self-study research as teacher educators investigating our general science teaching in the preservice teacher preparation at Monash University. The chapter does so by presenting two episodes during which we investigated whether or not the values of science we attempted to promote were (or were not) being recognized by our preservice teachers. This chapter captures the essence of our learning from the research into those experiences. Before going any further, however, we first consider some of the important aspects of values in science and the development of pedagogical knowledge that have been important in shaping our views of our developing pedagogy of teacher education.

Values of Science

Having completed some research on our practice as teacher educators, we realize that the values we hold greatly influence what happens in our classroom (Hildebrand, 2007; Pajares, 1992; Ratcliffe, 2007). The term *value* does not have a definition that is agreed upon. For purposes of this research, we use the term values to "refer to principles, fundamental convictions, ideals, standards or life stances which act as general guides to behaviour or as points of reference in decision-making or the evaluation of beliefs or action and which are closely connected to personal integrity and personal identity" (Halstead, 1996, p. 5). Hildebrand suggests that it is not necessary for teachers to articulate their values because their "pedagogical practices illustrate them" (p. 56). Hildebrand further proposes that "when investigating teachers' values—as enacted in the science curriculum—four layers, going from social practices to core values can be progressively explored" (p. 56).

Connected with the work of Hildebrand (2007) and others, Corrigan and Gunstone (2007) used science teachers' responses to the question "If you were working with other scientists, what would you value?" to develop five useful labels for the values of science: Science as a process, human qualities, cognitive, societal, and school science. While there are other more extensive collections of values of science (Siddique, 2008), we have found that these five labels have greater meaning and are easier for both teachers and teacher educators to connect with and use (Corrigan, Cooper, & Keast, 2010a; Corrigan, Cooper, Keast, & King, 2010b). Our research is looking to draw links between the values of science education that we portray and the way this influences the development of our pedagogical knowledge. Our values of science education will affect not only our personal beliefs and perceptions (one of the facets of pedagogical knowledge) but also the way we interpret other facets of pedagogical knowledge, as suggested by Morine-Dershimer and Kent (1999). Hildebrand states: "Our pedagogy signals our values" (p. 56). We used these ideas as starting points for meaningful reconsideration of our values, practice, and pedagogical knowledge.

Use of Values and Pedagogical Knowledge

Throughout our years as science teacher educators, we have undertaken analysis of our teaching practice (Cooper & Keast, 2008; Keast & Cooper, 2011). We have found the model of pedagogical knowledge articulated by Morine-Dershimer and Kent (1999, p. 23) useful due to the structure it provides for tracking change and growth of pedagogical knowledge as well as the factors that influence such growth. Their model links general pedagogical knowledge with personal pedagogical knowledge using reflection as the mediating process. The model helped us to realize that we began our collaborative self-study because of our personal beliefs that teachers are lifelong learners. We set out with the intention of using self-study to focus on our practice, making our tacit knowledge and values explicit to each other and viewing our practice from the other's perspective. It was our practical experience of levels of student engagement and disengagement and our personal belief that science education should be relevant to students' experiences of science that led us to analyze the different ways of making our teaching more relevant to our context. This analysis drove us to investigate instructional models and strategies, classroom management and organization, and classroom communication and discourse that would both support our values of science and create a learning environment that would engage our preservice teachers. We are also trying to create an environment where our preservice teachers feel confident enough to discuss their values of science and to question ours. Thus, the pedagogical knowledge model provided us with a scaffold for learning and growth as science teacher educators and our preservice teachers with a scaffold to monitor their own progress.

We introduced the concept of values of science to our preservice teachers by showing them a video of an experienced teacher who clearly promoted several values of science in his teaching of a Year 12 Biology class. The values were revisited with reference to our own teaching and the preservice teachers' teaching on practicum. By asking the preservice teachers to consider the decisions they will make when planning their classes on teaching practicum, we introduced the concept of pedagogical knowledge. Finally, we revisited the concept of pedagogical knowledge by combining references to our own teaching and to the preservice teachers' teaching on their practicum.

Methodology

Loughran (2004) argued that self-study describes the focus of the research and that self-study does not necessarily occur in the same way for each person or for each site. LaBoskey (2004) has suggested that teacher educators are simultaneously engaged with teaching and researching, and so the two are often difficult to distinguish. The data that were collected were quite different to other self-studies but were collected to be commensurate with the individual study and the questions

being asked by the teacher educators (Hamilton, Pinnegar, Russell, Loughran & LaBoskey, 1998; Pinnegar & Hamilton, 2009). Given our specific questions, we chose to collect data with purpose and intent in order to find answers that served our needs. In this study, we were interested in examining the values of teaching science teaching that we assumed we espoused together in our classrooms. We asked ourselves, "Do our preservice teachers see the values we try to promote as the heart of our teaching, or do they only see the pedagogy and technical skills of teaching?"

As a consequence of our learning from our previous research (Cooper & Keast, 2008; Keast & Cooper, 2011; Keast, Cooper, Berry, Loughran, & Hoban, 2009), our shared planning over several years, and our similar beliefs about teacher education, we wanted to identify the tacit aspects of our practice that we needed to make explicit for our preservice teachers. We wanted to "stand in and outside [of ourselves]" (Brookfield, 1995, p. xiii), and doing so required an alternative perspective on our practice; hence, we invited a research assistant to act as a critical friend, observing and analyzing our practice in order for us to see inside our practice from a fresh perspective (Brandenburg, 2008).

As with our past research into our practice, we documented our planning meetings, the content we were to teach, and the reasoning underpinning the approaches we would use to teach our science classes. We drew on the approach outlined in Hamilton's framework for inquiry, and we used the analytical frames of story of self, self-study definition, self-study methodology, and authority of experience (Pinnegar & Hamilton, 2009, pp. 44–46). The story of self was represented by our individual journals. The views of others, Rebecca's writing of Stephen's teaching, Stephen's writing of Rebecca's teaching, and our critical friend's writing of Rebecca's teaching represented defining our self-study and using self-study methodological practices to frame and then reframe practice. Finally, in explaining the reframing of an issue, we were deliberate in articulating our pedagogical reasoning and values of science for our critical friend and for ourselves. We wanted our critical friend to observe and investigate whether or not our preservice teachers explicitly recognized these values.

The data collected for this study came from multiple sources, as is often necessary in self-study (Loughran, Berry, & Corrigan, 2001). Included were field notes and audio recordings of our planning and debriefing discussions, videotapes of lessons taught, and our individual journals containing analyses of our teaching. In addition to these data sources, our critical friend also reviewed our video recordings and annotated them in terms of critical incidents and issues that attracted her attention in relation to our practice and our preservice teachers' learning about teaching. The journal was "the story of self" (Pinnegar & Hamilton, 2009, pp. 44–46) and allowed each of us to tell the story of our own teaching. This is not to say that the journal was a narration of our lessons; rather, it was an individual perspective on critical incidents in our own practice.

As Pinnegar and Hamilton (2009) asserted, teacher educators' practice is multilayered. We were able to explore these layers through the interjections we made in the moments of teaching. In one instance, for example, Stephen had been discussing the particle theory as the preservice teachers were making pancakes. In the moment of teaching, he was focused on explaining how this approach could be used with

classroom students to develop their understanding of particle theory. Rebecca interjected to explain how in her teaching she more commonly worked with ESL (English as a second language) students and had noted the use of similar terms to mean the same thing, for example particle and molecule. Rebecca noted and explained to the preservice teachers that such similarities often confuse ESL students; she had found it important to use the one scientific term consistently to minimize confusion. Taking a moment out, Stephen reflected on his teaching and its purpose. When he stepped back into role, he took a different tack with the class and asked what his purpose was in having them make pancakes. Why would he want them to be in the position of the learner in a teacher education program rather than taking the teacher's view? This interjection, rather than being seen as an interruption, was taken as an opportunity both to review and to analyze what they were doing and why. Critical incidents or teachable moments such as these were often the basis of their journal writing.

During the teaching, our critical friend documented our teaching by constructing field notes and later reviewing our journals to uncover what we saw as critical incidents or teachable moments. She paid particular attention to the comments of the preservice teachers in trying to gain an understanding of the purposes they saw for the teaching and the values of science they recognized in the teaching. In addition, each and every class (except the final debriefing sessions) was videotaped and the video footage analyzed by our critical friend. The final two sessions in the last week of semester were audiotaped and transcribed.

After each lesson, our critical friend reviewed her notes of the class and then reviewed the videotape for details of particular episodes of interest. Her notes were then sent to both of us for further analysis. In this way, our practice was being diagnosed through the definition of self-study (Pinnegar & Hamilton, 2009, pp. 44–46). She also listened and took field notes during our planning and debriefing discussions. Thus, our critical friend gathered data from multiple sources to gain a thorough outsider's view of our practice. Data were analyzed through a form of member checking (Robson, 2002) in which the three of us shared our analysis of the data and our conclusions and challenged one another's views. For example, the journals, field notes, and videotapes were viewed, read, analyzed, commented on, discussed, and categorized so that this process allowed for multiple views of the data, drawing out instances of the tacit knowledge of practice and the values of science and making them more explicit for analysis. In so doing, we were clearly making these instances explicit for ourselves, and thus, the research continually influenced our teaching. In this way, we were engaged in self-study methodology (Pinnegar & Hamilton, 2009, pp. 44–46), framing and reframing our practice to better understand and develop our pedagogy of teacher education and the values we assumed we were fostering in our classes.

Finally, in drawing conclusions about our practice and reflecting on the interpretations and insights drawn out by our critical friend, we were also framing the authority of experience. Answering questions about the difficulty of helping preservice teachers come to see and appreciate the values of science and science teaching, rather than just acquiring technical skills of teaching, was a strong element of how our authority of experience in teaching about science teaching played

out in our practice. Such reflections led to further questioning of our intentions, including whether or not preservice teachers were genuinely ready to focus on values and whether or not it is possible to help them see beyond their immediate needs for the classroom.

Findings and Discussion

The data presented here include excerpts from our journals and from observations that we recorded while watching video recordings of our classes. Commentary from our critical friend is also included. For clarity, all journal entries written by the authors are indented. Entries written by the authors are referenced using (SK) or (RC) and the commentary from the critical friend using (CF). Our critical friend's responses demonstrate her perspectives on our teaching that were also informed by her field notes and reviewing of video recordings.

Stephen's Journal for Week 1

SK: This first week is very important for setting the scene for the rest of the semester, I want to push their understanding and question what they really know about content. They enter our class expecting to be shown how to teach, and more importantly how to teach certain topics. I don't intend to do this, so this first week is about explaining why they won't be getting what they desire and keeping them onside. If it fell over badly this week, the whole semester of learning for them and teaching for me would be disastrous. It is about walking the fine line between pushing and listening, reading their reactions and moving them forward.

CF: Here Stephen exposes his concerns for his preservice teachers' expectations. On the one hand, he wants to meet the needs of his preservice teachers, and on the other he recognises that what they expect is not what they need to be learning about teaching. It is a dilemma as he is torn between meeting their needs and challenging their expectations. In his preservice teachers' eyes Stephen could well be seen as a living contradiction (Whitehead, 1993). Later he writes:

SK: Many of the preservice teachers at first thought this (making pancakes in science class for the purpose of investigating and explaining states of matter) was fun but didn't see the science. Important for us to note in our teaching that while it is fun, what is our purpose and what is the learning we want from our preservice teachers, just as they need to think about the learning of their students. The unpacking was important to demonstrate where the science was, and how such an activity could be used to bring out science concepts often taught in an abstract way using unfamiliar chemicals. By the end of the discussion most of the preservice teachers could see the benefit of this approach.

CF: The need to allow their preservice teachers into the way they think about their teaching is important to both Stephen and Rebecca. While fun activities and engaged students are important, making sure they see the science and recognise the scientific concepts is the main point to teaching science. While promoting the Human Qualities of science we are also promoting the cognitive value of science. They need to identify with the science concepts within the human endeavour appears to be an underpinning aspect of their approach to teaching about science teaching.

SK: There are many concerns I took into this week and just as many I take out of it. If I push them too hard about their lack of 'real' understanding of simple concepts like change of state and chemical reaction, it will take a few weeks to get them back to take risks and discuss openly what they know, what they don't know and how they know it. Did I push them too hard? We will only know next week! Humour and the practical nature of the activity helped this year to keep it less confronting than in previous years.

CF: In his journal, Stephen is telling his story, what Pinnegar and Hamilton (2009) described as a "story of self." Often the first step in self-study is to make explicit your own thoughts and ideas about your teaching; Stephen does that here.

Our critical friend made notes from her viewings of the videotaped lessons. The videos were then viewed by both of us to gain further insight into our teaching. The notes in square brackets [*comment*] show Rebecca's (RC) and Stephen's (SK) comments about the notes made by our critical friend. In this one 3-h teaching episode, there were 11 clips that represented the different parts of the 3 hour lesson and five paragraphs of analysis. The notes were analyzed in terms of teaching practice for the following themes:

- Technical skills of teaching [TS]
- Making teaching practice explicit [TE]
- Sharing pedagogical reasoning [SPR]
- Challenging preservice teachers' views of science [CVS]
- Expressing our values of science and science teaching [EV]

Excerpt from Critical Friend's Notes for Video Clip 2: Lesson 1, Week 2, February 2, 2010

- The pancake activity allowed preservice teachers to design their own experiments [TS]. [*They observed that this was different from 'normal' science teaching, SK*] It was a fairly open-ended experiment, allowing for different techniques in each group. Preservice teachers start to see the value of letting students explore and experiment without such structured and defined instructions [CVS].
- One preservice teacher mentioned that there are different ways to approach science and different ways to explain it [CVS]. [*Good we are breaking down the*

myth that teaching is a collection of good recipes, SK] The important part is choosing an appropriate model that meets the level and needs of your students and one that correlates with models used by other teachers in your school [SPR].

As the outsider, our critical friend observed and analyzed our practice, trying to make sense of the pedagogical reasoning and values made explicit to our preservice teachers. In this way, she helped frame and reframe our practice for us so that we could better understand our practice and examine more closely changes that we may not have been immediately aware of in our normal practice.

Critical Friend's Response to Stephen's Week 1 Journal

CF: Many human qualities of science were evident during this activity. Stephen allowed the preservice teachers to be creative in their methods and to be curious and ask questions about why the pancakes from each group looked and tasted different when each group was set the same task. The activity was quite open ended; the science was present, but it was up to the preservice teachers to explore and ask their own questions in order to investigate the science in a way that held meaning for them. Stephen's approach to the pancake activity prompted preservice teachers to revisit the initial question, "What is important in teaching science?" Is it content, or is it allowing students an outlet to explore creatively? This is a topic that Stephen often asks preservice teachers to return to and grapple with throughout the semester, and I believe this continues to reflect his valuing the human qualities of science.

Our critical friend's insights illuminate the role preservice teachers have in making meaning for themselves, and this accords with what we think we are doing through our teaching. As noted above, being comfortable allowing students to explore the science in an activity is a value we expect to be evident in our practice.

Rebecca's Journal for Week 4

RC: We started today by doing a bit of a stock take and trying to pull it all together, again a note for next year, perhaps do the discussion of the readings in this lesson as it is a good place to pull it all together and then have the preservice teachers think about writing cases. Realistically, had they read the articles they probably wouldn't have made much sense before now anyway!

CF: Rebecca's journal as her own story of self [illustrates how] she uses an opportunity to explore her thinking about her practice at a level not available to her in the 'moment of teaching.' She recognises here that the readings offer a good way to draw together the big ideas covered so far and help preservice teachers make sense of the many aspects of teaching science. She uses self-study methodology (Pinnegar

& Hamilton, 2009), critically analysing her practice and making changes for the future to improve the learning of her preservice teachers.

RC: Definitely having both Stephen and me in the room is important; we don't always agree, but we do seem to have similar purposes and a common end point. We do, however, have quite different ways of getting there and showing that to the preservice teachers is really important. There is not one great way to teach but there are some really important shared understandings and goals of science education that we need to make the preservice teachers aware of.

CF: Here Rebecca reveals how she thinks she and Stephen articulate the same values in class but through different approaches. This is a big revelation, one that neither realised before.

Critical Friend's Response to Rebecca's Week 4 Journal

CF: A lot of big discussions took place during class this week. Rebecca and Stephen began to pull things together from the previous weeks through a series of discussions that were primarily student led. Rebecca and Stephen asked preservice teachers what their expectations for this course had been.

This view suggests that we allowed our preservice teachers to lead their own development of ideas; we did not tell or direct but, by carefully asking questions and drawing the big ideas of the class together, we found ways of helping our preservice teachers make sense of the situation and their learning.

CF: They began to question why science classrooms look the way they do and why science teachers teach the way they do. This discussion was a great example of cognitive values such as scepticism and search for evidence. In her journal, Rebecca said, "There is not one great way to teach…" so for me this brings me back to her value of human qualities. This value was evident in the week 4 class as Rebecca pushed preservice teachers to be creative and open-minded in the way they approach teaching science. It is about being sceptical and discerning what is important, but it is also about having an open mind to new learning opportunities that you can provide your preservice teachers, even if they are unfamiliar with the idea.

Our critical friend identified the values Rebecca was promoting in her lessons. She was also able to identify a critical incident and bring to Rebecca's attention an event that may have otherwise gone unnoticed. Our critical friend frames what she sees in Rebecca's teaching to make it explicit for Rebecca.

CF: One preservice teacher claimed that to teach in ways that allow students the freedom to work creatively in science rather than following instructions for an experiment like a recipe would be easier to do in a primary classroom where one teacher teaches many subjects, but you couldn't really do that in a secondary class. Rebecca replied, "Why can't you?" With guidance and reassurance from Rebecca as well as peers, the preservice teacher was able to talk her way to

understanding and realise the immense possibilities for this type of learning experience within a secondary classroom. Rebecca was willing to question this idea and push the preservice teacher to think creatively about how to conduct a meaningful, rich science lesson, and she pushed the preservice teacher to have an open mind about what that [might] look like in a secondary science classroom.

Here our critical friend recognizes that Rebecca identified a teachable moment and made the most of the opportunity. She did this not by being authoritative but by allowing the preservice teachers to challenge her ideas and understanding of teaching. By questioning the preservice teacher, Rebecca moved her thinking forward. At the end of semester, our critical friend reviewed all the material at her disposal and wrote a lengthy account of what she saw in Rebecca and Stephen's teaching. The following extracts are taken from her written analysis.

Critical Friend's Analysis

CF: So is it important for preservice teachers to understand Rebecca's and Stephen's values, or do they just need to be given the tools to articulate their own? I do not believe that it is necessary for preservice teachers in the course to understand the extent to which Rebecca's and Stephen's values dictate the structure of the course. It is important that attention is given to this realisation and that preservice teachers are made aware. But most are not at the point in their development as educators to be able to connect to the discussion of Rebecca's and Stephen's values and make it useful within their own practice. When preservice teachers reach for an understanding of the values, they often miss and instead reach understanding of pedagogical issues. The reason for this is that they cannot connect to Rebecca and Stephen's context when it comes to values and growth in their teaching at a tertiary level. However, the context of pedagogical issues is common ground between science teacher educators and science teachers and this is why preservice teachers can better connect to this. They also better connect to the values through the experienced-teacher video because the context of a secondary teacher in the classroom is something to which they can relate. The course gives adequate attention to the importance of values, providing preservice teachers with the tools to begin to articulate their own values when they get to the point where an examination of their values becomes relevant to their practice. I think the course challenges the preservice teachers without pushing them beyond their current capabilities based on their current level of experience. But taking into account the limitations of preservice teachers' current experience, are Rebecca and Stephen able to push and challenge their own practice in a way that supports their journey of growth?

Our critical friend's perspective on our practice has added another view to our understanding of our teaching of science teaching. While our critical friend could identify the values we were promoting from the interactions with preservice teachers, an issue persisted. It appeared to be difficult for the preservice teachers to differentiate between the pedagogy and technical skills and the overarching values of

science being promoted. Taking the preservice teachers along with us on the learning journey, we could see a change in their attitudes to science and science teaching. However, we were aiming to make our values explicit; through our critical friend's reframing of our practice, we saw that we did not always meet that objective. Instead, the preservice teachers viewed our practice in terms of technical skills rather than as higher levels of pedagogical reasoning.

Rebecca wrote the following comments about our critical friend's perspective on her teaching:

RC: A surprise for me is the emphasis that I place on the cognitive values of science. This was certainly not something I ever emphasised as a teacher; in fact, when looking through and discussing the values as I have many times over the past few years, these particular values are the ones I find most difficult to connect with. It is part of who I am to make an effort to improve what I deem to be a weakness or to better understand what I am unsure of, but in this case the effort was not intentional. This slight focus on the cognitive values of science may also be due to my shift in understanding of what it is to be a science educator; my thoughtful consideration of these ideas has led me to promote a thoughtful consideration of what it means to be a science teacher with the preservice teachers in the class.

Our critical friend's perspective on her teaching helped Rebecca rethink her role as a science teacher educator and made her more aware of the many layers involved in her practice. Without the outsider perspective, she may not have noticed the emphasis on cognitive values.

Reframing Our Practice

Our critical friend identified several aspects of our teaching practice that we either had not focused on before or that were tacit to our understanding of practice. Using the analytical frame "story of authority" (Pinnegar & Hamilton, 2009), we outline the areas of our practice that we have reframed as a result of our analysis of our practice through the perspective of our critical friend.

Interjecting in the Moment

Our critical friend helped us to understand that *interjecting in the moment* to make our pedagogical reasoning explicit to our preservice teachers is an important part of practice. Previously, we did not realize that we took for granted the sharing of our pedagogical reasoning and its benefits for the class. She pointed out how important this was to help preservice teachers see and understand the decisions we were making about our practice as we were teaching them.

We realized that the benefits of sharing our reasoning in this way were twofold. Firstly, sharing our reasoning gave the preservice teachers an insight into the

reasoning behind a teacher's pedagogy. We now see the fact that this occurred in the midst of teaching as crucial modeling for preservice teachers. While this developed from our team teaching, it is inherent in what we now do and has evolved over the time we have been teaching together. Given that we had not thought about it before, it is now apparent to us that not everyone teaches in this way and that what we do is somewhat unique. Not only do we explain and highlight aspects of practice to our preservice teachers, but also we are willing to question each other publicly about our practices and purposes in front of our preservice teachers. This becomes valuable modeling for them, as later in the unit they are prepared to question their peers about their pedagogical reasoning and are also comfortable with being questioned.

Secondly, sharing our reasoning gives teachers a chance to analyze their teaching and its purpose in the moment. We now realize that teacher educators need to identify critical incidents in their classes and analyze them after their teaching to consider how they might respond differently when a situation occurs again. We find that we are able to analyze events within the teaching episode; the observer offers new insights and perspectives that often lead to a rethink or a teachable moment. By questioning each other about our practice publicly and in the moment, we create an open environment for the discussion of practice as we also illustrate the value of such explicit discussions.

Creating an Environment for the Public Discussion of Practice

Apart from our questioning each other's practice, our critical friend recognized that we withhold judgment when our preservice teachers are discussing their own learning about teaching science. By asking questions rather than telling answers and by extending their thinking with "tell me more," we encourage our preservice teachers to find their own voices, we show that we value their opinions, and we try to build their confidence for participating in the sense-making and meaning-making of teaching. Our critical friend made this tacit understanding of our practice explicit. We acknowledged that we did this to give them an opportunity to find their voices in the classroom, but we did not realize the full benefits of the way we modeled our practice until it was reframed for us by the following extract from our critical friend's field notes:

CF: Jeremy was a mature-age student and father of teenage children. He struggled with the content in sex education, but more importantly was torn between the tension of talking about sex with children his daughter's age and his beliefs that this was important for students to know and understand. The approach of making plasticine models in small groups of the reproductive system of the opposite gender and explaining these to the class had Jeremy questioning his ability to teach this well. Stephen wrote in his journal, "Today I really pushed Jeremy, not just with content (of reproduction) but also how and why we teach it. At times Jeremy really struggled with this, but never did he lose interest or not see this as a positive way to

improve his teaching." The purpose of pushing this so hard with preservice teachers was that this was a topic that we all find hard to separate the content from the values we bring with us. (CF)

It also emerged that, as the semester unfolded, the preservice teachers began to question each other and us about issues of practice and pedagogical reasoning. Our critical friend noted that this really helped the preservice teachers to make sense of the classroom situation and their own learning about teaching science.

Making Our Values Explicit

Our critical friend noted how often we returned to our cognitive values of science. We both acknowledged that we taught and espoused values of the human qualities of science with strong emphasis on creativity and societal values. However, our critical friend pointed out that while we shared and espoused similar values, we often did this in quite different ways. The fact that we used different approaches and paths to reach the same destination was valuable for preservice teachers to see so that they could realize that good teaching does not have to be the same. This became clear for us both when we analyzed the comments of our critical friend. In fact, good teaching in teacher education, like good teaching in school, is not about following a recipe; rather, it is based on sound pedagogical reasoning and principles, with student learning in the forefront of all decisions. This modeling of practice reinforced our willingness to share our practice with preservice teachers and opened up conversations about their developing understanding of pedagogy.

Advantages of Team Teaching

We have acknowledged the advantages of team teaching to each other for some time. We now feel more comfortable teaching together than we did when teaching our other units separately. Our critical friend's insights illuminated some of the benefits for our preservice teachers that were not readily apparent to us:

CF: I think having two people in the classroom is a big advantage. It wouldn't be possible with any two people, but because of the reasons I have explained previously, this team works very well together. With their combined experience, they are able to cover a lot of ground and have a better chance of connecting with more preservice teachers. The male/female perspectives I think also provide a dynamic that more preservice teachers can relate to. While one teaches, the other is able to observe, which allows them the perspective to see when the preservice teachers seem confused and unable to connect and when a different course of action might be more effective, or when they're really making strong connections and important realizations and need to spend more time in order to make that learning concrete. This

teaching team is a relationship that has been built over time. The two share a teaching history that has allowed for a rich, efficient team dynamic to form. The two have sacrificed in order to develop this team teaching approach for this course. Though they are not paid to share the teaching responsibilities, they continue to devote their own time to doing so because they have seen the immense benefits that follow.

Those benefits are not without risk. It is a risk they take to teach using the many innovative approaches that they do. It is a risk to structure the course in an attempt to not meet student expectations, as the new and unfamiliar can be very disconcerting for preservice teachers so close to running their own classrooms. From what I have observed this semester, I think that preservice teachers sometimes feel confronted by Rebecca and Stephen's approach, but I also strongly believe that they recognize how they learn from it as well. Rebecca and Stephen don't leave the preservice teachers unsupported to grapple with the challenges alone. They support them and provide tools that preservice teachers can utilize in the way that holds the most meaning for them. I think it is easier to take such risks in a team teaching situation than alone. As mentioned before, team teaching allows different perspectives that help to monitor more closely how those risks are playing out and how preservice teachers are reacting to them. So the team teaching allows Rebecca and Stephen a freedom and a confidence to be more flexible and to more readily meet student needs. Instead of going in a negative direction for an entire class because you can't find an escape route, the two can work together to keep the class and the preservice teachers on track and change direction if necessary.

Setting Clear Pedagogical Purposes for Our Teaching

Our critical friend helped us to realize that the way we plan our lesson, starting with our pedagogical purposes and then building content and context, sets up the way we teach about science teaching. It also means that we are quite open to being challenged about our purposes by each other and our preservice teachers. If we change tact from our plan during class, which is common, the observer will question why we have made an in-the-moment decision. Such discussions allow preservice teachers into our thinking as experienced teachers about why we make such decisions. Our critical friend noted the importance of this for preservice teachers to understand our teaching and learn about their own teaching:

CF: Rebecca and Stephen spend the first 4 weeks creating a strong foundation which preservice teachers come back to time and time again to link the things they are learning. I think that is what makes it possible for preservice teachers to make such strides in their understanding of pedagogy in such a short period of time. But, of course, not all preservice teachers make all the links and not all get to the point where they can clearly articulate their own pedagogy and especially their own values. They may not be ready to see that yet. Still, they have been presented with information and exposed to meaningful discussions that will support them when they are ready to take a closer look at their own pedagogy and the values behind

their pedagogical practice. Preservice teachers who weren't ready to make the links in the first 4 weeks were able to come back to that once they had had their own practical experiences to which they could relate the information. I believe that others will be able to do the same once they get to the point that they are ready to explore those things further. Rebecca and Stephen have structured the course in such a way that the information naturally links together so that when one thing falls into place or becomes clear, everything else will follow. This is why I am confident that, even beyond this course, these preservice teachers will be able to utilize the ideas from the course in their continuing growth as educators.

While we taught in this way, we did not realize all the effects such teaching had on our preservice teachers.

Conclusions

Self-study researchers have documented the importance of an outsider's perspective in framing and reframing practice (Brandenburg, 2008; Loughran & Northfield, 1998). In this collaborative self-study, our critical friend was able to identify teachable moments and critical incidents so that we could better understand the opportunities that arose in our teaching for making tacit aspects of our practice more explicit to ourselves and to our preservice teachers. In terms of our practice, our critical friend was able to identify some of the values we hoped we were promoting, including the pedagogical reasoning inherent in teaching about science teaching, as we tried to help our preservice teachers move beyond learning about science teaching as a technician. The values we promoted are an important aspect of how we teach and why we teach the way we do (Levinson & Turner, 2001).

After reframing our practice through the eyes of our critical friend, we have realized that openly discussing our pedagogy in front of our preservice teachers makes our pedagogical reasoning explicit and models the types of discussion that are so important for preservice teachers to engage in. The importance of learning how to participate in these types of discussions is underscored later in the semester when we encourage the preservice teachers to publicly articulate their own developing pedagogical reasoning. In one sense, studying our practice has confirmed for us that the pedagogical practices we have been developing help to scaffold the type of learning we aim for at the beginning of semester. Our critical friend has made explicit several tacit aspects of our pedagogical reasoning, such as interjecting in the moment. This has opened our eyes to the impact this practice has on us, individually and as a team, and to the impact it has on our preservice teachers and the course.

The insights shared by our critical friend have affected us in at least four ways:

1. We often act in the moment, usually in response to being challenged by each other and our preservice teachers. We are prepared to change the direction of the teaching to meet our pedagogical purposes and to take the time to explain our

actions as they happen. We are continually tweaking our teaching, reacting to our preservice teachers' needs in understanding teaching science rather than comforting them and meeting their immediate self-imposed need to gain a deeper knowledge of science content.

2. We dedicate all of each Thursday to live, think, and experience teaching about science teaching. We begin by setting up for classes early in the morning, then we teach the morning session, debrief over lunch, and reassess our plan for the afternoon class. After teaching the afternoon session, we conclude by debriefing the day and planning for the next week. If necessary, we work late until all avenues and concerns have been exhausted. The process is busy, hectic, and often overwhelming, but it is also satisfying, enlightening, and fulfilling. The immediacy of recording our reflections of the class, discussing the implications for the next lesson, the next week, and the next year are all present in the discussions. We also block ourselves from engaging in anything other than our teaching on this day so that our heads remain constantly in our teaching space. This is, in many ways, an absolute luxury and sheer pleasure that few teacher educators can afford.
3. Between semesters, as part of our research, we analyze our teaching, the semester, the classes, our pedagogical purposes, and the pedagogical reasoning that led us to do what we did then and what we will do in future. This more considered analytical review changes as our pedagogical reasoning continues to develop and grow.
4. Specific changes in our practice arising from such discussion include having students make pancakes in class rather than reading about and doing it at home. Recognizing the benefits of this change through our critical friend means that the change will remain in place until further evidence inspires us to reason differently. Discussing the readings to pull together the main ideas in the unit will now be done in week 4 rather than introducing readings in week 2 and discussing them in week 4. We are now clearer about our purpose for having the reading discussion linked to case writing.

Together, we were aiming to promote our science values for our preservice teachers in order to provide them with a better understanding of what it means to be a science teacher with a focus on students' learning. Our critical friend was able to recognize some of these values as she also brought a fresh perspective to the way that our teaching might be viewed and interpreted by our preservice teachers. In particular, she recognized that the preservice teachers were grappling with many ideas in the course, and she pointed out that their immediate focus was often more about classroom survival than about the higher-level thinking about practice that is so integral to our thinking about our teaching about science teaching. This self-study leaves us with a challenging question: "How do we teach about science teaching in ways that meet our preservice teachers' needs and also push them beyond those needs to develop richer understandings of the complex nature of practice?"

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The authors would like to acknowledge the valuable insights that our critical friend made during our work on this chapter. Her work is greatly appreciated.

Chapter 6
Using Self-Study to Develop a Pedagogy of Elementary Teacher Education: Addressing the Specialist-Generalist Issue

Tim Fletcher

In many elementary schools, the classroom teacher is responsible for teaching most, if not all, of the subjects in the curriculum. Elementary classroom teachers are likely to teach literacy/language arts, mathematics, science, social studies, and in many instances, visual art and physical education (PE). As a PE teacher educator (PETE), I am concerned about the impact of requiring elementary classroom teachers who have little or no background in physical education to teach PE classes. Although having a specialist to teach PE does not guarantee a quality program, specialists generally teach better lessons than classroom teachers (Graber, Locke, Lambdin, & Solmon, 2008). Compared to elementary classroom teachers, PE specialists exhibit higher levels of effective teaching behaviors such as having well-planned programs, individualizing instruction, providing more opportunities for physical activity and skill development, and having more success in enhancing students' fitness levels (Constantinides, Montalvo, & Silverman, 2009; Sallis et al., 1997). Further, specialists tend to feel better prepared to teach PE, enjoy teaching PE more, and are inclined to devote more time to teaching PE (Mandigo et al., 2004).

While there is indeed overlap between the disciplines of physical education and science (e.g., learning about the body, its functions, and its movements), I was invited to write this chapter because many of the challenges faced by teacher educators who prepare elementary classroom teachers to teach PE are also challenges faced by teacher educators who prepare those same teachers to teach science. The many challenges can broadly be broken down into two themes: *teacher-related factors* (such as prior experiences of the subjects as students, lack of confidence regarding content knowledge and pedagogical knowledge, and a lack of professional identity as a teacher of PE or science) and *institutional factors* (such as the limited

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time in the school day to teach all subjects and the subjects occupying a low priority in the school curriculum) (Morgan & Hansen, 2008a). How we address these challenges as teacher educators and teach about teaching through our subject areas in what is usually little more than one brief physical education or science methods course (in my case, a 12-h course) is of primary interest.

In this chapter, I use self-study to explore my learning about teaching teachers and the development of a pedagogy of elementary teacher education (Loughran, 2006). Although my focus is on PE, I draw from the literature of both PE and science teacher education and invite readers to search for instances that "ring true and enable connection" (Bullough & Pinnegar, 2001, p. 16) for them in their work or thoughts about preparing elementary teachers to teach science.

Research on Specialist and Generalist Teachers

Teaching is complex and teachers are required to think about and do many things. Teachers are expected to manage classroom activities efficiently, be strong communicators, build relationships, and reflect on their practice (Darling-Hammond, 2006). One of a teacher's more prominent roles – and some would argue, *the* most prominent role – is that of teaching subjects (Kosnik & Beck, 2009). Elementary teachers require a substantial amount of subject matter knowledge because they tend to teach most subjects in the curriculum. Although teacher educators might consider it unrealistic to expect elementary teachers to be expert teachers in each subject they teach, students, parents, and other community members do expect teachers to possess at least a minimum amount of knowledge that will allow students to learn the curriculum expectations and/or outcomes. Yet, many teachers at the elementary level cite lack of subject matter knowledge as one of the major barriers to implementing quality classroom programs (Kosnik & Beck).

In the Canadian province of Ontario, where the research for this chapter was conducted, elementary classroom teachers will teach most subjects in the curriculum. Few elementary schools employ specialist science teachers, and in the case of PE, generalists are responsible for teaching approximately 63% of elementary PE classes (Faulkner et al., 2008). In Ontario, this figure represents the various situations that exist from school to school and from district to district. For example, in some schools, a PE specialist will teach all pupils PE several times a week; in other schools, PE is taught by a combination of PE specialist and the classroom teacher, while in others still, all PE classes are taught by a classroom teacher. It is likely that at some point in their career, an elementary teacher in Ontario will be required to teach at least some science and some PE.

In Ontario, where the postbaccalaureate route to teacher education is typical (i.e., a 1-year qualification following an undergraduate degree), teacher candidates want to teach in secondary schools choose to specialize in two "teachable" subjects that were the focus of their undergraduate degree. Thus, someone who majored in biochemistry might choose biology and chemistry for teachable subjects, and a kinesiology major might choose physical education and biology for teachable subjects.

In their undergraduate work, it is more likely that prospective subject specialist teachers would have been exposed to and grappled with ideas, opinions, controversies, issues, promising practices, and challenges related to their subject area for at least 3 years before entering a teacher education program. In kinesiology/PE, such knowledge might be represented by learning about holistic approaches to health and wellness, participating in a wide variety of physical activities (from archery to swimming to badminton) or by learning about, for example, progressive approaches to teaching games, such as teaching games for understanding (TGfU) (Bunker & Thorpe, 1982; Kirk & MacPhail, 2002). It has been claimed that such depth of knowledge allows teachers to organize subject matter in ways that arouse students' curiosities, allow them to deconstruct and reconstruct their life experiences, and allow them to get the most out of their present and future (Goodson, 1993).

Because elementary classroom teachers teach multiple subjects, much of their subject matter knowledge will be drawn from their experiences and memories of how the subjects were taught to them when they were students. This is also the case for teacher candidates who choose teacher education as their undergraduate degree; a common route in Australia and in some institutions in North America (e.g., in the province of Québec). As Lortie (1975) found and many others have supported since, prior school experiences play a large and important role in beginning teachers' conceptions of what is required of a teacher. Of concern, then, are findings that many classroom teachers view their early experiences of PE negatively (Morgan & Bourke, 2008), a finding that also applies to many classroom teachers' experiences of science (Huinker & Madison, 1997; Rice & Roychoudhury, 2003).

Negative school experiences are exacerbated by findings that classroom teachers also view their preservice teacher education as inadequate in the subject areas. Some of the reasons that teacher candidates have this view are insufficient time to learn content and pedagogy and to develop confidence in teaching the subjects, failure to see oneself as a teacher of science and/or PE, inability to make connections between subject content and teachers' lives, lack of success in the subject as a school student, and lack of strong modeling in practice teaching placements (Bencze & Hodson, 1999; Black, 2004; DeCorby, Halas, Dixon, Wintrup, & Janzen, 2005; Morgan & Hansen, 2008b; Moseley, Ramsey, & Ruff, 2004). In PE, it has been found that classroom teachers' PE experiences as school students and teacher candidates are statistically significant predictors of the quality of their PE programs (Morgan & Hansen). How we prepare elementary teacher candidates to teach PE and science, and how candidates see PE and science being taught in schools, requires sustained, in-depth examination.

Research Methods

Context

Given the nature of the challenges presented to teacher educators who are asked to prepare elementary teacher candidates to teach PE, I felt that I would have needed at least an entire credit course to even begin exploring how to teach PE with my class.

At OISE/UT, where I taught PE methods as a doctoral student, a full credit course is considered to be 72 h of course work and instruction. Along with completing coursework in foundational areas such as school and society, educational psychology, and so on, intermediate/senior (grades 7–12) teacher candidates receive a full credit course in one chosen subject area of specialization, junior/intermediate (grades 4–10) teachers receive a half-credit course (36 h) in one chosen subject area, and primary/junior (grades K–6) do not choose a subject specialization. Also, because of the lack of PE specialists in elementary schools (grades K–8) in the province, there are few opportunities for teacher candidates to either observe PE being taught by a specialist or to try teaching PE themselves and be provided feedback by experienced teachers of PE during their field experience. According to Graber et al. (2008), it is fairly typical that North American teacher education institutions provide teacher candidates with one brief PE course and no practice teaching requirement. So, I was responsible for teaching a 12-h course (four 3-h classes) with the broad aims of having teacher candidates reflect on their own experiences of PE and learn about PE content and pedagogy. As someone who has dedicated more than 10 years to learning to teach PE, I still feel I have so much to learn. It was no surprise that in my first year teaching teachers, I thought: How can *anything* be learned in 12 h?

Self-Study Methodologies

I have been engaged in self-study for 3 years to explore and attempt to understand the challenges I faced and the ways in which I responded to problems of practice. Self-study provided me with an appropriate methodological framework to study my practice because it involves our personal and teaching stories that arise out of our own challenges, frustrations, and dilemmas (Samaras & Freese, 2006). By using self-study, I hoped to address my own assumptions about the teacher candidates I would be teaching, in particular, their experiences of PE and learning to teach PE. I was buoyed by the hope that understanding the nature of the teaching and learning situations that I experienced as a beginning teacher educator would help me develop a deeper awareness of my practice and how I could enable teaching and learning in the future (Bullough & Pinnegar, 2001; Loughran, 2006).

Due to the limited amount of research using self-study to examine PE in teacher education, it has been difficult to take Zeichner's (2007) suggestion to make and analyze connections across studies. Therefore, I have had to adopt a wide lens by making connections between self-studies that have focused on preservice teacher education in order to inform my own practice. Studies of science education have also provided much food for thought because, as mentioned earlier in this chapter, many of the challenges we face in elementary science and PE teacher education overlap.

The overarching theme of my self-study was the development of my pedagogy of elementary teacher education, and there are several research questions that drive this research:

- What are my assumptions about preparing elementary teacher candidates, and how have these assumptions framed my approaches to preparing generalists to teach PE?
- What are elementary teacher candidates' experiences of learning to teach PE?
- How has self-study enabled me to develop a pedagogy of elementary teacher education?

Data Collection and Analysis

My data gathering methods followed suggestions by Kosnik, Cleovoulou, and Fletcher (2009), who outlined the importance of gathering one's own data and that of "important others" in self-study. I also used the literature as a data source; this both informed my practice and thinking at the time of data gathering and its subsequent analysis. The approach I used to collect and analyze data was primarily qualitative, as outlined by Punch (2009). My own data consisted of journal entries and recorded conversations with a critical friend (Costa & Kallick, 1993). The journal entries were written reflections made following each class I taught. These entries were largely open-ended, but I focused my reflections on the research questions. The recorded conversations were with a critical friend; Shawn Bullock and I met twice a month during the 2010–2011 academic year to discuss our beliefs, experiences, and practices concerning learning about teaching teachers.

The data gathered from teacher candidates included semistructured interviews with a sample of 10 teacher candidates who were enrolled in the Bachelor of Education program to become elementary classroom teachers. These teacher candidates were purposively selected based on their responses to a survey of 308 elementary teacher candidates' experiences of PE (Faulkner et al., 2004). I sought to interview teacher candidates who had a mixed range of experiences of PE as school pupils. I am one of four PE teacher educators who taught in this large B.Ed. program. As such, I taught several of the interview participants who were interviewed as part of this research. Interviews were conducted three times with each participant throughout a 1-year teacher education program as part of a larger study on the experiences of teacher candidates learning to teach PE. The interviews took place (a) before they attended the mandatory PE course, (b) in the weeks immediately after they attended the mandatory PE course, and (c) after their completion of the second of two practice teaching placements.

I used elements of a grounded theory approach to analyze the qualitative data. I say "elements of a grounded theory approach" because I did not strictly follow protocols suggested by, for example, Glaser and Strauss (1967) or Corbin and Strauss (2007).

Instead, the analysis was approached as bricolage (Denzin & Lincoln, 2003). In applying this form of analysis to interview data, Kvale (2007) states: "Many analyses of interviews are conducted without following any specific analytic method. The researcher may then freely change between different techniques and approaches. Bricolage refers to mixed technical discourses where the interpreter moves freely between different analytic techniques" (p. 115). Analyzing through the lens of a bricoleur allowed me to move freely between data and theory. Kincheloe (2005) uses the metaphor of bricolage as a crystal, where the analysis "expands, mutates, and alters" (p. 347); new patterns and shapes emerge; and unanticipated outcomes emerge from the process.

When analyzing the journal entries, recorded conversations, and interviews with teacher candidates, I began by reading them several times to identify themes related to the central issues of the study. Using the analytic principles of constant comparison (Glaser & Strauss, 1967; Punch, 2009), I continually went over the materials for clarification, continuing to add, delete, modify, and establish themes until theoretical saturation occurred. Continual reference to the literature added deeper insight and allowed for further interpretation and crystallization of the data.

Quality in the Self-Study

Because self-study rests within the qualitative research paradigm, Craig (2009) suggests that "interpretation and meaning-making, rather than explanation, sit at its core" (p. 22). Therefore, the term *trustworthiness* of findings, rather than validity of findings, lends itself more readily to self-study. Ways to check the trustworthiness of qualitative findings include triangulating the different data sources and using member-checking when gathering and writing up data obtained from participants (Punch, 2009). Mulholland and Wallace (2003) suggest extending judgments of the quality of qualitative research beyond trustworthiness and proposed three sets of criteria that guided how I attempted to obtain an overall quality in the analysis:

- *Strength*: Requires research to be conducted in ways that provide evidence of thoroughness, trustworthiness, credibility, and fairness.
- *Sharing*: Allows the reader to experience vicariously the world of the participant(s) and offering a sense of believability.
- *Service*: Concerns the ways in which education is enhanced for the researcher(s), participants, and readers.

While I did not gather tangible evidence of how I obtained these criteria, the guidelines were used as a framework and I invite the reader to judge the quality of the work and its potential for educational improvement based on these three aspects.

Findings

Becoming an Elementary Physical Education Teacher Educator

Prior to my first year teaching in the elementary teacher education program at OISE/UT in 2008–2009, I had spent several years teaching PE in secondary schools and had conducted research for my master's degree in that context. Yet, I had not been in an elementary school in a professional role. So although I could claim some knowledge of PE content, pedagogies, policies, and the like in school settings, I did not feel completely comfortable to be placed in the position of preparing future elementary teachers. In the year prior to beginning teaching in the teacher education program, I had completed a course in my doctoral program called "Current Issues in Teacher Education" and was a member of an informal "Becoming a Teacher Educator" group (see Kosnik et al., 2011). One of the major issues we spoke of and read about was the inaccurate assumption that classroom teachers could easily make the transfer to teacher educator (Dinkelman, Margolis, & Sikkenga, 2006). So while naïve in the world of teacher education, I felt somewhat grounded in that I did not see myself as a teacher educator at that stage – particularly as an educator of teacher candidates at the elementary level – nor did I claim to understand what was involved in developing a pedagogy of teacher education. However, there was a distinct tension in this recognition because I felt that the teacher candidates *did* see me as a teacher educator with all that that title or label encapsulates and means to them.

My initial views and assumptions about the PE experiences of the teacher candidates were shaped largely out of context because in my first year teaching teachers I had not understood their experiences from *their* point of view. Most of what I claimed to know about their experiences was based on what I had learned from reading journals and books about the matter and also from my own experience as a secondary PE teacher. Various sources had informed me that many elementary teachers' experiences of PE were negative (e.g., Morgan & Hansen, 2008b) and that these experiences tended to be shaped by the PE curriculum or by the PE teacher.

From a curricular perspective, I had read that the activities they tended to recall participating in throughout their PE programs consisted mostly of a few competitive team sports (Morgan & Bourke, 2008). Therefore, I thought that most of what the teacher candidates who I would be teaching experienced in school PE would have been sports popular in North America: volleyball, basketball, soccer, softball, touch football, and so on. Participating in these sports is not inherently problematic – sports comprise an important part of PE programs – it is more the way that these sports tend to be taught that has caused student alienation (Tinning, 2010). I did not expect to hear that they had participated in outdoor/adventure activities focused on team-building and cooperation, various forms of dance, health-based fitness, or combative/self-defense activities.

I had also read that the extent to which teacher candidates identified as "sporty" people was an indicator of their experiences and participation in PE (Garrett & Wrench, 2007). For example, those who did not identify as sporty may have spent much of their time during PE class on the sidelines and, if not actually on the sidelines, then occupying a peripheral role in the playground or gymnasium while those who were already good at the activity tended to dominate the lesson. Therefore, I assumed that it would be challenging to create a climate where teacher candidates were willing to be involved in the activities I had planned because they may not see themselves or feel comfortable in the role of active participant.

From a teaching perspective, I expected to hear that teacher candidates' images of their PE teachers were most likely to reflect those you might see in movies. For instance, in their article titled *Butches, Bullies, and Buffoons*, McCullick, Belcher, Hardin, and Hardin (2003) found that PE teachers in the movies were characterized as incompetent, domineering, and adhered to several gendered stereotypes. Such depictions often portray PE teachers as people who shout a lot ("20 more sit-ups!") and love to blow a whistle, play favorites toward the more athletic students, and walk around a gym with a clipboard. These movies tend to depict PE teachers more as military officers than as individuals who are caring and nurturing toward children and adolescents. Morgan and Hansen (2008b) confirmed that elementary classroom teachers recalled similar images of their PE teachers.

Although these assumptions about teacher candidates' experiences were derived mainly from researchers' voices, I could certainly relate to some of what I was being told based on my experiences as a secondary PE teacher. At times, I found it quite uncomfortable reading – particularly in terms of the PE curriculum – because the secondary PE program I taught did more to perpetuate those negative experiences that I read about rather than challenge them. For instance, the program I taught consisted mainly of team sports that I taught using a traditional skill-drill-modified game structure rather than a constructivist approach such as TGfU. Also, one of the hardest challenges for me to address was involving all students, both those who did and did not identify as physically active people. Taking these and many other aspects into consideration, this reflective analysis of my classroom teaching did not do much for my "teaching ego," nor for my confidence going into my initial classes in the teacher education program.

In considering the research on PE teachers, I felt a little more comfortable in challenging the norm that moviemakers and many people create. I definitely do not resemble the portrait of the stereotypical PE teacher depicted – I am fairly quiet and use a whistle sparingly, I try extremely hard to create positive relationships with everyone in my class, and I have never owned a clipboard. However, while many have written about the importance of developing relationships between teachers and learners, the teaching-learning process cannot end there (Loughran, 2006). This shortcoming was evident during my first year teaching teachers. At the beginning, I was basing my "success" as a teacher educator only on relationships: on fun, participation, and attitude rather than on learning. Much like PE teachers who determine the effectiveness of their teaching by students being "busy, happy, and good"

(Placek, 1983), following one class, I wrote about how learning had taken a lower priority to simply having teacher candidates participate in the lesson:

> I have been judging my success on whether they enjoyed themselves, found the class fun, or were participating… Perhaps I am resigned to the fact that they cannot learn a great deal of content knowledge in such a limited time, so emphasis gets placed on addressing attitudes and some basic pedagogical strategies. (Journal Entry, 2 October 2008)

And it is about this point where I recognized a weakness in my own practice that had to be addressed: If you pushed those in my class (either in secondary school or preservice settings) for what they actually learned from me, I would be very interested to hear what, if anything, would be said. Although my classes had teacher candidates participating in physical activity, I do not feel I had been doing enough to teach, to facilitate learning and understanding, or to allow for different strengths in several domains to be developed (physical, cognitive, social, emotional).

Analyzing my assumptions about the PE experiences of teacher candidates enabled me to identify the areas of my practice that most needed attention if the teacher candidates I was teaching were to go forth into elementary schools feeling positive about PE (as a subject) and about teaching PE. But it also helped to shape a vision of what I thought would create a positive pedagogy of elementary teacher education for me as a teacher educator.

While the self-study had opened up my own mind to what could be done to improve my practice, I also needed to understand what the PE experiences of elementary teachers were, from their own perspective and using their own voices, and what they felt could be done to improve PE experiences.

Elementary Teacher Candidates' Prior Experiences of Physical Education

My doctoral research sought to understand the school PE experiences of elementary teacher candidates, investigating the nature of their experiences and addressing Darling-Hammond's (2006) suggestion that researchers explore the "black box" of what goes on in teacher education programs. During the 2009–2010 academic year and in my second year of teaching elementary PE methods at OISE/UT, I conducted surveys of a large sample of teacher candidates and interviewed ten throughout their 1-year program, several of whom I taught (see the "Data Collection and Analysis" section of this chapter).

Curricular influences on PE experiences as both elementary and secondary school students emerged strongly from the interviews. Among those who recalled positive aspects of their PE experience, Andrew (a pseudonym) enjoyed those activities that were noncompetitive and were focused on improving his health. For example, he cited a PE course in his senior secondary school years focused on personal fitness that required him to develop his own fitness program based on his personal needs and goals. He learned about and participated in physical activities such as

distance running, flexibility programs, and strength and conditioning programs. Similarly, Jane's fondest memories of PE were in a noncompetitive environment where students learned about recreational physical activities. She recalled learning about darts, snooker, fishing, cross-country skiing, and so on, some of which she still participates in today. Thus, several teacher candidates welcomed alternatives to competitive team sports in their PE experiences as school students and saw how they could continue participating in these activities later in life. Campbell also recalled fondly many of her PE experiences, however, for reasons not focused on learning through or about the body. She saw PE as a welcome "brain break" in the school day rather than as a crucial site for learning.

For those teacher candidates who reported having negative PE experiences, several spoke with particular strength about their dislike for PE. Natasha, Ralph, and Julia were three who were forthright in their dislike for PE in school, the latter two claiming to hate the subject. Ralph felt that the elementary PE programs he participated in lacked structure while Julia pointed out the repetitive nature of her secondary school's PE program. She commented: "They just did the same thing every year. Everybody knew that all of the classes did the same stuff. In my mind that is just what the gym program is." Upon probing what types of activities were repeated, competitive team sports and fitness testing emerged as the most common activities and these led to their dislike of the program. Ralph reflected that the narrow focus on sports in particular left him feeling like an outsider in the PE landscape. He stated:

> When there was structure, it was so much around team sports. Certainly I don't mind some social aspects, but to focus so much on football or on games like that, I mean… I'd really have liked those teachers I had to have remembered that not everyone in the class was athletic.

The public nature of PE was another reason for Natasha viewing her PE experience negatively. Despite being physically active both inside and out of school, Natasha did not like her classmates knowing when she was not successful at a task:

> I didn't like feeling like I couldn't do what I was being asked to do… If I couldn't do it, it was so obvious to everyone… If you go out and you miss the basket they don't pass it to you anymore because they know you're not going to get it in; everybody knows that you suck at basketball. And that's OK; I'm not really an insecure person, but that was just something that discouraged me right away.

On the surface, this problem may seem beyond a teacher's control; however, strategies that encourage all students to be participating in a task (such as small group activities) are ways to alleviate feelings of being "on display" in the gym.

While all the teacher candidates recalled some enjoyment from PE (e.g., Julia enjoyed basketball, Natasha enjoyed track and field, and both Ralph and Natasha thoroughly enjoyed health topics), they did not recall learning lifelong skills or attitudes, which are the underlying objectives of most PE curricula, nor did they recall being *taught* well. For example, Natasha felt that her teachers did not go to great efforts to teach their students:

> I never felt like they were trying harder with me, or trying to make me feel like I could do it. I didn't feel like they would come to me and say "Oh, I see you're having trouble with dribbling, let me show you a different way of doing it. Maybe you should try doing this, or practice this." I don't really remember that. I just remember a lot of: "Natasha, stop being lazy" or "Natasha, you only did 4 push-ups. Let's go, there's only 8 minutes left."

Because of the dynamic environments in which PE takes place, differentiating instruction in PE can be particularly challenging for teachers. However, several participants did not feel that their teachers went to any great efforts to help them learn about aspects of a healthy active lifestyle that made it relevant and meaningful to them. The intersecting nature of the curriculum and the teacher is at the core of any student's experience with a school subject and what was required of me as a PE teacher educator was to channel how teacher candidates began to see themselves in the context of elementary PE as teachers.

Based on their prior experiences of PE, I asked participants their ideas about what an ideal PE program would look like. Several common ideas emerged, including a broad approach to physical activity, not just playing sports; emphasizing and integrating health aspects; providing differentiated instruction; explaining why things are being learned in class and making activities relevant to learners' lives; and being integrated throughout the elementary curriculum. While nuanced, many of these ideas are what I envisioned as belonging in my own ideal PE program. I imagine that the latter three points would also be important aspects of teacher candidates' images of "ideal" elementary science programs. It became clear that those individuals who had an overall negative experience in PE were able to articulate reasons for their negativity and think of solutions that would move toward positive experiences for their students. Understanding their visions enabled me to move forward in developing a pedagogy of elementary PETE that both the teacher candidates and I would find positive and meaningful.

Developing a Pedagogy of Elementary Physical Education Teacher Education

My pedagogy of elementary physical education teacher education is always in a process of development; it is evolving and ongoing. Based on analyses of my experiences and practice and the experiences of teacher candidates, I wanted to disrupt my own pedagogies of PE that I began to realize were actually perpetuating many of the negative experiences that teacher candidates had spoken about. I wanted to articulate a pedagogy of elementary teacher education that enabled teacher candidates to critically analyze their prior own experiences and to move forward in developing their own pedagogy of elementary PE. My main approach was to be explicit about why I was teaching what I was teaching and two ideas helped me do this: by developing priorities and by articulating my vision for elementary PETE.

Priorities in Teacher Education

I continue to be influenced by Kosnik and Beck's (2009) ideas surrounding priorities in teacher education. In the limited time that I had to teach PE to teacher candidates, prioritizing elements was a key notion that I hoped would allow learning to

take place, both from my point of view and that of the teacher candidates. I realized this tension early in my second year of teaching teachers:

> Again I felt rushed and I should be listening to my own advice. When I was supervising practicum placements I kept asking students "What's the rush?" I think the old *less is more* adage is so important for teachers and I know I'm not following that approach. By trying to rush things we are not achieving any level of depth and that is one of the fundamental principles of constructivist theories of learning – something that I have claimed I teach by. I must alter my planning by reducing certain elements of the class; but this is hard to do because we are so limited by time. One way of addressing this is to develop my own priorities: What do I think is most important for the teacher candidates to learn or to engage with? (Journal Entry, 15 October 2009)

In the brief time that I had with teacher candidates in PE, I did not think that we could develop the levels of subject matter knowledge necessary to understand in any depth, for example, planning or assessment in PE. Consequently, I chose to prioritize classroom community and organization and vision for teaching.

Classroom Community and Organization

I felt that by prioritizing classroom community and organization, I could provide teacher candidates with a comfortable environment in which they could (i) learn about teaching PE and (ii) learn about how to create their own sense of community in PE. It was clear that the negative experiences of several teacher candidates in their PE experiences as students could have been alleviated with better development of a sense of community in the class. To provide examples of how community could be created in PE, I introduced the Teaching Personal and Social Responsibility (TPSR) curriculum framework (Hellison, 2003), which emphasizes social and emotional development through physical activity. In this framework, students are provided with cumulative levels of personal and social responsibility, which, broadly speaking, begin with respect and self-control, such as respecting each class member's right to participate free from harassment or humiliation (Level 1), to demonstrating effort and participating (Level 2), to showing self-direction (Level 3), culminating with caring and modeling leadership (Level 4). Hellison also provides a lesson template that makes time for the teacher to develop relationships with students, reviews prior experiences with activities, integrates physical activity with responsible participation, and provides an opportunity to reflect on what was learned in the lesson. This structure gave both me and the teacher candidates opportunities to learn about their experiences, both prior to and during the course, and to build on those throughout the four 3-h classes. In the "active" components of each class I taught, I made a conscious decision to limit the amount of time spent on teaching formal games, such as soccer, basketball, and so on, and included, for example, cooperative games, health-based fitness circuits, dance, and integrated health concepts. I posted each of my lesson plans (and my reflections afterward) on the class conference so that the teacher candidates could see how I planned and implemented each of the lessons we experienced and reflected on my thoughts about the class, my teaching, and their learning. This also provided them with opportunities to critique my planning, teaching,

and reflecting. In this sense, it was somewhat of a circular process and enabled opportunities to revisit and retry strategies and ideas based on their experiences.

The TPSR framework was helping me make the tacit explicit (Loughran, 2002) in terms of what it was that I prioritizing in teaching PE and allowed me to make direct links to their experiences:

> I am glad that I took a bit more time to explain the TPSR model as it seemed to resonate with several members of the class. We tend to take for granted that a lot positive social/emotional benefits can be taken from sport and physical activity, but we really need to make teaching those things explicit in our lessons/classes. TPSR provides a way of doing this – more through a way of infusing the principles into every lesson rather than just talking about these benefits when we think it is appropriate. (Journal Entry, 18 October 2009)

My feeling that the TPSR model resonated with the teacher candidates was supported in an interview with Jane. She found the PE course helpful and different from what she was exposed to as a school student:

> It was so different from anything that I personally experienced in PE class in high school or elementary school and I think that that's what makes it so good to a group of teacher candidates who… a good chunk of them hate PE… Exposing them to the possibilities of what a PE course could be or what they could do with kids at the elementary level… Because I think that PE is very physical and to have in the curriculum other things that you can address besides your skill level… that was really nice. I never thought about doing that in a PE class before. That was a big thing I took away were the different levels, and having them present in the gym and discussing them with students – I thought that was really nice. Even adapting it; if it were me I'd have my own students creating, "What would a 1 look like? What would be examples of that? What's a 2? What's a 3?" So the students have a say in making that up; I would probably do that.

Also evident in Jane's response was her ability to be able to take elements of the TPSR model and adapt it to her students' thoughts and feelings about what was important to them in PE. It should also be noted that Jane, and several other teacher candidates, desired more information about "traditional" approaches to PE, such as formal games and sports. Although they endorsed the use of the TPSR model to a certain extent, they still felt it was important to understand how to conduct more traditional approaches to physical education.

Vision for Teaching

Developing and articulating my vision for teaching and for teacher education has become another priority for my practice. By selecting the TPSR framework and the principles it espouses, I was articulating to teacher candidates aspects of what I felt was important for PE to offer to students; however, I also made sure to explain that they were not expected to "fall in" with my vision; they were encouraged to critique, disagree, and establish their own vision. When one teacher candidate did do this, I must admit to initially being taken aback; however, this proved to be a powerful moment in clarifying my ideas. Andrea challenged my emphasis on cooperation at the expense of competition in the classroom. Her suggestion was to emphasize both and that to eliminate competitive elements would deter many students from enjoying

PE. This was a mainly internal conflict for me because I am a notorious fence-sitter; yet, her critique forced me to address where I stand on these issues:

> My present stance on the role of competition in the PE classroom is that it can be included but is it necessary to include? There are different ways that someone can be competitive and there are certain forms of competition that I think need to be avoided. For instance, if competition is included, we must be careful to avoid fostering those characteristics or stereotypes of which we are trying to break down – that in order for you to experience success in this activity, you need to demonstrate the qualities of strength, aggression, toughness. How many other parts of school life have similar aims? Not many I would argue. Therefore, is the PE class the right environment to introduce kids to competition? I think the purpose of PE is introduce kids to the joys and benefits of movement and participation, with the hopes that they will find activities which they enjoy, or are stimulated enough by, in order for them to participate in it over the long-term, rather than to introduce them to the world of cut-throat competitive environments. I question whether it is the school's role to be responsible for this; it can be, but it does not have to be. (Journal Entry, 1 December 2009)

Becoming more comfortable with my vision for teaching enabled me to better articulate it to teacher candidates and encouraged me to explore and refine it further. In the past year, Shawn Bullock (a science teacher educator) and I have engaged in a collaborative self-study to examine our use of literacy pedagogies and their utility in framing our respective visions and pedagogies of teacher education. In Ontario, the concept of physical literacy has become an overarching theme for the revised K–12 Health and PE curriculum, and in order to become clear on its philosophy, aims, and potential to improve PE, I have grappled with its value for elementary teacher candidates and my own practice. The "big ideas" around which physical literacy is conceptualized have resonated with my own approach to teaching PE and teacher education. It has also helped me to be clearer about the "why" of my vision. For example, I relate to the focus in physical literacy on learning about a wide variety of physical activities (rather than on primarily competitive team sports) and enabling individuals to develop skills, attitudes, and knowledge that can lead to lifelong learning and participation (Mandigo, Francis, Lodewyk, & Lopez, 2009).

Through collaborating with Shawn and discussing physical literacy in my case and scientific literacy in his, I have filtered the elements of physical literacy into two terms that are meaningful to me, and, I hope, the teacher candidates: (a) transferability (of, e.g., skills and concepts across activities and domains) and (b) empowerment (through developing skills, attitudes, and knowledge that improve health in a broad sense). Physical literacy has given me a place upon which to hang my theoretical hat in terms of teaching vision and has helped me become clearer in articulating it to teacher candidates. By being able to articulate my own vision, I feel I am in a better space to be able to assist them in developing their own vision for teaching PE in elementary schools.

Conclusions and Implications

Self-study has provided me with tools that have helped me to interrogate and better understand my teacher education practices. Further, by understanding the prior experiences of elementary teacher candidates, I have been able to disrupt aspects of

my practice that perpetuated negative experiences and did little to challenge practices rooted in traditional and often exclusionary types of PE curriculum and teaching. Had I not understood the nature of teacher candidates' negative experiences as school students, I may have gone on with what I had been doing as a classroom teacher, armed with the inaccurate assumption that learning was taking place if they were having fun and participating.

I once believed that specialist PE teachers should be responsible for teaching all PE classes in elementary schools and that this was the only solution to improving how subject matter was taught at the elementary level. While I still believe that there are benefits to this approach, this self-study leave me less inclined to think about the issue in absolute terms. My thoughts are tempered by the realities of the education system, including the fact that a massive financial investment would be required either to prepare more subject specialists at the elementary level in teacher education or to have secondary specialists complete courses in elementary education. In Ontario, where literacy and numeracy take priority, shifting financial resources to other areas of the curriculum seems unlikely. Therefore, improving how elementary classroom teachers are prepared to teach subjects such as PE and science seems like a more appropriate and feasible approach.

Rather than dwelling on the negative aspects of having generalist classroom teachers teach subject matter, I now believe that there are several positives that may have been overlooked in the literature that provide clues as to why elementary classroom teachers may hold a key to educational change and improvement. For example, even when classroom teachers do come to teacher education with negative experiences, it is up to teacher educators to channel those experiences and have teacher candidates envision what would have made their school experiences positive and meaningful. As shown through the interviews, when participants in this research were asked to do this, their responses were closely linked to the progressive approaches to PE advocated by many researchers and policy makers. It is here where change can occur. Just as Lortie (1975) reported, those who choose to become teachers are likely to do so because they were successful at school and, in the case of subject specialists, mostly enjoyed the subject and the way it was taught when they were students. Thus they tend to adopt a custodial approach to teaching with aims to preserve its traditions and customs. This is particularly the case for prospective teachers of PE (Curtner-Smith, 2001), and I hold the analysis of my own story in this chapter as an example and further evidence of this assertion.

In this sense, if any subject is hoping to undergo change in the way it is thought about and taught, elementary classroom teachers may be the most likely candidates to adopt that change at the school level. This would require them to analyze their own learning experiences and be made aware of ways that the subject can be made positive and meaningful for their own students. I have made it clear that time is far too limited to achieve these aims in preservice teacher education; however, ongoing professional development programs in the beginning years of teaching may enable such change to be achieved.

There is an onus on those of us involved in both preservice and in-service teacher education to help teachers challenge their prior experiences of subject matter as school students and teacher candidates and shape positive visions of how

they might teach subject matter in the beginning years. Our task is made particularly difficult in subject areas such as PE and science where teacher candidates have often reported negative experiences with the subject matter when they were students. Self-study has provided a means to analyze and prioritize aspects of my practice and to create meaningful learning opportunities for teacher candidates. In turn, these processes have contributed to the development of my pedagogy of elementary teacher education.

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Chapter 7
Learning to Teach Physics Teachers: Developing a Distinct Pedagogy of Teacher Education

Shawn Michael Bullock

On paper, I could not have been better prepared to work with physics teacher candidates. My doctoral studies were filled with opportunities to both engage with teacher education research and work closely with teacher candidates. My dissertation followed five physics teacher candidates over the course of their B.Ed. program using methods of participant-observation, focus groups, and individual interviews to tune in to how they framed issues of learning to teach. I was appointed a Graduate Teaching Fellow for a practicum supervision course that provided me with the opportunity to work with teacher candidates during field experiences. Finally, I benefited from the ongoing mentorship provided by my doctoral supervisor, an experienced teacher educator and self-study researcher, as we shared teaching responsibilities for a physics methods course. Yet, despite all of my preparation, the first 2 years as an assistant professor have been as challenging as my first 2 years as a secondary school teacher. In this chapter, I explore the problem of developing a *distinct* pedagogy of teacher education as a new assistant professor. Although it might seem obvious that each teacher educator would have a unique pedagogy, in this chapter, I develop the idea of distinct pedagogy as pedagogy shaped by distinct events, or turning points. Despite a well-established identity as a teacher and a nascent identity as a teacher educator developed in graduate school, I found myself relearning how to teach physics teachers when principles developed from prior experiences proved insufficient in my new role.

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Context and Methodology

My self-study is set within the context of my practice as an assistant professor with responsibilities for teaching in both the teacher education program and the graduate program at the University of Ontario Institute of Technology (UOIT). Founded in 2002, UOIT is one of Canada's newest universities. Seven faculties provide programs for approximately 7,000 undergraduate and 500 graduate students. The Faculties of Education and Social Sciences and Humanities are located in the centre of the city of Oshawa, while the remaining five faculties are located about 6 km to the north. The Faculty of Education offers an 8-month, post-degree teacher education program leading to a Bachelor of Education. A concurrent education program is jointly administered with the Faculty of Science; students enrolled in this program complete some education courses and practice during their undergraduate studies before joining the Faculty of Education in their fifth year. The Faculty of Education also offers both M.A. and M.Ed. degree programs in Education and Digital Technologies. I joined the faculty in July 2009.

I have made the formal and systematic study of my practice a major component of my research program since my early days as a doctoral student. Initially, I studied my pedagogical development as a way of naming my prior assumptions about teaching teachers with a view to interpreting how my prior experiences as a classroom teacher framed the ways in which I was learning to teach pre-service teachers as part of my responsibilities as a doctoral student (Bullock, 2007). Although I continue to find studying my own practice to be a useful tool for challenging my assumptions about pedagogy, I now rely increasingly on the formal methodology known as self-study of teacher education practices (S-STEP), often referred to simply as self-study, as a way of developing an epistemological framework for how and why I teach in particular ways (Bullock & Christou, 2009). Self-study of my practice provides what Dewey (1938) referred to as *warranted assertions* for making claims. Loughran and Russell's (2007) claim that teaching can be considered a discipline has had a major impact on the way I think about my role as an education professor because it means that I must develop warrants for teaching that extend beyond stories of personal experience of what worked and what did not.

Self-study methodology provides a systematic way to develop warranted assertions for making claims about professional knowledge of practice by encouraging scholars to describe, interpret, and analyse their pedagogies of teacher education. It draws from and builds upon Schön's (1983, 1987) constructs of *reflection-in-action* and *knowing-in-action* by acknowledging that professional knowledge cannot be transmitted exclusively in propositions. Professional knowledge is tacit, reflexive, and grounded in personal experience. Self-study researchers draw on a variety of research traditions in their work, including action research, ethnography, narrative inquiry, and other, mostly qualitative, traditions; thus, 'one true method' for conducting self-study research has not emerged (LaBoskey, 2004; Loughran, 2005; Pinnegar & Hamilton, 2009). A recurring emphasis in self-study literature is the

problematic and the unexpected features of practice because self-study methodology 'looks for and requires evidence of reframed thinking and transformed practice of the researcher' (LaBoskey, 2004, p. 859). LaBoskey's (2004, pp. 859–860) four methodological considerations for conducting self-study provide a useful framework for my ongoing research:

1. Self-study is aimed at identifying and reframing problems of practice encountered by the researcher with a view toward improving his or her own pedagogy.
2. Self-study challenges the researcher's tacit understanding about teaching and learning by encouraging interaction with colleagues, students, and educational research.
3. Self-study generally employs multiple, usually qualitative, methods that are used in the broader education research community as well as qualitative methods that are unique to self-study research.
4. Self-study should be made available to the broader education research community for the purpose of consolidating understanding and suggesting new avenues for research.

Self-study of teaching and teacher education practice is far more complicated than simply writing about what went well or poorly in the classroom. It often begins with stories of practice, often focusing on the problematic or novel, and frequently moves in directions not originally anticipated by the researcher. Self-study research can produce clearly stated, warranted assertions about how an educator came to understand his or her own practice differently as a result of engaging in rigorous analysis of practice.

When I took up my appointment at UOIT, I began a research program on Developing my Pedagogy of Teacher Education. This program, which now involves studying my teaching in both the teacher education program and the graduate program, involves a variety of methods all designed to help me to describe and interpret the ways in which I am attempting to teach my courses. Parts of this research program have involved critical friends to help me analyse particular features of my teaching. Other parts of this research program rely on my own interpretations and analysis of classroom events. I regularly post to a password-protected blog, usually soon after I teach a class. I also use transcriptions of audio recordings to augment the data from the blog. The data collected and reported on for this chapter were collected using these methods. Data were analysed using techniques such as coding and constant comparison (Patton, 2002). In particular, I use the concept of turning points to highlight particularly relevant data.

Together with a colleague, I have defined a turning point as a 'rich description of a problematic issue' (Bullock & Ritter, 2011, p. 174) that invites careful analysis and helps one to understand pedagogical practice in a systematic way. More specifically, we offer four criteria for identifying turning points in self-study data (Bullock & Ritter, 2011, p. 175):

1. There is an affective (e.g., emotional or motivational) element to the data.
2. The data frame a problem of practice.

3. The author of the data is implicitly or explicitly asking for help from a critical friend.
4. The data are bounded by the action-present; there is still time to take action on the problem.

Although the third point implies a collaborative approach to self-study between two academics (e.g., Schuck & Russell, 2005), the notion of critical friendship might be more broadly conceptualized as a willingness to put data associated with personal practice out to the research community as a whole for review, analysis, and discussion. This willingness to make public the typically private world of the classroom is a hallmark of self-study methodology (Loughran, 2005). In this chapter, I report on two sets of turning points that challenged my pedagogy of teacher education: reframing how I teach physics teachers and the tensions of technological expectations. Before developing these themes, it is important to take note of my prior assumptions about teacher education.

The Road to the Academy: Developing Principles of Teacher Education

The concept of the 'apprenticeship of observation' (Lortie, 1975) continues to challenge me to think carefully about the implications for teacher education of the acculturating effects of mass schooling. The obvious consequence is that teacher candidates come to their teacher education programs with a lifetime of witnessing teachers' actions, often with little more than an intuitive sense of why teachers act the way they do. After at least 16 years of experiences with school, almost every teacher candidate can do a reasonable impression of how a teacher is supposed to act at the front of a classroom. Thus, teacher candidates certainly do not come to their programs as blank slates. Just as teacher candidates approach their new roles from perspectives constructed from a lifetime of classroom experiences, so too did I approach my new role with prior assumptions about how a teacher educator behaves. In this section, I describe two of the major sources for my assumptions about how to teach teachers: a series of self-studies that began when I was a teacher candidate and research conducted for my doctoral degree.

Learning from Self-Study

My first experiences thinking about the problem of teaching teachers came when I was a teacher candidate in the 1997–1998 academic year at Queen's University. One of the most powerful set of assumptions about how a teacher educator should behave

followed from a series of conversations about teaching I had with my physics methods professor, Tom Russell, who provided weekly comments to notes that I sent him about my teaching experiences during my practicum. In the second semester of that year, Tom invited me to comment on notes he made about his perceptions of the physics methods class he was teaching, which I was a part of. Our initial critical dialogue about teaching helped to shape the years of mentoring and professional friendship that followed. As we noted at the time, a commitment to discussing ideas about teaching in learning in a structured way required us to 'put faith in the process with little sense of the possible outcomes' (Russell & Bullock, 1999, p. 150). Although I did not know it at the time, the process that we were trusting was self-study methodology.

I followed a somewhat traditional route into teacher education; after 5 years as a secondary school teacher, I enrolled in full-time doctoral studies with concurrent responsibilities for teaching in the pre-service teacher education program. During the 2 years prior to beginning my doctoral studies, I gained some experience teaching teachers in a unique role that framed me as a kind of in-school consultant, exempt from regular classroom teaching duties. My duties as a learning plus teacher were to find ways to help students who were at risk—particularly those who struggled with basic reading and writing skills—to succeed in school. The school district provided me with a broad range of professional development activities that I was ostensibly supposed to share as best practices with colleagues who would then use these approaches with their students. In its initial iteration, my role was grounded in the train-the-trainer approach favoured by many corporations. I noted:

> My early experiences in teacher education were firmly rooted in what Schön (1983) called the swampy lowlands of professional practice. The school board and the training it provided represented a kind of ivory tower that seemed disconnected from the teaching situations that I found myself in on a daily basis. As expected, there was often considerably resistance to the idea of an in-school teacher consultant. I responded by presenting myself as a resource to help teachers work through professional problems rather than as someone who was simply trying to transmit school-board initiatives and policies (Bullock, 2007, p. 82).

Fortunately, I had a supportive administrator who understood that the most effective way to increase the quality of students' learning was to create productive, professional learning conditions for teachers in the school. I worked hard to ensure there were opportunities for my colleagues to have in-school meetings to talk about their teaching and their concerns about students' learning:

> Rather than pushing a district-sponsored agenda, I noticed that encouraging teachers to talk about their practice addressed most of the requirements of the school district. In particular, it was useful for teachers to have inter- and intra-departmental conversations about teaching strategies. Often, the results of these conversations were team-teaching collaborations not only between other teachers and me, but also between the teachers themselves (Bullock, 2007, p. 83).

After 2 years of working with colleagues as an in-service teacher educator, I felt confident in my abilities to work with pre-service teacher candidates. I summarized

my first set of principles for working with teacher candidates in the following way (Bullock, 2007, pp. 83–84):

1. Teachers' professional knowledge is tacit, and professional dialogue is a powerful way to make teacher knowledge explicit (Russell & Bullock, 1999).
2. It is important to provide experiences that encourage teachers to articulate their pedagogy in order for them to realize the characteristics of their default teaching style.
3. It is difficult for teachers to change their default teaching style because there are powerful cognitive and social factors that encourage a transmission-based approach to pedagogy.

The first problem of practice that I encountered as a pre-service teacher educator was the realization that my prior experiences as an in-service teacher educator were not sufficient preparation for my new role (Bullock, 2007). Although it was important to articulate my assumptions about teaching education at an early stage in my career, I soon realized just how much I had to learn about working with teacher candidates. One obvious difference was that I spent the majority of my time working with teacher candidates who were seeking certification as physics teachers, as opposed to working with teachers with at least 10 years experience across a range of disciplinary backgrounds. The other difference was that I was engaging with teacher education literature as a consequence of my doctoral work and, as a result, taking early steps in self-study methodology.

After a number of years working with my supervisor on collaborative self-studies about how we were teaching the physics methods course, I embarked on a collaborative self-study with another doctoral student, Ted Christou, to study a pedagogical problem that we faced as doctoral students charged with teaching two very different courses in the pre-service program (Bullock & Christou, 2009). Ted was responsible for teaching the mandatory philosophy of education course, which might be thought of as the most theoretical of all courses in the pre-service program. I was responsible for teaching one section of the course linked to practicum supervision, which might be thought of as the most practical of all of the courses in the pre-service program. In our collaborative self-study, we explored the complicated relationship between theory and practice in teacher education with a particular emphasis on how these concepts played out in our courses, in our teacher candidates' prior assumptions about our courses, and in our expectations for our developing pedagogies of teacher education. We concluded:

> As beginning teacher educators, we see our task as one of helping candidates challenge the familiar rhetoric surrounding theory and practice. A critical first step in this process involves interrogating our own assumptions about theory and practice in teacher education.... Teaching, when enacted, does not look like theory and practice combined together in some calculated fashion. Teaching is a fluid, dynamic process that takes many forms (Bullock & Christou, 2009, p. 87).

Our collaborative self-study continues to serve as an important reminder of the dangers of trying to separate theory from practice artificially in teacher education courses.

Learning from Research

The other major source for developing principles of teacher education was the research I conducted for my doctorate (Bullock, 2011). I combined ethnographic methods with collaborative self-study in order to describe, interpret, and analyse how physics teacher candidates constructed professional knowledge of teaching from on-learning experiences in a teacher education methods course and teaching experiences during their practicum placements. I was a participant-observer during each meeting of the physics methods course over the year, and concurrently, I engaged in a collaborative self-study with the professor for the course, Tom Russell. Conducting ethnographic research in the same methods course that I took when I was a teacher candidate and taught by the same professor provided me with powerful 'reading positions' (Segall, 2002, p. 8) that allowed me to bring both an insider and an outsider perspective to the research. Five teacher candidates volunteered to participate in the research; I conducted four focus groups with them over the course of the academic year. In addition, I interviewed each of the teacher candidates individually, after each focus group, to give them an opportunity to provide additional clarification to their thoughts and to share some ideas that they might not have been comfortable sharing in the larger group.

Several conclusions can be drawn from this research. First, the data clearly suggest that method courses can be relevant to teacher candidates' developing ideas about pedagogy; coursework in teacher education can make a difference. Second, the effects of the practicum placement may well be a conservative force in education, rather than a force for change. Third, collaborative self-study provides an important vehicle through which teacher educators can interrogate their assumptions about teaching teachers. Finally, the differences between what a teacher educator intends to teach and the messages that teacher candidates take from a course were striking. Although all five participants in the study were enrolled in the same course and each participant explicitly named several ideas about teaching that had been constructed as a result of the course, the ideas that each focused on were quite different. This last conclusion had a particularly strong effect on how I reframed my ideas about teacher education as I left my doctoral studies behind to embark on my new role as an assistant professor.

The First 2 Years

In the previous section of the chapter, I identified the two major sources of principles of teacher education based on self-studies conducted as a pre-service teacher, in-service teacher educator, and doctoral student and from research. I was eager to begin my new position, and I was conscious of the need to begin my physics methods course by living my principles of teacher education and sending the message to my class that I was more interested in working with the

experiences we constructed together than with providing tips and tricks for teaching physics during field placements I had to find ways to disrupt their initial assumptions about what can be accomplished in a teacher education methods course.

I had about a month between my arrival at UOIT and the beginning of my first methods course as a professor. One of the first things that I did was apply for, and receive, ethical approval to continue studying my own practices and to keep a research journal for data-gathering purposes. Initially, my principles of practice for teaching future physics teachers were these:

1. Teachers' professional knowledge is tacit, and professional dialogue is a powerful way to make teacher knowledge explicit (Russell & Bullock, 1999).
2. The apprenticeship of observation (Lortie, 1975), which names the effects of attending school and witnessing teachers' behaviours over many years, provides teacher candidates with a default pedagogical approach well in advance of their arrival at a Faculty of Education.
3. The content of a teacher education methods course is pedagogy, so how I teach is far more important than what I teach.
4. Teacher education courses can have an important effect on how teacher candidates construct professional knowledge about teaching and learning (Bullock, 2011).
5. Learning to teach is a difficult journey, fraught with tension, and so it is particularly important to create an environment of trust a methods course so that candidates feel comfortable talking about the tensions they experience during their pre-service program.

Reframing How I Teach Physics Teachers

After working closely with Tom Russell through different iterations of a collaborative approach to teaching physics teachers and devoting my PhD research to an in-depth study of how five teacher candidates learned to teach physics, I was excited to begin teaching my first physics methods course on my own. Somewhat arrogantly, I felt 'as prepared as I could possibly be… now I "just" have to find a way to live my pedagogical values'. I was also excited to learn that, since the first practicum experience at UOIT is a placement in either a grade 7 or grade 8 classroom, I had a compelling reason to focus on teaching science as well as on teaching physics.

The first challenge to my developing pedagogy of physics teacher education was the need to construct an assessment system that would allow me to determine a final grade for my teacher candidates. At Queen's, I had enjoyed the 'luxury of a Pass/Fail system… that took marks-seeking behaviour off the table and allowed candidates to focus on what they learned rather than what mark they were going to get'. UOIT mandates a letter-grade system and requires a minimum average of B – (72%)

for a candidate to do practice teaching. I resolved this initial dilemma rather quickly in the following journal entry:

> I had to realize quickly that UOIT has different rules about assessment than Queen's does; there is no point in wishing for a Pass/Fail system if it is unlikely to occur in the near future. Instead, I have made the decision to use the requirement of coming up with letter grades as an opportunity to teach about assessment and to offer the Ideas-Connections-Extensions (ICE) approach to assessment as a productive way to create a rubric… I have spent a considerable amount of time developing specific criteria for each assignment and I have set 72% as the minimum requirement for a 'pass'. Hopefully this will open the door to some relevant discussions about pedagogy and assessment.

Throughout the year, I was surprised by how rarely assessment was an issue in my physics class. The candidates seemed to accept readily the structure of the rubrics I had created, particularly, because the rubrics avoided the unhelpful language of 'most of the time, some of the time, and always' that characterize many rubrics created in school districts in Ontario.

The other early success that I had with the teacher candidates in my physics class involved my introduction of predict-observe-explain (POE) pedagogy (Baird & Northfield, 1992) on the first day of class, both as an alternative to the traditional way that science is demonstrated in schools and as a way to set the stage for a collaborative learning environment in which exploratory, hypothetical talk about teaching was emphasized and encouraged. As I have noted elsewhere (e.g., Bullock, 2007), POEs are the most comfortable form of pedagogy for me, as I have devoted considerable time to studying this teaching procedure both as a teacher and as a teacher educator. Doing POEs in the first class of the academic year continues to help me find ways to call candidates attention to features of their learning, as evidenced by the following two journal entries:

> *Year 1*: It is amazing how strong the desire is to find the 'right' answer, particularly when the equipment is so deceptively simple. One of the compounding factors about teaching at a university where everyone is conditioned to have their laptops out is that some of the candidates don't like to wait for the POE process—I've seen some Googling—which of course negates some of the point of the process. It reminds me of Tavris and Aronson's (2008) idea about cognitive dissonance; we're conditioned to minimize our experience of dissonance and so it shouldn't surprise me that some people want to short circuit the inherent discomfort in POEs.

> *Year 2*: I started out with three POEs, partially as a way of showing off my favourite pedagogy for the science classroom and partially as a way of setting up an atmosphere that underscores the importance of process over product. I think schools do a good job teaching us to focus on the right answers, and reading John Holt's book *How children fail* many years ago taught me that exclusively focusing on right answers can make some students terrified of the school experience. Of course, I believe that there is a place for 'right answers' in the science classroom, but there is also a (larger?) space for the kinds of opportunities that POEs provide for students.

Both entries highlight the way that I use POEs to signal the type of learning experiences that I wish to co-create with my teacher candidates. One of the big ideas that I try to get across early is the importance of thinking about science as more than a collection of right answers; teacher candidates are frequently amazed

at just how little their undergraduate coursework in physics, mathematics, and engineering has prepared them to make accurate predictions about how demonstrations will unfold.

One of the most significant challenges to my pedagogy of physics teacher education occurred due to a quirk of timetabling in my first year. Initially, I was responsible for teaching the mandatory, one-semester *Teaching and Learning with ICT* course to all secondary-level teacher candidates, which meant that those enrolled in physics had me as a professor for three courses (physics is a two-semester course). Midway through the first semester, however, I was asked to fill in for a colleague and teach the second part of the mathematics methods course. Given that 9 out of my 11 physics methods students had mathematics as their other teaching subject, I found myself teaching nine candidates four courses in the 2009–2010 academic year. I summarized the experience in these words:

> It is particularly challenging teaching two methods courses with nine people in both because I have to be mindful of what I have already said and done in the physics class before teaching the math class. Of particular concern are the two people who aren't also in the math class; I have to constantly check in with them to make sure I am not making assumptions about what their experiences have been in whatever their other methods course is.... Of course I also have to avoid repetition between the two courses, yet there are some big picture issues that I think merit consideration in both classes. Walking this tightrope is becoming exhausting; questioning my every move about whether or not this learning experience should occur in the physics class, the math class, or both.

Unfortunately, I again found myself in a similar situation in the 2010–2011 academic year. This time, I was no longer responsible for teaching the *Teaching and Learning with ICT* course, but I knew from the beginning of the year that I would be responsible for teaching the second half of the mathematics methods course. The numbers in each class made for a strange situation: 17 of 24 candidates in my physics class had mathematics as their other teaching subject; the mathematics methods course had 34 teacher candidates in total. Thus, in second semester of the 2010–2011 academic year, I faced the strange situation of walking into a class where I knew half of the candidates well, the other half not at all, and was responsible for teaching the second half of a methods course. I noted some of my concerns at the beginning of the second semester:

> The situation this year is bizarre to say the least. My dedication to focusing on big picture issues in teaching and learning and calling attention to the effects of learning in the methods course is working against me, somewhat. How do I repeat 'big picture' learning experiences in classes that are back-to-back, where half the students have already had the experience? The only solution seems to be to cut my losses to a certain extent and just try to split up the kinds of experiences I would have put into one course… [for example] we'll plan a unit in the physics course, and do microteaching in the mathematics course.... The biggest challenge will be to develop a relationship with my math class quickly so that I can have the same kinds of conversations with them as I do with my physics class. I'm not sure if that is realistic or not?

Ultimately, the official end-of-year evaluations revealed that, overall, both groups of teacher candidates thought highly of me and of the two courses. Yet, there was a marked difference between the types of comments made by candidates in the physics

course and by those in the math course. Candidates in the math course tended to write anonymous comments that focused on the activities that we did in the mathematics course, with a particular focus on the value of experiencing different approaches to teaching mathematics. Candidates in the physics course, however, tended to write comments that had very little to do with physics experiences that we had in class; their comments focused more on big picture issues of teaching and learning that, in my opinion, are not specific to any particular discipline. This experience was sufficient to convince me of the importance of being able to start a year with a group of teacher candidates.

The final major challenge to my developing pedagogy was the self-imposed requirement to do more with research literature in my physics methods course. Research into how people learn physics has been conducted for more than 30 years; a great deal of this research has been done by experienced physics professors who have turned their attention to the dismal performance of many university students in their introductory physics courses. This body of research, often termed physics education research (PER), is often published in physics journals rather than in education journals. Although there are clearly differences between teaching an introductory university physics course and teaching secondary school physics, many of the findings of PER are relevant to teacher candidates. For example, one of the clearest conclusions to be drawn from physics education research is that physics students are more likely to develop sophisticated conceptual understandings of material if they are taught using approaches that require active participation and that name and challenge students' prior assumptions (Lising & Elby, 2005; McDermott & Redish, 1999; Redish, 1994). Different authors have offered several possibilities for creating an active, student-centred approaches: Redish (2003) suggests a physics classroom centred around *interactive lecture demonstrations* that require students to make predictions and explanations based on instructor-driven demonstrations (similar to P.O.E.s), while Mazur (1996) favours a technique called *peer instruction* that asks students to engage in debate in pairs about a physics problem and then to commit to explanations with a vote, and McDermott (1995) suggests a modular approach to teaching physics that focuses on developing in-depth understanding of only a few concepts. Each of these authors and physics education research reports in general provide valuable of ideas and discussion points for teacher candidates. The sheer volume of literature would be overwhelming, however, for most beginning teachers.

I made *Five Easy Lessons* (Knight, 2004) the course text with a view to encouraging the candidates to engage with physics education research literature. Knight's book summarizes 25 years of research into how people learn physics and does a particularly good job of identifying common student misconceptions about physics. During both my first and second years of teaching, I have noticed that candidates seemed to 'resonate with the idea that you can do research on education' likely because 'most physics education research relies on familiar pre- post- intervention methods'. I introduced my classes to the PEEL database (http://peelweb.org) to provide candidates with specific teaching procedures to explore as possibilities for addressing the misconceptions outlined in Knight.

The Tensions of Technological Expectations

One of the main features of undergraduate and professional programs at UOIT is the commitment to mobile learning. Every undergraduate student is issued a laptop for the duration of the program. Students receive software bundles relevant to their program of study and 24/7 technical support, including the option of obtaining a temporary laptop to use in case their own laptop requires extended repair. The Faculty of Education is blanketed in wireless protocol, with enough power outlets and LAN connections for every teacher candidate to plug in if necessary. Given that UOIT bills itself is a mobile-enabled institution that students pay extra money on top of tuition to be in the laptop program and that my contract stipulates that I incorporate technology into my teaching, it is not hard to imagine why the expectations around using technology weighed heavily on my mind.

It is difficult not to notice the abundance of visible digital technologies on UOIT's campuses. Power outlets and LAN ports are conspicuous, classrooms have touch control panels at the front of the room, and desks are configured to allow people to use laptops at all times. Groups of students cluster in hallways in between classes with laptops open, balanced precariously on their knees. The fact that most students are using similar models of laptop adds to a feeling of uniformity, indicating that this is a campus-wide initiative rather than a coincidence. It also feels a bit Orwellian at the same time. I approached my position with a mixture of excitement and trepidation:

> One of the most appealing things about teaching at UOIT is the mobile-enhanced environment because I think that there is a lot of potential to use technology to create a different kind of learning experience, particularly given that I know exactly what kind of hardware each student brings to class. At the same time, however, I am very aware that students pay a considerable amount of money for a laptop that is loaded with a lot of software that they expect to learn inside and out. The problem is that I am unconvinced that software alone will make any kind of difference to the quality of students' learning. It seems problematic to add 'teaching software skills' to an already packed agenda in the physics methods course. How do I focus students on the quality of the learning experience created with software as opposed to software as an end in its own right?

This problem of practice that I encountered caused me to consider my initial pedagogy of teaching physics teachers in light of the implicit and explicit expectations of using technology at the school. I felt a tension between using technology to meaningfully teach about teaching science and using technology because I believed the students (and the university) expected me be a technology guru. I was initially unsure that I was suited for this role, as I noted:

> What does it mean to be an expert technology user in teacher education? It seems to me that digital technologies can rapidly become a 'wow' factor in the classroom; which is fleeting at best and distracting at worst. I've heard many times that professors and instructors here [across the university] have made a commitment to using technology in their teaching. But 'using technology' could be interpreted as 'using PowerPoints', which are just a crisper version of overhead slides.... We have SMARTBoards [interactive whiteboards] in almost all of our classrooms at the Faculty of Education, but they are set up at the front of the rooms just like a chalkboard would have been, which tends to imply that the professor or instructor will spend more time using the technology than the teacher candidates… what, if any, effect will that have on candidates' learning? Did I just become a Luddite?

Some of the tension in this turning point came from concerns I had with my own background in technology. For the first time in my life, I felt somewhat out of my depth as a technology user, even though 'I can trace my own use of technology back to the late 1980s when, as a teenager, I was heavily involved in the early BBS [Bulletin Board System] movement that preceded widespread adoption of the World Wide Web'. I was self-conscious of the fact that 'I have only one computer programming course to my name, yet I am teaching about technology in a university environment'. I wondered whether 'an expert-amateur/enthusiast knowledge of technology was enough to provide meaningful learning experiences for my teacher candidates'. Finally, I was 'keenly aware that I had not engaged deeply with the academic literature around the use of digital technologies in post-secondary environments', and so 'I had some catching up to do'.

My previous experiences as a teacher educator at Queen's University, co-teaching a physics methods course with an experienced teacher educator and teaching a course that involved supervising teacher candidates on practicum, helped to frame my expectations around using technology. Although I was reasonably confident in my ability to do something meaningful with teacher candidates throughout the year, I was concerned about my ability to incorporate technology 'ubiquitously and meaningfully' into my physics methods course. The overarching technology expectations at UOIT 'gave a different feeling from what I was used to at Queen's, where any use of technology felt like a bonus'.

The tensions between my prior experiences teaching physics methods and supervising practicum and my new role as an assistant professor came into sharp focus when I found out I was responsible for teaching the *Teaching and Learning with ICT* course as a part of my teaching load. I can trace the beginning of my concerns from a journal entry a few days before classes began in my first year:

> Three days before my first week of classes at UOIT and I cannot help but remark on the inordinate amount of time I have spent preparing to teach my 'Teaching and Learning with ICT' course. I am very cognizant of the fact that I am responsible for teaching all of the intermediate-senior students a mandatory course that could be thought of as the 'unique' feature of the Faculty of Education. Moreover, I am becoming increasingly sensitive to the fact that many of my colleagues seem to be expecting me to teach 'skills' in the course, so that they can rely on teacher candidates being able to do technology-rich assignments. I'm not sure how I feel about this course being about skill-building… What do I do with a course that has computer engineers and computer newbies in the same group? How can I make 'skills' meaningful to such a wide range of students? How can I focus the attention on *learning with technology* rather than learning technology?

Thus, the stage was set at the beginning of my first year to contrast the institutional expectations about using technology with my own expectations about how to teach teachers.

Although I was reasonably pleased with the way the first weeks of my physics class unfolded, my frustration with teaching the ICT course reached a peak after the third week of classes:

> I don't feel like I am doing anything of substance, it feels like a dog-and-pony show with technology. I have the technical skills and the knowledge to keep them interested and 'wowed' by the technical potential, but I haven't come anywhere close to unpacking the issue of teaching and technology, other than a brief discussion about avoiding terms such as

> 'e-learning', as though it was any different than (non-e?) learning.... Invariably, I feel pretty good after the class because I know that most of the teacher candidates (TCs) have been engaged by the 'flash-bang' on the screen. During the final third of every class, I provide TCs with the opportunity to work independently on any or all of the topics that are of interest to them. They can download a PDF module that I've prepared on any or all of the programs that I introduced. But again, the focus is invariably on the technical skills/capabilities of the TCs and the software, not the pedagogy. I wonder if it would be better to arrange for online modules/tutorials so that TCs could work through them at their own pace, and then we could meet a few times during the semester to talk about the pedagogical possibilities of the software that they explored?

Unfortunately, I was unable to move the course much beyond the model of show-and-tell followed by do-and-practice. It proved 'difficult to focus on the big picture when many candidates were struggling to access the correct menus and to conceptualize the possibilities of using robust software packages such as Adobe Dreamweaver'. Teaching this course did, however, assuage any fears that I had about content knowledge of technology. I was more than capable of responding to candidates' questions, and I knew software well enough to provide appropriately differentiated instructions for both novice and expert users. I was frustrated by the lack of time in the course to explore the issue of *how* digital technology can affect the quality of students' learning. In hindsight, I would have liked to focus more on the bigger themes around technology and pedagogy and less on the mechanics of how to use particular software packages.

Although teaching the mandatory ICT course for teacher candidates did boost my confidence as a subject-matter expert in technology, at least from a skills perspective, my second set of challenges around developing a technology-rich pedagogy of teacher education came just before beginning my second year at UOIT when I found out that I would be teaching two-M.Ed.-level graduate courses: Introduction to Adult Education and Digital Technologies in Adult Education.

The master's program at UOIT has a singular focus: education and digital technologies. Although many of the traditional curriculum, cognitive, leadership, and policy courses can be taken in the program, the focus is always on the role that digital technologies can play in education. The graduate program is taught completely online: classes meet once a week for 3 h in a synchronous Adobe Connect environment, where members of the class can interact using audio and video tools. The courses are supplemented with asynchronous tools such as wikis and course web sites.

On the surface, it might seem as though teaching two graduate courses has little to do with developing my pedagogy of teaching future science teachers. Yet, the content of both of these courses is of direct importance to teacher education, which is, after all, a type of adult education. In both cases, I had to engage with relevant literature to prepare for the courses. The second course in particular required me to think deeply about issues around using digital technologies in adult education environments, including teacher education courses. The courses gave me the perfect opportunity to try a variety of pedagogical approaches that explicitly focused on big pictures of teaching using technology. Although a full review of my technological pedagogical development at the graduate level is outside the scope of this chapter,

the following quotation from my research journal helps to frame how teaching at the graduate level might inform how I work with teacher candidates:

> I've noticed that I feel much less pressure at the graduate level when it comes to teaching using digital technologies. Of course, a big part of the increase in comfort level is that we [the class] are compelled to interact using technologies; we have no choice in the matter. In addition, the *content* of my graduate courses is both the research literature and the way that we interact as a group in an adult education environment, which is in this case a digital environment. I feel like I have the freedom to explore cloud-based technologies, such as ether pad [a real-time document sharing device], twitter [a microblogging service], and YouTube [a video sharing service to which I uploaded video podcasts for the course]. I don't feel like any of these technologies are add-ons, because the content of the course is how technology is used in adult education environments. I have begun to think of the graduate courses as a petri dish for testing, collaboratively discussing, and analyzing the effects of digital technologies on the quality of adults' learning. Already, I can definitely envision which technologies I would like to use with B.Ed. candidates and which technologies I would not use.

It is interesting to note that I have begun to view teaching in the graduate program as another lens to think about how I teach in the B.Ed. program. Students enrolled in my graduate courses play a valuable role as 'critical friends' (Costa & Kallick, 1993) as we explore the challenges and capabilities of teaching and learning together using digital technologies in an online environment. The next step is for me to adopt a similar approach with my physics teacher candidates by finding ways to have conversations about the capabilities of digital technologies in the B.Ed. methods classroom, supported by new insights gained from both exploring the literature and from successes with graduate students.

Conclusions: The Road Ahead

This chapter began with the premise that I was well prepared to assume a role as a teacher educator working with physics teacher candidates. Systematic study of my practice was a regular feature of my prior experiences as both an in-service teacher educator and a beginning teacher educator in a PhD program. As I became more conversant with the self-study literature, I realized that self-study offered a powerful methodology for making warranted claims about my developing pedagogy. Through collaborative self-study with critical friends, I was able to develop principles of practice grounded in my experiences as a doctoral student and teacher educator.

Although these principles were important in that they named my initial assumptions about teacher education, they did not provide a convenient set of answers for the problems of practice I encountered as an assistant professor negotiating the demands of a new role and working to meet the learning needs of candidates preparing to be physics teachers. For example, it might be relatively straightforward to say that 'it is difficult for teachers to change their default teaching style', but it is quite a different matter to do something about it. How can I live my pedagogical values in practice?

One of the most powerful lessons from my first 2 years as a faculty member is just how difficult it is to focus on big picture issues in teacher education as I encounter problems of practice in my work with future physics teachers. It is one thing to have principles to aspire to, but it is quite another to use these principles as a rudder to navigate the tumultuous waters of practice. In this chapter, I highlight eight turning points that contributed to two overarching themes: challenging my developing pedagogy of physics teacher education and challenging my technological pedagogy of teacher education. In all cases, the turning points were bounded by an action-present during which time I could take action on problems of practice and pay close attention to the reactions that were inevitably produced.

What I have realized from this self-study is that the specific features of the turning points are, in many ways, not as important as the effects they produce. In 5 years time, I am unlikely to remember clearly the specific challenges I faced when asked to teach multiple courses to the same group of people or the tensions I felt when providing a skill-based pedagogy to coursework in technology. What matters more, in the long term, are the ways in which my turning points contribute to overarching themes in my development, themes that in turn challenge my principles of teacher education.

The subtitle of this chapter is *Developing a Distinct Pedagogy of Teacher Education*. Initially, the term *distinct* might seem unnecessary, given that every teacher educator's pedagogy will be distinct and unique based on a variety of contextual factors. Such an interpretation uses the familiar definition of *distinct* as a synonym for *different* or *discrete*. I wish to push the concept of a *distinct* pedagogy of teacher education further, to refer to the multiple interactions that occur between my guiding principles and the problems of practice I encounter. Here, I frame the idea of distinct as a clear, unmistakable impression. Thus, a distinct pedagogy of teacher education recognizes the effects that problems of practice have on one's prior assumptions and principles.

My first 2 years as a faculty member were a significant test of my pedagogy of teacher education. The fact that I became a faculty member at a relatively new university with a major focus on use of technology generated many challenges; comparison with my former institution was inevitable. In some ways, the challenges associated with having to provide letter grades for the first time or trying to do more with research literature were mundane relative to the enormous cultural change associated with working at a mobile-enabled university and the associated expectations for using technology. Although my overarching principles of teacher education have not changed substantially, they have been challenged continuously by the multiple impressions made by new problems of practice. Each problem required action; those actions led to turning points in my thinking, and these left their marks on how I think about teaching future physics teachers. The process of developing a distinct pedagogy of teacher education, framed specifically around the joint challenges of teaching future physics teachers and using technology in meaningful ways, is far from complete.

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Chapter 8
Developing and Assessing Professional Knowledge as a Science Teacher Educator: Learning About Teaching from Student Teachers

Pernilla Nilsson and John Loughran

Self-study reports demonstrate that teacher educators can develop richer understandings of the complexities of teaching and learning, both for themselves and for their student teachers, through careful analysis of practice. Generally, the self-study literature tends to illustrate that learning about teacher education practices has focused more on programs and individual's practice (e.g., Berry, 2007; Brandenburg, 2008; Darling-Farr, Clarke, & Erickson, 2007; Samaras, 2006) and less on the particularities of the content being taught. Only recently have collections of self-studies of defined subject areas within teacher education emerged in the literature (e.g., Crowe, 2010; Schuck & Pereira, 2011). When teacher educators actively develop, assess and articulate the questions, problems, tensions and dilemmas in their practice within a specific subject area (e.g., teaching about the teaching of social studies, mathematics or science), specialized knowledge of that practice emerges. Such studies are important as they demonstrate the development of knowledge of practice within a specific content domain and offer new insights into teacher education practices.

Cochran-Smith and Zeichner (2005) called for more scientific research on teacher education – particularly in relation to how such studies could influence teacher education practices. As such, self-study research (Hamilton, Pinnegar, Russell, Loughran, & LaBoskey, 1998; Tidwell, Heston, & Fitzgerald, 2009) offers one way of responding to that call by facilitating the development and dissemination of learning from researching teacher educators' practice. Self-study research offers a

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powerful way of making explicit what one does and why, thus opening up to scrutiny the relationship between knowing and doing in teaching about teaching (Loughran & Berry, 2005).

Baird (2004) was of the view that teacher educators who begin by investigating their students' understandings of aspects of their teacher education program may learn something about the nature of their own actions as teacher educators and therefore gain new insights into the unintended effects of these actions. Wilcox, Watson, and Paterson (2004) drew attention to the fact that teacher educators' personal and professional learning is supported by their reflection on moments of disruption in their practice. The ability to reframe situations (Schön, 1983) and to actively seek out the disruptions and dilemmas that can make learning from researching practice uncomfortable is central to self-study. Berry (2004) captured the essence of this point when she stated that

> By researching their own practice, teacher educators ask themselves about the problems of teacher education and question how their own actions contribute to these problems. Developing a better understanding of the relationship between what teacher educators say and do is an important first step towards addressing such issues in their own work. In this way, the development of knowledge of teaching about teaching becomes both a personal quest, supporting the development of the teacher educator as an individual, and a professional responsibility, supporting the development of teacher education as a profession. (p. 1304)

Self-studies can pave the way for meaningful professional learning because they are embedded in teacher educators' real concerns and dilemmas within their practice. Pinnegar and Hamilton (2009) suggested that to understand practice more deeply, there is a need to use the voices of others in the practice setting to support the interpretations being made in that setting; there is a need to 'provide evidence of our claims about what our practice produces through their [students'] assignments, reflections, interviews, or actions in our practice' (p. 15). Therefore, drawing on the experiences of others is important, not just as a valuable source of data and analysis (Pinnegar & Hamilton) but also as a way of gaining alternative perceptions on situations under examination.

Unpacking teaching and learning to teach from the point of view of student teachers' experiences offers real ways for developing deeper understandings of their needs and their concerns (Nilsson, 2008). By using such experiences as data for investigating one's own practice, a self-study methodology allows that which may not have been seen, realized or understood in the practice setting to become more visible for teacher educators. Publishing such research then helps to share that learning with others and in the case of this chapter (and this book), does so in the context of teaching about science teaching.

Research Design and Context

As Baird (2004) so clearly explained, a self-study practitioner seeks, through reflection, a deeper understanding of context, practice and the interaction between the two. Through investigating her student teachers' understanding of their professional

learning (specifically in relation to pedagogical content knowledge) over time, emphasis on the nature of her own actions as a teacher educator and the effects of those actions on her student teachers becomes central to the study.

The data at the heart of the self-study that is reported in this chapter is based on what became known as the science education CoRe project (Nilsson & Loughran, 2011) that was designed to explore the development of student teachers' pedagogical content knowledge in the teaching of science. This chapter is then built around the question: 'What can a teacher educator learn through analysing her student teachers' teaching and learning experiences and how does that learning influence her teaching about science teaching?'. As such, this self-study explores the learning that emerged when the first author analysed her student teachers' learning about science teaching through the lens of their self-assessments of their developing pedagogical content knowledge (PCK; see Shulman, 1986, 1987) as captured through their use of content representations (CoRes; see Loughran, Berry, & Mulhall, 2006).

Pedagogical Content Knowledge

When Shulman first introduced the construct of pedagogical content knowledge, it captured the attention of researchers because it carried the allure of being a specialized form of knowledge of practice. He described it as 'the blending of content and pedagogy into an understanding of how particular topics, problems or issues are organized, represented and adapted to the diverse interests and abilities of learners, and presented for instruction' (Shulman, 1987, p. 8). Since that time, PCK has been interpreted and researched in many different ways, but it has always maintained a place in the academic literature as an idea that has attracted considerable attention and consistently been revisited. For example, studies have been conducted to compare and contrast individual teachers' perceived PCK (e.g., Magnusson & Krajcik, 1993), the PCK of teachers as a group (e.g., Clermont, Borko, & Krajcik, 1994), as well as very specific studies based on particular content and topics (e.g., Parker & Heywood, 2000). Gess-Newsome and Lederman (1999) offered a compelling overview of PCK that has been influential in the work of many, but, generally, PCK research tended to focus mostly on the work of practising teachers. However, in recent times, student teachers' learning about PCK has become increasingly apparent as a field of research (Nilsson, 2008; Woolnough, 2009), and with efforts to make PCK more explicit through the work on CoRes and PaP-eRs (Loughran, Mulhall, & Berry, 2004), new ways of understanding the development of student teachers' learning about science teaching and learning have emerged.

Briefly, a content representation (CoRe) is a detailed description for teaching a concept whereby the 'big ideas' for the teaching of that concept are explored and developed through specific pedagogic prompts: What do you intend students to learn about this idea? Why is it important for students to know this? What else do you know about this idea that you do not intend students to know yet? Difficulties and limitations with teaching this idea, knowledge about students' thinking that influences your teaching of this idea, other factors that influence your teaching of

this idea, teaching procedures and particular reasons for using them and specific ways of ascertaining students' understanding (for a full description, see Loughran et al., 2006). As such, working with a CoRe can help science student teachers conceptualize their professional learning and empower them to actively develop their professional knowledge of practice in specific content (i.e. offer glimpses into their developing PCK).

This chapter reports data from a program in which the semester begins with the student teachers being introduced to the CoRe approach. They then chose a specific science topic (chemistry or physics) to teach, both in the Science Learning Centre (SLC) at the university (in the middle of the semester) and during their 6-week school practicum (at the end of the semester). All student teachers (individually) complete an initial CoRe before teaching in the SLC (CoRe pretest). The CoRe acted as a prompt for student teachers to think about such things as that which they consider to be the 'big ideas' associated with teaching their topic based on their experiences, their knowledge of the content and of students' understandings, the teaching procedures (and particular reasons for using these) and their specific ways of ascertaining students' understanding or confusion around these ideas.

After their teaching experiences (which comprised that of the SLC, and their school practicum experience), all student teachers (individually) completed the CoRe for a second time (CoRe post-test). Following the CoRe, post-test participants compared and contrasted their two CoRes to determine how their thinking had changed and why. Through this reflection on their developing understanding of their teaching of science through CoRe construction, a formative assessment of their developing PCK was possible from both the pre- and post-test CoRe completions and the subsequent personal reflections on possible reasons for change from the participants' perspective. (There were other aspects to the CoRe project including self-assessments of level of confidence, perceived value, and understanding associated with CoRe completion on a scale of 1–10, as well as focus group interviews. However, data reported here is limited to that noted above because of the scope of the chapter.)

A teacher educator using such data through self-study methodology is able to learn about and develop their practice in meaningful ways because she or he is better informed about student teachers' issues and difficulties in learning to teach science. As such, student teachers' reflections on their approaches to teaching specific content offer feedback on their teaching and learning experiences in their teacher education program. Hence, the CoRe was experienced by the student teachers as a holistic tool to provoke their thinking about that which was important and why in the teaching of their chosen science topic.

The project was conducted within a primary science teacher education program in which student teachers ($n = 33$) used CoRes (Content Representation) as a tool to unpack their approach to the teaching of a science topic and the reasons for that approach. As such, the CoRe (Loughran et al., 2006, 2004) was used as a way of capturing the complexity and diversity of student teachers' PCK as well as to explore the questions, problems, tensions and dilemmas they experienced in their science teaching practice.

Beyond the data sources noted above, a critical friend (second author) was also employed in order to move beyond the individual practitioner and invite critique from another source. Methodologically, the use of a critical friend was important because 'working together and sharing ideas, issues and concerns with critical friends [can] help practitioners see beyond their own "world views" and broaden their perspective on situations in meaningful ways' (Loughran, 2004, p. 158). As such, a critical friend acts as a sounding board, asks challenging questions, supports reframing of events and joins in the professional learning experience (Schuck & Russell, 2005). Therefore, in this chapter, the critical friend played an important role in supporting and encouraging the teacher educator's self-study of practice through on-going conversations and e-mail contact designed to challenge and highlight discomforting situations that at an individual level may have been unattended or overlooked.

The results of the self-study (detailed in the next section of this chapter) are reported in the first author's voice as it is her experiences, her learning, and the development of her professional knowledge that is at the heart of this study. In essence, that learning is in response to two central questions:

1. What outcomes from the CoRe project informed my thinking about student teachers' learning about science teaching?
2. In what ways did these insights influence my conceptualization of teaching about science teaching?

Data Analysis

As the method section of this chapter makes clear, the self-study at the heart of this research project emerged as a consequence of a serious focus on the learning from teaching about teaching science (through the lens of PCK) in a primary science teacher education program. As has been noted many times in the self-study literature, the essence of learning through self-study is encapsulated in the nature of the knowledge that is developed as a consequence of the research. In this study, the notion of assertions (see, e.g., Berry & Loughran, 2002; Loughran, 2006) has been used as a way of framing and explicating the learning through the research as a form of knowledge that might not only speak to and inform the authors' practice but also be identifiable, meaningful and useable for others in their practice.

The language of assertions should be such that they easily make sense to the reader; hence, the wording of each assertion has been carefully constructed in the hope that such meaning is clearly conveyed. To ensure that the assertions are fully understood as evidence-based, and therefore carry a significant level of trustworthiness (i.e. as described by Lincoln and Guba (1985), that they are worth paying attention to), each of the assertions is explained with the data embedded in the explanation. In that way, it is anticipated that each assertion will then clearly demonstrate that the teacher educator has reframed (Schön, 1983) the practice setting in such a way as to question the taken for granted of existing teaching about science teaching.

Assertion 1: Student Teachers Do Not Learn From What I Say; They Learn From What I Do

This assertion is based on a realization that was similarly noted by Russell (1997) as he came to see the importance of his teaching about teaching in new ways as a consequence of listening more carefully to his student teachers' experiences. As Russell came to see his practice anew, he developed the mantra 'How I teach IS the message' not only as a way of directing and informing his pedagogical practices but also as a way of guiding his student teachers' learning about teaching. As such, he was constantly reminded of that which most influenced teaching and learning in his classes. In a similar vein, the assertion that 'Student teachers do not learn from what I say, they learn from what I do' offers a salient reminder that the very nature of teaching is crucial in shaping student teachers' learning about teaching. It also means that a teacher educator who works in that way is actively pursuing pedagogical practices through which actions and intentions are more closely aligned.

In working with a CoRe, a major conceptual issue is that of formulating the big ideas for the science topic under consideration. Big ideas offer a different way of thinking about how to structure a science topic from the typical curriculum approach that tends to be based around 'chunks of content' or information laid out in a stepwise fashion. However, simply telling student teachers that big ideas are not 'chunks of content' does not equate with their understanding how to conceptualize them in the way intended. They need the experience of attempting to develop big ideas and to analyse their attempts before they can grasp the full extent of how to conceptualize a topic in that way.

Although it appears obvious that experience matters in learning, the default position in teaching is often that of telling students about a problem then supplying them with the solution. That tends to happen more often than allowing them to struggle with the situation in order to better understand how to resolve the situation on their own. Hence, telling and doing are not the same thing for a learner, even though it can often feel that way to the teacher. Sandy's experience of formulating her big ideas is a reminder of that very point:

Sandy: In my CoRe 1 I wrote as my Big Ideas that the students should learn about nitrogen and oxygen. But in my CoRe 2 I thought it was more important to learn that air is something and that it exists even if we cannot see the particles.

The student teachers' self-assessments of their CoRes provided insights into issues that they considered problematic in terms of framing science content that, as their teacher, I overlooked. This is an example of not questioning the taken for granted assumptions. The student teachers found the notion of a big idea challenging because they had not previously experienced thinking about a topic in that way. I had introduced the CoRe in a way that I thought was thorough and careful. However, even though I talked a lot about the notion of big ideas and gave several examples of big ideas in science for different topics, the student

teachers still struggled with how to formulate them when constructing their first CoRe (CoRe 1).

In reviewing their learning, it became clear that the manner in which they were taught about big ideas had little impact. Actually, in retrospect, I am not so sure that I really understood the difference between a science big idea and sequential textbook information. 'Telling them' may have satisfied my need to get information across to them but it did not satisfy their learning needs. Helen illustrated that point well:

Helen: I think that doing the CoRe made me focus much more on what were the essential ideas in my teaching… yes, such as the Big Ideas and why they were big. As such it helped me to get to the heart of what is important for students to learn. The CoRe made me aware of aspects outside the actual teaching that I as a teacher am confronted with in my daily work. We get a lot of tips on how to reflect but I must say that the CoRe gives something like a whole picture of what I need to consider when I plan my lessons.

Helen illustrates a crucial aspect of learning about how to formulate science big ideas: Learning is embedded in reflection on experience, and teaching should create the invitation for learners to engage in such reflection. The student teachers' self-assessments were another reminder of the importance of creating experiences and situations for student teachers to facilitate deep reflection and to give them time and space to refine and reconsider their own personal approaches and/or perspectives:

Mary: To use the CoRe as a tool for planning… I have really understood the importance of taking the time and energy to reflect… because the questions are so important as a starting point for me to reconsider my own professional knowledge. The importance of a deeper and more structured reflection is something that I have learnt.

The CoRe data provided evidence of how my student teachers' personal assessments became an object for constructive discussion and how that promoted reflection on their beliefs, concerns and needs – all of which are essential for good learning. Hence, as became increasingly evident, their experiences of using a CoRe helped them to better understand their own development of PCK. In so doing, the complexity and diversity of their own learning helped them see how that influenced their thinking about their teaching of their students. In many ways, their learning about teaching mirrored those things that were apparent to me in my teaching with them:

Ann: I have noticed that a lot of students have difficulties seeing and understanding [science ideas] and that you need to explain, experiment and discuss this more carefully than I thought in the beginning. The things that seem to be easy and obvious for me can be very difficult for my students. This is really something I need to reflect on in the future. I experienced that the science content is quite easy for me and it might be difficult for me to understand that the students think that it is difficult. This is an important insight that I will bring to the future. I am aware that I need to reflect on this when I plan and conduct my lessons… I also see the importance of reflecting after the lesson on what I have experienced and what I can learn from my failures and successes.

The ways in which these student teachers assessed their development (through using the CoRes) and shared their reflective experiences reinforce the importance of learning being embedded in experience and that telling does not equate to teaching:

Fiona: It is not good to 'hurry' through the concepts and the lessons just because you want the students to learn as much as possible. This will only lead to you losing the students because it does not get interesting when they think that it is too difficult. Then the students might lose their confidence and also their interest. It is much better to be calm, clear and structured so that the students really learn what you intend them to learn, before you go further to the next step. You cannot start to build a house by building the roof.

Student teachers need opportunities and possibilities to recognize and reflect on their successes and failures in order to develop confidence in the authority of their own experience (Munby & Russell, 1994). As Munby and Russell explained, student teachers need opportunities to develop deeper understandings of their own behaviours and the ideas that shape their actions and to be supported in learning to trust their judgments about their learning from their own experiences. Developing confidence in the authority of their own experiences stands in stark contrast to mandated learning derived from the information presented through the authority of position. In essence, it does not matter so much what they are told to do, rather it matters how they are guided to reflect on their learning.

My student teachers' reflections on their teaching and learning experiences of using the CoRe, as a way of paying attention to their developing PCK, became a mirror for me to look again at my own practice. I began to more clearly see what I was (or was not) doing in my teaching and what I was 'telling' them to do when I thought I was creating learning about science teaching situations. This experience of learning about my practice by being more attentive to their learning made clear that it is not what I say, it is what I do that matters.

Assertion 2: A Teacher Educator's Pedagogical Purposes Do Not Automatically Translate into Student Teachers' Learning

As a science teacher educator, I have certain pedagogical purposes that underpin my teaching about science teaching such as to stimulate student teachers' development of content knowledge, PCK and self-confidence in teaching science; stimulate their engagement and motivation; and, further, challenge their thinking about science teaching and learning. I often contextualize my practice through my own teaching experiences and/or through an appropriate theoretical lens. My teaching is therefore based on the view that theory informs practice and gives meaning to our understandings of teaching and learning practices and that reflection on experience is one way of building professional knowledge. As a consequence, I know that in my teaching of science teaching, I often refer to my own experiences of teaching science in an effort to make my learning accessible to my the student

teachers. I do not believe this kind of thinking is unusual in a teacher educator's practice: If I share my experiences with my student teachers, or link the practice to theory, then they might learn through that approach. However, their self-assessments continually illustrated that my pedagogical purposes were not always recognized by my student teachers and certainly did not necessarily translate into their learning about teaching in the ways I envisaged.

Working with the CoRes has helped me see what it takes for student teachers to begin to examine the complexities of teaching and learning in science. No matter how much I am able to share my experiences of confronting students' alternative conceptions in my practice, it does not substitute for when student teachers seek out students' alternative conceptions in their own practice. Even though I can tell my preservice teachers that students often have difficulty in understanding concepts such as air takes space or that heavy objects can actually float in water, it is not until they experience *their* students' confusions, questions and reasoning themselves that they actually grasp the pedagogic essence of those ideas. Student teachers learn more through reflection on their teaching experiences than they do through reflecting on my teaching with them. That is not to dismiss the value of my teaching, but rather to acknowledge that it is a starting point for their learning about the complexity of science teaching, rather than as an end unto itself:

Chris: I thought that I knew a lot about students' conceptions and ideas. But when we had the lesson I understood that students have much more ideas than I ever could think of. They have a lot of different preconceptions and I guess that this is so hard to learn about in theory. Because how would you ever be able to be 'lectured' about students' spontaneous ideas and questions? So actually, I realised during the semester that the more teaching experience I got the more I came to see that students have a lot of ideas that are hard to predict… that really opened my eyes to how complex teaching is and how hard it is to learn to teach. The more you know, the more you understand that you don't know.

Teaching science is more complicated than student teachers initially believe. They need to experience students' confusion with concepts in order to genuinely grasp how that occurs and what it feels like to have to resolve such situations – experience precedes understanding. My student teachers' self-assessments continually highlighted how they had to have an experience in order to put their learning into practice in relation to their teaching and their students' learning.

Student teachers rarely, if ever, put the lessons I learned from my experiences into their practice. For example, despite demonstrating time and time again that students' ideas (i.e. working from students' prior knowledge) are crucial to shaping science learning, it was not until student teachers experienced it themselves in practice that they really understood the importance of accessing the learner's prior knowledge. Student teachers learned to tune in to their students' thinking in different ways, and this change in their perception affected both the student teacher and their class:

Ellen: Today, in the end of the project, I realise that the students' influence on lessons do not always need to be misconceptions. Students often have a lot of good thoughts and you have to be aware of and stimulate these thoughts.

Ann: When we did the mind map and this little guy came up with the suggestion that oxygen is blue. I was a little bit shocked and I did not know how to handle that comment. I mean, I did not want to say to him that he was wrong because I knew that he must have thought of the pictures of the human body where the veins are blue and the arteries are red. But I was not at all prepared for this and then the next time I did my CoRe I was much more aware of the different ideas that can come up… no perhaps not the different ideas but instead the fact that it is very difficult to predict a lesson in a correct way.

The CoRe project helped me see the power of doing research on student teachers' experiences in order to understand the complex interplay between my teaching and their learning. I now see the need to carefully clarify my purpose and select experiences for my student teachers that challenge their thinking and stimulate their personal growth. My student teachers do not necessarily interpret the pedagogical purposes that underpin my actions as important in shaping their learning about their practice. I need to be more attentive to student teachers' ways of expressing their experiences. As the data (above) suggests, the notion of alternative conceptions was clearly a crucial cornerstone in better linking specific content knowledge and pedagogy appropriate to developing better understandings of that knowledge in action. However, that purpose was not realized. Rather, many of the student teachers initially simply overlooked alternative conceptions as an influence on learning or lacked the confidence necessary to seek out and address alternative conceptions in their practice. As a consequence, I realize that I need to better understand how to use what I know about students' alternative conceptions in order to support the growth of my student teachers.

For many beginning elementary science teachers, there is a considerable difference between being aware of alternative conceptions and attempting to bring them to the surface in their teaching. The latter is considerably more demanding. It became increasingly clear that my pedagogical purpose of trying to identify important difficulties or limitations to science teaching and learning were not always visible or successful in influencing my student teachers' learning:

Mary: I have now had several lessons about water and I now know what the students have difficulties with and what they feel is hard to believe. Now I know more, but in my CoRe 1 it was mostly guessing. On the question of students' conceptions and misconceptions I thought it was very difficult to complete my CoRe 1 as I did not have any idea of what to answer… Now I know a little bit more about what a child at the age of 8–9 years can understand or misunderstand. But I have also realised that you cannot generalise for all students, they are all different.

There is little doubt that creating opportunities for student teachers to experience complex teaching situations, reflect upon them and then move beyond their immediate needs and concerns involves thoughtful approaches to teaching about teaching. As a teacher educator, it is important to be mindful of the importance of finding

ways for student teachers to identify with particular teaching situations so that they are more confident about taking risks and creating their own opportunities for complex teaching situations:

Alan: Before the school based practice I thought that I had several ideas about students' conceptions. But now I realize that I had a quite limited understanding of things that students might experience as difficult. I might have got some specific sporadic ideas during my teacher education but I must admit that it is not very multifaceted or definitive. So I don't even want to count it as an artificial experience that I could rely on. It could be compared with as if I know how to say yes and thank you in Japanese, it does not say that I know the Japanese language. But now after this semester with the CoRes and the teaching experiences I think that I have more to say and that is at least enough to be counted as an experience. I feel that I know more about these things and that I know some of the most common misconceptions connected to the Big Ideas even though I do not know their proportions… Before my school based practice I did not think about students' questions. But now I try to think of metaphors and explanations and also in particular to reflect on what the students might ask. When I had the lesson and heard all the students' hypotheses and questions I came to see that students have a lot more in their heads than we teachers can ever think of.

Assertion 3: It Is Easier to Justify Your Actions Than to Study Your Practice

Reflection in action has long been recognized as an integral aspect of learning about and refining practice (Dewey, 1933; LaBoskey, 1991; Schön, 1983; Zeichner & Liston, 1996). Like many teacher educators, I encourage my student teachers to reflect on the 'what, how and why' of their teaching so that they might begin to see into the complex nature of science teaching. As assertion 2 suggests, I believe that theory informs practice and gives richer meaning to understandings of teaching and learning. Such a view creates an interesting dilemma for me as it can easily become a 'taken for granted assumption' in my teaching and lead to a situation in which I justify my actions rather than reflect upon my practice. Underpinning this situation is the need to find a balance between meeting student teachers' learning about teaching needs and helping to push them beyond their needs in order to challenge their learning. Berry (2004) explored aspects of this issue through her notion of tensions. In so doing, she recognized the problematic nature of teaching about teaching and how important it is to see practice from different perspectives, i.e. to seek to reframe (Schön) situations, not just accept them at face value.

As the student teachers' reflections were mirrored back to me through their self-assessments, I could see how important it was for them to see that I have questions about my own practice such as why do I choose particular experiments for them to

experience, what influences how I respond to their needs and concerns, and why is practice problematic? When I analysed my student teachers' self-assessments, it became evident that they often transferred directly (without questioning why) my activities into their own teaching. Although I could happily justify my actions with them, when I reflected rather than rationalized, I could see that they were mimicking my practice without grasping the fundamental pedagogical reasoning at the heart of informed decision making in practice:

Fiona: What I am very satisfied with in my CoRe 1 was the method part and what to do but actually I found it difficult to explain WHY I chose these methods. That is why it is important to have an aim and a purpose with everything that you do.

I have learnt that by paying more careful attention to reflecting on my practice rather than justifying my actions, the pedagogical reasoning underpinning my teaching of science stands out more for my student teachers. In so doing, it helps them question their own teaching and to recognize the problematic nature of practice in a positive way:

Julia: When I compared how I had graded the meaningfulness in CoRe 1 and 2 I see different things that I felt were easy before but that I now experience as more difficult… which teaching methods I will use is also something that I consider as being more difficult [now].

Ellen: The question of why I want them to learn is good because you cannot answer that it is included in the school curricula… no you need to think of why the science content is important for the students. And I think that it is easy to forget about that. Yes, we are perhaps too focussed on what we and what the curricula bring up and we don't always consider the relevance for the students…

I need to remind myself to not allow the assumptions that underpin what, how and why I teach to become an excuse for my behaviours. It is sometimes easier to explain away some approaches because of the good intentions underpinning them than to seriously question approaches to teaching and learning. The taken for granted can mask the reality of the situation. I have become much more sensitive to that possibility through reflecting on my students' self-assessments:

> Analysing my student teachers' self-assessments became an eye opener for me about how easy it is to stick to your habits without reflecting on how your activities actually impact on student teachers' learning about science teaching… I want my student teachers to connect theory to practice and to use different pedagogical theories to inform their practice. But on the other hand, in what way do pedagogical theories inform our practices as teacher educators? It is much easier to justify activities than to really reflect on practice… I do not always communicate the reason for the activities to my student teachers. In the student teachers' reflections I noticed that a lot of activities they do with the children are the same activities that I do with them… the way the CoRe project required my student teachers to reflect on their Big Ideas and why they chose their different activities has made me question my own practice and the activities I choose. (e-mail correspondence with critical friend, 27 December 2010)

Assertion 4: Engaging with Science Must Be Seen as More Than 'Activities That Work'

Student teachers have a natural tendency to want to accumulate as many teaching procedures as possible in order to keep their students busy in the classroom and to have at their disposal a good range of teaching activities. My experience is that they filter their experiences in my classes in such a way as to build up a bank of activities that are easily transferrable to their classroom practice. As a consequence, I recognize the personal struggle between my desire to be acknowledged and appreciated as a teacher who can give them what they ask for and making clear that the different teaching activities fit together in a holistic way and are underpinned by pedagogical purposes. Finding a balance between giving them 'tips and tricks' and stimulating them to be more responsible for developing deeper understandings of science teaching is an ongoing issue.

When I analysed the CoRe data, I came to see how my student teachers often highlighted that they were doing experiments because they wanted their students to experience science as fun. One of my intentions in teaching about doing experiments is to help them see reasons for doing experiments, yet as their CoRe data illustrated, many did experiments without any deeper reflection as to why. A lot answered the CoRe prompt of 'why is this important for students to learn?' with 'they must see science as something fun and exciting'. Fiona's response (below) is indicative of that type of thinking:

Fiona: Here my Big ideas were different as I have changed my Big Idea in CoRe 2 to 'air takes space'. Now I realise that the Big Ideas in my CoRe 1 were a little bit unnecessary. I think that I should have explored these ideas further. I planned to use a vacuum pump but honestly I don't even know if I had a purpose with this activity. I only wanted to use it to make a 'fun experiment'… actually I don't know what I was thinking of here.

What becomes clear through the CoRe data, and why this assertion is so important for teaching about science teaching, is the need to find ways of helping student teachers see that enjoying an activity, being busy or entertained, is not the same as being engaged in learning. In my own teaching, I need to ensure that my student teachers see beyond science as fun activities or as Appleton (2002) described it – 'activities that work'. I need their learning to be a catalyst for developing more sophisticated thinking about science teaching and learning. However, if they only interpret my science teaching as an array of activities that work, then I need to find ways of making more explicit how the use of experiments matters for building conceptual thinking – both of science content and their science pedagogical content knowledge.

Over the years, I have developed a repertoire of successful teaching strategies and science activities that I know will engage student teachers in the classroom. From a student teacher's perspective, however, my practice might be interpreted as 'activities that work'. I now see a need to be much more sensitive to that as a shaping force for how I develop my practice with them so that they see beyond a superficial

interpretation of my pedagogy that meets their needs, towards a pedagogy of teacher education that challenges their thinking about practice at a deeper level:

Sandy: Concerning my teaching methods I have chosen the same methods in my CoRe 1 and CoRe 2 as I felt that the students were excited and liked what we did in the SLC [Science Learning Centre].

The same perhaps applies to the relationship between developing their understanding of the science curricula and the notion of big ideas. In their self-assessments, only a few mentioned the school science curricula and how the notion of big ideas actually helped in terms of implementing the curriculum in a meaningful way in their practice (which further reinforces assertion 2). I felt disappointed with that outcome because we had worked a lot with the national science curricula and I thought that the student teachers would see stronger connections with big ideas and the nature of the curricula:

Andy: We had chosen sound as we had looked into an experimental book that consisted of several physics experiment. We did not have very much knowledge about the content so when we tried to formulate the Big Ideas we worked them out from the small amount of facts that we had read in the literature.

When we started out with the CoRe project, we anticipated growth in students' learning about science teaching, but for some, that growth led to a regression in their personal self-assessment scores. This result (from the difference between self-assessment scores from CoRe 1 to CoRe 2) is, however, somewhat paradoxical because a decrease in confidence scores does not equate with a decrease in confidence in practice. Rather, it illustrates how student teachers come to see complexity of practice in new ways.

Learning about teaching science, if it is to go beyond accumulating activities that work, requires risk taking, and student teachers need opportunities to take risks and to learn from their experiences in positive ways. The change in confidence scores therefore draws attention to the fact that taking risks and experiencing the discomfort of being less certain about what is [or might be] happening encourages student teachers to question more deeply the nature of teaching and learning in science. Furthermore, experiencing a sense of frustration is important if they are to see and feel pedagogical problems in ways that will support risk taking and lead them to act in different ways:

Ellen: Another thing is that through the self-assessment when I compared the two CoRes I came to see how I developed or did not develop and that I even felt less confident the more I taught… Children are different and the situations will always differ. They have a lot of questions and ideas and the more you communicate with them the more you learn. Especially I became aware of the fact that students know much more than we think and that teaching is very complex and a lot of things can happen.

I need to provide my student teachers with chances to take risks and to experience uncertainty in their teaching in order to see beyond an activity that works

approach to science teaching and to seriously engage with teaching as being problematic. This change needs to begin with the ways in which I construct and conduct my practice with them.

Conclusion

This study illustrates how careful attention to student teachers' experiences, ideas, issues and concerns about learning to teach science can help a teacher educator explicate and articulate her knowledge of practice. In so doing, the research reported in this chapter adds to the literature on a pedagogy of teacher education that has been growing in importance over the last two decades (Crowe & Berry, 2007; Heaton & Lampert, 1993; Korthagen & Kessels, 1999; Ritter, 2007; Russell & Loughran, 2007). The four assertions outlined in this chapter offer strong reminders about important issues that influence teaching about science teaching. Although well explained in the literature, self-study is inevitably very personal. In conducting this self-study, I (Pernilla) have come to see a tension between my beliefs and my actions in a way that challenges me to work towards a balance between my desire to offer my student teachers important knowledge of primary science teaching (such as different teaching approaches that work) and helping to push them beyond their initial needs in order to challenge their learning. However, what also became clear through this self-study is that student teachers need activities to feel confident and better prepared for their teaching, but my role as a teacher educator is to construct experiences that lead to careful analysis of the use of these tools. This tension therefore continually shapes my practice in ways that have become clearer and more defined as a consequence of conducting this study.

The experience of developing my understanding of practice through the frame of assertions has helped me build further on the idea of purpose in my practice and has also helped me to better see myself as a science teacher educator struggling with dilemmas. Learning about teaching is problematic. Part of my role is to help student teachers in their journey from learner to teacher, which is a never-ending process of investigating and analysing their own learning in order to formulate their personal professional theories and to use these theories to guide future actions (Nilsson, 2008). The challenge for me as a teacher educator is to guide this journey in a way that helps them to recognize the problematic nature of teaching and learning about teaching and to see their practice from different perspectives. At the same time, structuring my learning through the notion of assertions offers me an interesting way of being reminded about the issues and concerns in teaching about teaching science. The assertions act as advance organizers in ways similar to that described by Ausubel (1960) and help me approach my practice in a way that is open and responsive to my student teachers' learning. Assertions help me to build opportunities for my student teachers to become more confident in learning from the authority of their experience. They thus help to stop me falling for the false sense of security that accompanies subconsciously operating

through the authority of position, which can so easily happen when telling masquerades as teaching.

Through this self-study, my student teachers' experiences and dilemmas became a mirror for me in terms of seeing the same in my own teaching about science teaching, reminding me again of the ideas of Bishop and Denley (2007) who stated that 'becoming a science teacher is not only a case of learning a predefined set of procedures and a static body of knowledge, it is about engaging with a dynamic and exciting subject and facing the challenges of presenting to students in an accessible way' (p. 2). Reframing my practice through self-study has produced better insight into the complex process of becoming a science teacher and what I as a teacher educator can do to support that process:

> I think it is interesting to [have done this] self-study because even though you do research on your student teachers' learning, that which you, as a teacher educator, learn from your student teachers is not always evident. However, working with a critical friend pushing your ideas further by asking the right questions puts your ideas under the magnifying glass… I guess that as experienced teacher educators we have (at least most of the time) quite clear ideas of what and why we are doing things, but these ideas might be not be very well expressed or articulated for ourselves or for our student teachers. Doing a self-study forces you to break down your old habits, which can be quite painful and create a lot of work, but it is a true way of actually improving your practice as a science teacher educator. (e-mail correspondence with critical friend, 9 January 2011)

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Chapter 9
Following a Student into Her Science Classroom to Better Understand the Tensions of Science Education

Deborah J. Trumbull

For many years, I have followed selected graduates of the Cornell University Teacher Education program, visiting them in their schools, observing their classes, and interviewing them about their work. Although these research projects were not designed as self-studies, what I have learned from the work has contributed substantially to my practice as a teacher educator. In this chapter, I analyze the story of a graduate who moved successfully into high school teaching in New York State. Of course a mere story, however good, is not enough. Berry and Kosnik (2010) stress the need for self-study to move "beyond the story," adding that "going beyond the story is not a cookie-cutter formula" (p. 218) and that it can be done in many ways. In the same issue of *Studying Teacher Education*, Loughran (2010) builds on Zeichner's (2007) challenge to ensure that self-studies contribute to the improved practice of the self-studier and other teacher educators and that self-studies also aim to influence policy. As Loughran points out, doing so requires that we "see beyond the story itself and push toward a sophisticated articulation of the knowledge that lies beneath the story" (p. 223). He notes the importance of "naming and framing the knowledge gained from self-study" (p. 223).

Naming and framing enable authors and readers to "seek the general from the particular" (p. 224), a conception of generalization developed by Donmoyer (1990) in his argument for the values of case study. Shulman (1986) made a similar point when he argued that "generalizability does not inhere in the case, but in the conceptual apparatus of the explicator. An event can be described; a case must be explicated, interpreted, argued, dissected, and reassembled" (p. 12). Of the studies Loughran mentions, Berry's (2008) explication of tensions inherent in teacher education best helped me to focus this story. The tension that I set out to explore in this self-study to explore is not new in teacher education, but it seems particularly salient

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in the USA. at this time: the tension between preparing new teachers able to enact reforms that are called for by leading bodies in science education and preparing new teachers able to succeed in the worlds of practice in today's schools.

I believe this new tension is exacerbated by current educational policy in the USA, where I am far from the only critic. Ravitch (2010), for example, makes a powerful case that the current emphasis on testing and use of test scores for making decisions about students and teachers is having negative effects: "Accountability makes no sense when it undermines the larger goals of education" (p. 16). Ravitch deplores the pervasive influences of a business mindset, with its focus on the bottom line, and explores how judging success only on results from single high-stakes tests narrows the scope of teaching and eliminates important curricular discussions. Wendy's story in this chapter illustrates some of the effects of such a focus. In her presidential address to the American Education Research Association, McDonnel argued that it is crucial to "reverse the causal arrow to examine what kinds of politics education policies create" (2009, p. 417). This story of Wendy illustrates unintended consequences of current education policies and current beliefs about education.

The story builds around a case study of one science teacher. Wendy (a pseudonym) majored in biology, completed the certification program with a master's degree, and moved into teaching. A former graduate student and I analyzed work that Wendy wrote during her time in the certification program. I visited her school in her third year of teaching, observed her classes, interviewed her before and after my observations, and talked with other teachers. This case study explores how Wendy understood biology content and teaching and her development of a teacher identity (e.g., Beijaard, Meijer, & Verloop, 2004; Beijaard, Verloop, & Vermunt, 2000). The case focuses on how Wendy's knowledge and views contributed to her identity and success as a teacher in a highly resourced and academically oriented high school. The cover story (Clandinin & Connelly, 1996) presented by the school describes a place that fosters student development and high achievement. Wendy's experiences reveal some of the secret stories (Clandinin & Connelly) about life in the school and how they constrained her development.

Pedagogical Content Knowledge as an Aspect of Learning to Teach

Since the initial work of Shulman (1986, 1987), much has been written about the particular kind of knowledge developed by teachers through teaching. One facet of this knowledge has been pedagogical content knowledge (PCK), which is an amalgam of knowledge of one's content area, knowledge of teaching approaches and strategies, and knowledge of students. Together, PCK enables a teacher to help her students master the important content in the discipline. PCK continues to be an elusive yet powerful construct for those of us in science teacher education; elusive because it is a form of knowledge enacted in actual practices requiring careful planning to elicit, and

powerful because, among other things, it provides a framework that helps integrate findings from the alternative conceptions research (e.g., Duit, 2004; Pfundt & Duit, 1994). The implicit argument in many studies seems to be that if beginning teachers know the alternative conceptions held by novices about key science ideas and recognize that novices indeed have formed alternative conceptions, then they will be much better able to respond to these nonorthodox ideas appropriately and also better able to recognize other alternative frameworks that interfere with development of the accepted science understandings (De Jong, Van Driel, & Verloop, 2005; Loughran, Berry, & Mulhall, 2006). The extensive research on alternative conceptions in science, then, provides a way to buttress beginning teachers' understandings of their content with understanding of how their students might think about that content and with teaching strategies to respond to student difficulties. A teacher education program, then, must foster in its developing teachers the propensity to take their students' ideas seriously, to seek to make sense of them, and to respond constructively.

Identity

Becoming a teacher requires preservice teachers to develop a new identity, a new way of being. Bullough (2008) noted that teacher development is idiosyncratic, shaped by both biography and teaching context. His extensive collaborations with teachers have documented the myriad ways that contexts and individuals interact in development. Bullough used the work of Goffman (1959) and Harre and van Langenhove (1999) to describe the development process, noting that "through interaction speakers constitute and reconstitute one another in a kind of moving and often competitive symbolic dance with contextually set rules and established but ever-shifting boundaries" (Bullough, 2008, p. 54).

Beijaard et al. (2000) also used the notion of identity to understand teacher development. As befitting a symbolic interactionist frame, they describe how identity develops through interactions in social situations as individuals come to take on social roles and internalize them. In their explication, it is clear that these interactions involve individuals' interpretations of their experiences and others' reactions to them as actors in the setting. Identity changes as individuals reinterpret earlier experiences, have new experiences in new contexts, and evaluate these new experiences. Identity development is not a passive process; it requires self-evaluation and reflection on one's self and one's experiences.

Beijaard et al. considered that professional identity involves three areas: subject-matter expertise, didactic expertise, and pedagogical expertise. They cite the line of research initiated by Shulman's conceptualization of teacher knowledge as pivotal for the increased attention paid to teachers' subject-matter knowledge, particularly pedagogical content knowledge (Shulman, 1987). Didactic expertise refers to the skills that teachers use for managing: managing student actions, managing their presentation of material, and so on. Development in this area is, of course, crucial

for new teachers, but as Beijaard and colleagues make clear, it is only one aspect of professional identity, albeit the one to which novices most often attend. Principles, skills, and general techniques are all part of what Beijaard et al. (2000) refer to as didactic expertise. Understanding context, however, and responding with what is best for the persons involved correspond to pedagogical expertise.

Beijaard et al. pointed out that pedagogy, in contrast to didactics, constitutes the moral and ethical side of teaching. For example, the teacher's involvement with students is an aspect of pedagogical expertise. "This encompasses, among other things, what is going on in students' minds, ways of communicating with and speaking about other people, and personal or private problems students have" (p. 751). I believe a key aspect of pedagogical identity is the concern with students' understandings and willingness to take their conceptions seriously, as something more than mere wrong ideas.

Evidence Analyzed to Prepare the Case Study of Wendy

The Interview About an Instance (IAI)

For many years, I have used an assignment designed to demonstrate to preservice teachers that novices, not science or mathematics majors at university, hold ideas about everyday phenomena that are often quite different from orthodox disciplinary conceptions. The assignment was called the interview about an instance (IAI), based on the work of Bell, Osborne, and Tasker (1985). Preservice teachers had to interview novices to learn how they thought about some instance that instantiated some key notions from the discipline. The Instance could be a common scenario, an apparatus, or a demonstration.

In prior research, I examined how this assignment worked (Trumbull, 1991; Trumbull & Slack, 1991). There were several aspects of the IAI with which students had difficulties. Some had trouble thinking of concrete instantiations of key concepts, such as using the boiling of water to probe ideas about phase change and energy. Some had trouble identifying key conceptions in their disciplines, focusing instead on isolated facts. Some could develop good instances embodying key notions but had trouble eliciting an interviewee's ideas because they unconsciously (or perhaps consciously) turned the interview into an oral examination. Some, after being successful at all the preceding aspects, had trouble making sense of what their interviewees said, resorting to identifying correct and incorrect ideas rather than looking for an underlying framework that could explain the interviewee's conceptualization. My analyses of the IAI showed me that even though I was teaching an education course, I could not ignore students' content knowledge but had to work with them to articulate, refine, and perhaps revise what they understood. I had not thought of this assignment as fostering development of PCK, but I have come to use it as one way to initiate a deeper understanding of subject matter and foster the propensity to attend seriously to learners' alternative conceptions.

Observational Assignments

I developed other assignments to help preservice teachers observe more professionally in their fieldwork placements. Three different assignments asked them to describe the pupils they were observing, to characterize a pupil that intrigued them and explore what was intriguing about that child, and to interview one or two students after a lesson to explore what they had learned. These assignments, including the IAI, were all completed during the first pedagogy course in the teacher education program.

Student Teaching Portfolio

Students completed a portfolio during their student teaching. The final section of the portfolio asked them to analyze what they had learned about themselves, their pupils, their content area, and the system.

Analysis of Wendy's Work

A graduate student (now a colleague) and I analyzed the work completed by over 20 students in three successive cohorts. We began our analysis of the new assignments using a constant comparative/grounded theory approach (Strauss & Corbin, 1990) but soon moved to the approach described by Charmaz (2000). Our analysis was an iterative process combining successive waves of careful reading and coding of data and reference to the wider research literature to refine initial codes and then movement back to the data. Three of us developed the early codes using one cohort of students, and then Fluet and I used these codes to develop categories linked more carefully to the literature. We checked our categorizing for consistency and then analyzed the work of preservice teachers in three subsequent cohorts. We looked at work completed in my course, the first of the pedagogy courses, and work completed in the portfolio that documented and analyzed their student teaching experiences (Trumbull & Fluet, 2007a, 2007b, 2008). We used these categories to analyze Wendy's work on the observational assignments and I used categories from prior research to analyze her work on the IAI. On the observational assignments, we identified two key categories: perspective and making claims.

Perspective

Preservice teachers wrote their assignments from different perspectives. Becker and colleagues used G. H. Mead's conception of perspective to understand differences they observed between the actions of medical students. A perspective is "a co-ordinated set of ideas and actions a person uses in dealing with some problematic situation, to refer

to a person's ordinary way of thinking and feeling about and acting in such a situation" (Becker, Geer, Hughes, & Strauss, 1961). Individuals' interpretations of their experiences contribute to, and are reflective of, the formation of identity, so it is important to look at how interpretations are made. The notion of perspective also helped to connect Wendy's story to the wider framework of education in the USA. Writing in the journal *Symbolic Interaction*, Luescher (1990) points out that Mead's notion of "the objective reality of perspectives" (p. 1) has not received the attention it should and goes on to explore how the notion can bridge micro- and macrosociology. "Ultimately, Mead made use of the concept of perspective in order to describe 'the world in its relationship to the individual and the individual in his relationship to the world'" (Mead, 1938, p. 115). Luescher noted that in using the notion of perspective to examine everyday experience, "perspectives are embedded in temporal relations, in short, in the context of action" (p. 3) and that there is "an unavoidable connection between action and its justification, including the constant necessity of ethics, be it only because ethical statements always anticipate a part of the future" (p. 3). I should note here that our use of the terms "teacher perspective" and "student perspective" has meanings opposite to the way Korthagen, Loughran, and Russell (2006) used those terms. We used perspective to characterize the ideas and actions the preservice teachers revealed in engaging with the assignments and how they responded to the opportunities the assignments were meant to provide, not whether preservice teachers considered the perspectives of the students with whom they were working.

Making Claims

We wanted to educate reflective teachers. For analysis, we operationalized reflection by noting if and how the preservice teachers used evidence to support claims they made and, when they used evidence, if they were able to regard their conclusions as tentative (Rodgers, 2002). This gave us three levels of reflection. Spontaneous interpretations were claims that provided no supporting evidence, revealing lack of reflection. Certain claims were made with supporting evidence but failed to consider any alternative interpretations. Tentative claims involved the use of evidence and included more than one possible interpretation of that evidence, which we considered the highest level of reflection. After several trials with coding, we soon came to agreement and could use these three categories consistently and with explicit justification. We counted the number of claims made by each preservice teacher and characterized each claim.

Doing the Interview About an Instance

In analyzing the IAI, I looked at knowledge of content, ability to elicit interviewee ideas, ability to relate an analysis of interviewee ideas to standard concepts, and ability to avoid turning the IAI into a session of teaching or testing.

Pedagogical Content Knowledge

For this case study, I also looked for evidence of Wendy's content knowledge and/or nascent pedagogical content knowledge across all the assignments.

Wendy as a Transitional Preservice Teacher

Wendy interested me because she seemed so transitional, and here I present extended quotations from her work to show this transitional status. Wendy generally made more claims than most of the other preservice teachers studied but rarely made any tentative claims. Wendy never wrote an assignment consistently from a teacher perspective; she mixed teacher and student perspectives in her work. Even her portfolio, the culmination of her student teaching, showed these shifts of perspective. Wendy's performance on the IAI showed many of the difficulties I had documented in earlier research, but she improved greatly when she did the IAI a second time. The following quotation from her first assignment illustrates a mix of both spontaneous and certain claims and also use of the student perspective:

> This student seems quiet, reserved, and appears to be studying notes intently whenever class is not going on. At the same time, she is often seen during lecture slumped over her desk with a sleepy expression in class that the teacher likes picking on, or she actually is asleep in class. (Wendy, A1)

It is not clear what "quiet" and "reserved" meant for a student in that classroom, although "slumped over her desk with a sleepy expression" provided explicit evidence of the student's behavior. That "the teacher likes picking on [this student]" is not only a spontaneous claim offered with no evidence but an illustration of Wendy's student perspective because the term "picking on" is such a loaded term—one that a student would use to describe a teacher she did not like—and Wendy failed to describe the teacher's actions or explore possible reasons for the actions.

In the assignment that documented student learning for a particular lesson, Wendy's student perspective was evident, as was her failure to speculate in ways that might have helped her develop her pedagogical content knowledge. She failed to explicate the key ideas students should be learning or speculate about whether high school students with no knowledge of chemistry could develop understanding of these key ideas. She interpreted the lesson from her own experiences as a college student:

> I noticed that the lesson was very diluted in detail, with no mention of leading and lagging strand definitions, Okazaki fragment formation when creating the complementary strand on the lagging strand, 5'-3' movement of DNA polymerase, and the name of the unwinding enzyme (helicase – even though it was described just as a general "enzyme"). Overall, it felt that this class understood the steps behind DNA replication as taught by the teacher. However, there were some concepts that were so overly simplified that they were conveying the wrong idea, and I wonder how this is going to affect their learning of biochemistry later on. [Wendy, A3]

As with her spontaneous claim that the teacher was "picking on" a particular student, Wendy failed to ponder why the teacher might have "diluted" the detail in this lesson or acknowledge that the level of understanding expected for a high school class should differ from that expected in her advanced college class. Wendy did not attend to student learning, noting only that it "felt" like the class understood. We see how her student perspective has curtailed speculation that might have helped her develop pedagogical content knowledge.

Although Wendy referred to interviewing several people before she was satisfied she had a good interview to write up and hand in, the IAI assignment she handed in had many problems. After consulting with me, she rewrote the assignment and submitted something much better. In fact, she revised and resubmitted three of the five assignments as she worked to keep her grade high. Each time, with guidance, she improved. A failure to speculate about content knowledge was apparent in her first interview about an instance. Wendy chose to interview novices about their experiences with the common cold. This Instance has worked well for many students because most people have had colds and developed ideas about how to treat them or avoid them. Conversations can reveal a novice's conceptions about key biological conceptions such as the germ theory of disease, the immune response and associated physiological changes, bacterial versus viral infections, spread of disease, and the like. Although Wendy listed many of these topics in her description of her Instance, she failed to provide detail about them and indicate how they related to the Instance.

In preparing the IAI, students develop an interview guide, a list of possible probes to explore interviewee's possible responses. Developing these probes should require thinking about what an interviewee might say. However, Wendy developed and used a strict interview protocol, which she followed rather closely instead of following up on what her interviewee actually said. Her first two questions were:

1. Explain how you felt the last time you had a bad cold.
2. Did you have a fever? [This question served as an opener because several later questions involve asking about technical details of the body's response to a fever.]

The first question, although it might invite conversation, could also easily move the interviewee's focus from simply describing the last cold to seeking to *explain* how he or she felt. (The difference is subtle, but Wendy was interviewing other Cornell students who have been trained to be sensitive to the difference between describe and explain.) The second question takes away any opportunity to follow up with what the interviewee actually said. Wendy's parenthetical remark showed her conception of the IAI as an oral quiz, which would allow her to "ask about the technical details." One segment from her assignment reveals the effects of her approach on her interviewee:

> When asked when the last time she had a cold was, she told me that it was almost a month ago, and described it as "I was extremely tired… and umm… my throat hurt… bad runny nose, sinuses were overreacting. Generally just felt bad, couldn't get over it." She was unaware of whether or not the sickness had involved a fever because she had never taken

> her temperature. She also mentioned that colds were caused by viruses, but sounded unsure. When asked about why fevers occurred, there was a great deal of uncertainty and slight impatience with the question – "I guess… the inflammatory response… I guess antibodies trying to fight off infection, I don't know!" She also was unsure of what cells were involved in fighting colds, and assumed they were B-cells.

This segment shows several missed opportunities to follow up on the interviewee's thinking. Wendy could have asked "What do you mean, 'your sinuses were overreacting'?" or "Did you do anything to try to get over it?" Instead, Wendy moved into her planned fever question. Although she noted that her interviewee had "a great deal of uncertainty and slight impatience," Wendy never attributed this response to her interviewee's intuition that Wendy was looking for orthodox answers. Wendy's evaluation of her IAI performance was:

> However, overall I believe that I was able to help my interviewees think about a subject in ways they had not considered before, and search for the reasons they act in specific ways to counteract a cold, which seemed they had not given conscious thought to in the past.

This sentence encapsulates Wendy's failure to understand that doing the IAI should enable her to elicit and explore an interviewee's conceptions, an important aspect of developing PCK and a professional identity. Her view of teacher as giver of information permeated her first attempt.

Wendy completed another interview and made significant progress. Although she did not develop the content section, she avoided blindly following her list of questions and did follow up on her interviewee's thinking. She wrote:

> From repeating this project, I learned that my abilities to elicit people's ideas and to understand them have improved with a better knowledge of what this project is actually asking of the interviewer and the purpose and necessity for natural conversation in the interview. From this interview and the previous two interviews I conducted, I have learned to improve my interviewing skills by not leading the interviewee into agreeing with me or manipulating him or her to say what I want to hear. My abilities to elicit people's ideas and understand them have improved since the last time I conducted the interviews because I am more aware of keeping myself from "leading" or "teaching" my own ideas about the topic, and I am leaving the opportunity open for them to express what they believe, what they are interested in, and what they want to elaborate in detail for me. I am also improving in my ability to probe the interviewee to tell me more when there is an idea that I am not clear about, so I am getting more than just a surface understanding of the meaning behind what the interviewee is trying to say.

Here we see Wendy coming to realize, at least, the purpose of the IAI. It is less clear that she sees how listening carefully and probing ideas relate to teaching.

Another example of a mixed perspective appeared in her portfolio, written over a year after the earlier segments. She stated the goal that her students learn to think independently. However, her justification for this goal was not a concern that students develop as persons able to think independently outside classrooms or that biology knowledge was built by connecting ideas. Rather, her justification stemmed from her own experiences as a college student:

> Students moaned and groaned about having to think through what was given in notes and homework to figure out the answer on their own, and were not used to my habit of integrating inquiry into my teaching, but I was determined to make them think about "why."

> Personally, I have had a terrible experience with chemistry lab work in college because my high school chemistry classes were run the same way [as her cooperating teacher did] and I did not want to see my own students face the same fate in upper-level science classes due to a lack of understanding and expectation of being spoon-fed answers. [Wendy, Portfolio]

In summary, while in the teacher education program, Wendy failed to write consistently from a teacher perspective, did not attend carefully to key biology concepts underlying factual material and how they could be taught, and seemed to hold a strong view of the teacher as the giver of information. However, she worked hard and had moments of insight, as demonstrated in her revised IAI. I should make clear that Wendy did show confidence, organization, and good didactic skills in my observations of her, both in student teaching and in her third year of teaching. She adopted a persona that students teased her about, calling her "Dragon Lady," but she enacted this role with humor and an obvious willingness to help students perform well. She was business-like, made her expectations clear to students, and was well organized in the classroom. Students appeared to respect and like her, taking time to talk with her before, during, and after class.

Wendy as a New Teacher

A symbolic interactionist perspective holds that identity develops through interactions within particular contexts and with particular individuals. The school in which Wendy was teaching when I visited her was a highly acclaimed school in a well-to-do area of New York State. The median household income according to the 2010 census was $78,000, and the median family income was $98,700. More than 50% of the population over 25 years old held at least a bachelor's degree. Wendy's school was only a few blocks from the lovely old town center. When I pulled into the school parking lot, the guard helped me to find a parking spot but asked me to make sure, when I checked into the main office, that the car could stay there. The personnel in the main office cordially assured me that my car was fine where it was. I could hear a very good orchestra rehearsing when I went looking for the Science Department office. The hall monitors I passed were pleasant and helpful. The school has a reputation for being an outstanding public school. In the published data about student performances on the New York State Regents examinations, students at East High scored highly in all content areas. (For information on the examinations in biology, see http://www.nysedregents.org/livingenvironment/).

The methodologist in me cannot resist the opportunity to illustrate the iterative and on-going nature of this work. I had analyzed my observations and interviews with Wendy to highlight the conditions of practice that constrained or encouraged her development of PCK and professional identity. Her quotations revealed some of the secret stories (Clandinin & Connelly, 1996) of the school, aspects not unfamiliar to anyone who has worked in prestigious schools. Then I read an ethnographic study of a similar school (Demerath, Lynch, Milner, Peters, & Davidson, 2010) and realized that the categories in the findings in that study reflected many

aspects that Wendy had experienced: "The class cultural community achievement ideology, the schools' institutional advantaging of its pupils, … and parental intervention in school" (Demerath et al., 2010, p. 2935). My visit was far from an ethnographic study, and it was not my intent to develop the kind of analysis that Demerath and colleagues did. However, the similarities between their analysis and Wendy's experiences are striking, and so I use two of their main categories to frame the following sections.

Cultural Community Achievement Ideology and Advantaging Students

When I visited her classroom, Wendy introduced me as her former professor from Cornell. Usually, this introduction elicits very little response, but in this classroom in this school, there was a significant reaction from the students. Several students approached me with questions about applying to Cornell, what grades were expected, how many letters of recommendation were needed, and other related questions. I was clearly a resource from which they hoped to learn about the secrets for a successful college application. I later asked Wendy about her students. Her answer revealed her relations with students, her humor, and some of her expectations:

> They tell me all sorts of stories. Like this year I have one student, they're like, "Did you know he got hit by a car three times?" I'm like, "Well, you know what? He's got the top average in all three classes. He must be getting smarter every time." [We laugh.] So I think they're pretty comfortable with me. They know I care a lot about how they do. So I think that makes them want to try really hard. So like, before their midterm, I called—I must have called like four or five parents the night before the—two nights before the midterm. I told them, "You know, your kid has to come in for extra help." I'll give them extra help as long as they need it, as long as they come in, and I want to see a real improvement for their midterm. And I had them come in for like 4 hours maybe…. Those kids saw a big improvement, as long as they would buckle down and study.
>
> I put a lot of pressure on, like even the kids who are doing well, to do even better. Because the thing is, when you're doing well it's easy to kind of just, you know, "I'm going to glide by. I don't have to work that hard here. And I'll do O.K." But I think, you know, you could do better than that. So I push them all: "I ***know*** you could do better than that." It's like, "So what if it's 95? You could have a 97, right?"

Clearly, performance on the tests was important to Wendy and, by inference, to the parents of the students, if not to the students themselves. Wendy worked hard to ensure that her students would succeed and surpass. At this school, however, Wendy was not offering extra help simply because she personally felt it was important. "We're required to give extra help every day for at least half an hour after school. And then on the day before testing day to, like, I think, stay until 4."

In addition to providing mandated extra help, the school allowed students who were unhappy with their grades to do test corrections and improve their grades. Just when I wondered if Wendy were going to complain about all the extra work these expectations entailed, she said wistfully, "I wish we had that in high school."

> They're very competitive here. [laughs] I don't remember high school ever being like this, is the funny part. I was the weird kid 'cause I was so crazy about my grades and stuff, but I think I would have fit right in here. [laughs]. I wish this was my school.
>
> I feel like the kids are all very busy. They're very overbooked. Like they got a gazillion things going on, and just to catch them for like—. I know, with after-school activities, just to catch them for rehearsal [for a performance she directed]. They have like five things that they have lined up after school to deal with. The kids are there all the time. You'll find them there until like 8 or 9 at night, so—. *Doing school stuff?* Yeah. Like sports and clubs, and more clubs, and yeah. Extra help. Extra help's a big thing in my school.

The Biology Curriculum and Wendy's Understanding of Biology

Wendy planned extensively with the two other biology teachers, and their tests were always given on the same day. "We give the same test for all three teachers, and there really cannot be any changes between teachers… They're all based on the Regents questions that you can find in the published Review Books." *Do you compare scores [across classes]?* Yeah. *How are you doing?* It's a good record this time. The mean was 83 for my three classes, so I think we're good.

With a set curriculum and common tests that were designed to prepare students for the end-of-year Regents examination, there was little room for variation. Wendy mentioned feeling that she could not miss a day that she went in even when sick. I asked why, because with joint planning it seemed as though the other teachers could help a substitute teacher; Wendy revealed the pressure she felt and a concern that she had to be there to present the material:

> It's like I feel like no matter what, when there's a sub in the room I feel like the kids aren't—. Well, first of all, they can't really get lectured to. They can't get new material that well.

Although the curriculum was constrained by the State Examination and the joint planning, Wendy hoped to engage her students. She liked that some students considered that her class was fun. I asked her what made it fun:

> I like to talk about how bio is, like, applicable to regular life. And disease and stuff? Disease really gets kids. They love hearing about that. Things that go wrong with their bodies. Finding ways to give them a reason for why you're learning it. I mean, if you don't care about why you're learning it, you're not—there's no reason to pay attention. But if it actually matters, then I think you would pay more attention.
>
> So I try to get them into a lot of discussions and stuff like that, thinking about how things work, connecting the ideas. Because I feel like a lot of kids don't connect the ideas. They learn one isolated thing after another. They don't connect them. And then it makes it really hard for them to, like you know, put ideas together when you problem solve. Like the new bio state test is a lot more problem solving than—back before it was more like regurgitation of facts.

Wendy still used external factors (in this case, the requirements of the Regents exam) as the rationale for encouraging her students to put ideas together, rather than the importance of doing so to better grasp the nature of biology or to be better citizens after school life, illustrating "constrained professionalism" (Willis & Sandholtz, 2009).

To probe her view of biology as a field, I asked her what she wanted her students to remember in a year. She first replied with the standard "eight life functions," and we both laughed at this textbook response. She went on to present a human-centered approach to biology, not necessarily inappropriate for high school students, and one consistent with other statements, even her choice of topic for the IAI 5 years ago:

> You know, what you could use biology for. Things that go wrong with your body. Your body always tries to maintain a constant state. Your body doesn't ever try to get away from that constant state too much. If you're getting away from it, something's going wrong. So it's called "being sick." Um, what else? Oh, we're doing the reproductive unit right now. It's like, how not to get pregnant. [laugh] What the menstrual cycle is. And pregnancy is how the mother nurtures her young. All the human body systems, how those work together…. And how much more complex we are than, say, a one-celled organism. Like bacteria. They're considered a living thing, but that means they do all the same life functions, but they're a lot more simple than us. And even if something's small, it can still do a lot to hurt you. So it doesn't matter we're bigger than, say, a bacterium.

To explore her ideas about more general biology conceptions, I asked her about evolution. Her answer still emphasized a human-centered approach to biology but also reveals the school community and how she has adapted to it:

> We'll be teaching evolution later on. Now the thing with my school is, there's a lot of kids that are very, very religious in the school. I talk about evolution, I'm like, "O.K., if you don't want to believe it I'm not out to change whatever you have, O.K.? But I'm just trying to tell you what scientists have found. And that this—there's this stuff out there that scientists have found. And this supports what they believe is evolution. And, you know, if you don't—if this bothers you, I mean, you learn about other religions in social studies. You learn about Christianity in social studies. You learn about Buddhism in social studies. Are we asking you to convert to it? No. O.K." But they have their beliefs too. And with evolution I always stress that, "You know, you see microevolution happen very easily. Like with disease, you can see that stuff changes very rapidly. That's how you get mutations, right? So this is how you see a disease changing. But with macroevolution, you know, there's stuff out there that scientists use to prove that they think it exists." But whether or not they believe it in the end—I mean, that's up to them. So, I don't want to press it too much, because I feel like we'd get a gazillion phone calls on that.

Wendy did not acknowledge that evolution is a conception that unites all of biology; it is not something taught in one isolated unit. At this point, my self-study took an unexpected turn, forcing me to consider how I had failed to help this future biology teacher conceptualize the importance of evolutionary theory to biology.

Parental Intervention

Wendy's description of changes the teachers made to the honors program made it clear that the staff wished to avoid parental displeasure. The school integrated honors students into the regular classes but expected the honors students to do more work. Wendy described the evolution of the current structure. Previously, the honors students were required merely to pass in short book reports about a recent newspaper article concerning biology. Wendy said that had found that many students submitted poorly written reports or nearly direct copies of the articles. The only criterion they

were meeting was submitting something on schedule. When the teachers raised the standards for these reports, students then resorted to sharing articles, so that one article could be used by three students and submitted to the three different biology teachers. The teachers soon realized that the students were sharing reports. In the year I visited, the honors students were required to do additional reading. She explained:

> Every time the kids have a quiz, they [honors students] take two quizzes in that time period. They take the same regular quiz. They also take an honors quiz with, like, questions that have five choices instead of four…. I take my questions out of the SAT Two books. I modify it a bit for them. And then on their regular tests they have an extended honors section…. Now this year it's done a much better job of rooting out who belongs in the honors program and who doesn't, but we got a lot of parent backlash on it. I don't know if we're going to keep it for next year…. At the beginning I got all sorts of backlash. It's like "You can't make them take an extra quiz. You can't make them do this. Why is it different from last year?" We got that question about 60 times. So, I mean it's hard to make a change.

Clearly, the teachers' expectation was that honors students should be able to complete extra independent work, which would reveal their abilities to perform successfully in the next year's science class. However, Wendy avoided at least some possible parental complaints by not holding honors students accountable for independently studying and learning material:

> To cover my bases, I cover everything. Like even the honors stuff, I'll water it down. This way the honors kids can understand it, this way the regular kids get some extra knowledge. I'll put a star at the top of the PowerPoint. I'll be, like, "Look, this is all honors stuff. If you don't understand it, O.K., just listen. It's probably for your own good anyways. But if you're in honors, O.K., this is the watered-down version of it, all right? Take whatever you saw in your honors packet, I'm going to make it easier for you to understand."

Wendy also accommodated parents by handing out weekly homework packages, not nightly homework, to review material and practice state examination questions. The packets provided flexibility and helped the support teachers:

> This way it gets around like, say, absences and also like religious holidays, because there's so many of them….And it also makes it so the ESL teacher and the special education teacher, they have all the work in advance. I give them like targeted vocabulary. Like words that they actually—words that would be useful for them to solve a problem on this topic on the state exam. Because I feel like the State Exams word certain things in very particular ways. Like "Restore chromosome number." I mean, that just means when a sperm and egg get together, it brings the chromosome number back to 46. I also give them multiple-choice practice, which is based on the real State Exam questions. Short-answer questions, too. And also some, like, standard textbook assignments, like actual reading comprehension from the textbook.

The Context of East High and Wendy's Development as a Teacher

Wendy seemed comfortable in the identity she is developing in East High. Wendy's opportunities for further development of pedagogical content knowledge and pedagogical identity were constrained by the "middle class logic of individual

advancement" (Demerath et al., 2010, p. 2946) and also by the structure and importance of the end-of-year Regents examination. Wendy seemed not to view these factors as limiting. Many of her initial beliefs and values were strongly reinforced; as she said, it is the school she wished that she had attended, with its strong emphasis on grades and competition. The intense focus on doing well on examinations, imposed both internally and externally, and the large number of activities in which her students were engaged, limited how well Wendy could come to know her students. In her descriptions of her students, she focused nearly always on how they performed: were they organized students, did they do their work well, how freely did they talk in class, how did they explain things, and so forth. Only rarely did she mention a more personal connection with the students. Rather than spending time exploring their ideas, getting to know them as people and improving her PCK and pedagogical identity by attending carefully to their thinking, she worked to prepare them for success on the Regents examination.

The circumscribed curriculum constrained Wendy's opportunities to continue to explore and learn more biology. Instead, she is becoming an expert on what is likely to be on the Regents examination and how she can ensure her students do well on this high-stakes test. She made an effort to make the content interesting and useful to her students, which she felt would motivate them to learn. But I could not get a sense that there were some things that she included because they were just so intriguing and central to biology as a field of study. As Demerath and colleagues found, students in schools like East High tend to have a highly instrumental view of content knowledge; they need to learn what they will need to get a high score on the high-stakes examinations. Wendy's effort to build on their interests enforced an instrumental view of biology and deemphasized some of the content central to biology. Generally, though, Wendy seemed to feel little tension between school expectations and her own. Pressure, yes, but not tension. The fit between Wendy's initial beliefs and the climate at East High was a good one.

However, it is not a fit that supports Wendy's growth as a teacher. The strict focus on academic achievement, as indicated by performance on the Regents examination and reinforced by the departmental testing policy of joint tests across teachers, limited the freedom Wendy has to explore her content. The concern with parental pressure limited the biology teachers' opportunities to let at least their honor students explore content because there was a need to justify possible poor grades.

Tensions of a Science Teacher Educator: Idealism Versus Realism?

When I began the case study of Wendy, I hoped to illustrate the ways in which current conditions in schools, with heavy emphasis on test results, limit the opportunities for teacher and student growth. The tension I framed for myself left me asking: As a teacher educator hoping to recruit and educate bright and energetic new teachers, what mention do I make of current conditions? How much do I explore these conditions and how practice might be constrained by them?

As I have analyzed this self-study, I see that I have erred in the way I framed the tension, because I was presenting it far too rigidly as an either-or situation. I could nurture new teachers eager to go out and change the system and enact all the current reforms stressing inquiry teaching and student-centered approaches, or I could try to ensure that new teachers know all about the format of typical standardized examinations and the kinds of standards in place in the states in which they are likely to teach. I can now see that by framing this tension in this way, I limited my possible responses. I thought back to a book that was very influential for me, Berlak and Berlak's (1981) *Dilemmas of Schooling,* in which they describe key dilemmas in education: "Each dilemma captures contradictions that are simultaneously in consciousness and in society" (p. 124). The dilemma language thus links the individual and society. What was most important for me to consider was that Berlak and Berlak also presented the possibility that a dilemma could be resolved transformationally.

Instead of viewing state-mandated tests as inherently evil, I should help preservice teachers understand them as a cultural condition of practice and learn how to use them productively by linking the test content to the broader content area, for example. Thus, Wendy could have been prepared to see not just that the state exam required students to link specific content but that the field of biology is linked by certain key ideas. Homeostasis is certainly one key idea, and she did use her knowledge of that idea to organize her teaching about human biology. She might have used others. So once again, as in 1991, I realize the centrality of content for my teacher education work. A productive teaching move with Wendy could have involved asking her to consider why a high school teacher might present a simplified version of a complicated process or why a high school teacher might not provide the detail that would be required in an advanced university class. Since working with Wendy, I have emphasized pedagogical content knowledge through readings and discussions and explicated the role of my assignments in helping students to develop their own pedagogical content knowledge.

A student such as Wendy, who is transitional in terms of taking a teacher perspective or making tentative claims, could also benefit for a more careful analysis of dilemmas, to understand more fully the complex relations between individual and social-cultural assumptions. Such consideration could help new teachers better analyze the pressures of the situation in which they practice and develop their identity. As Berlak and Berlak wrote:

> Each dilemma captures not only the dialectic between alternative views, values, beliefs in persons and in society, but also the dialectic of subject (the acting true "I") and object (the society and culture that are in us and upon us.) It does so by formulating in each act both the forces which shape teachers' actions (those forces that press toward particular resolutions to a dilemma) and the capacity of teachers not only to select from alternatives, but to act to create alternatives. (pp. 124–125)

Finally, I close on a somewhat ironic note, given my previous emphasis on explicit analyses. Two years ago we asked graduates if the program had helped them to research their own teaching and to use student responses to revise their approaches. Many students said the program had not done so, and I realized that by focusing on

my resistance to mandated high-stakes testing, I had not attended carefully to the use of formative assessments of a range of types in the classroom. My thinking about teaching had been subtly manipulated by the national testing policy; my personal resistance to the policy had shut down my consideration of the importance to excellent teaching of regular and rich assessments of student learning. I found that students were quite responsive when I increased the emphasis on assessments, particularly formative assessments, and that they were better able to see how they could both prepare students for high-stakes tests and facilitate achievement of their own goals for their students' learning. What so often intrigues me about my work as a science teacher educator is that I began changing my practice before I had fully articulated the tension in my practice.

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Chapter 10
Helping Preservice Science Teachers Analyze Their Practices as We Study Our Own

Patricia D. Morrell and Adele C. Schepige

This chapter reports a collaborative self-study by two science teacher educators who share a commitment to helping preservice teachers' learn to teach science using reform-based pedagogical practices. In an attempt to make the tacit explicit (Loughran, 2002), we focused on our students becoming reflective practitioners. Our study describes and explains the changes we made to our science methods classes to help improve our students' abilities to analyze their science instruction and the outcomes of that change on our students, ourselves, and our future teaching.

Background

Reform of both science and mathematics curricula and classroom practice has been a focus of many professional groups for many years (Aldridge, 1989; American Association for the Advancement of Science, 1989, 1993; Grouws & Schultz, 1996; National Committee on Science Education Standards & Assessment, 1992; National Council of Teachers of Mathematics, 1989, 1991, 1995, 2000; National Research Council [NRC], 1996a, 1996b, 1999). The main elements of these reform practices focus on a constructivist view of teaching and learning and include teaching strategies such as encouraging discourse among students, supporting inquiry and problem-solving, and assisting students in thinking about their own learning.

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Teachers teach as they were taught (Britzman, 1991; Judson & Sawada, 2001; Lortie, 1975), and most in-service and preservice teachers have not been exposed to many reform-based teaching lessons in their own education. If we want our new science teachers to use reform-based strategies, their science methods course is a logical place to both model these practices and encourage preservice teachers to reflect critically on their teaching through the lens of reform-based practices. This is one way that methods instructors can assist student teachers in putting theory into practice. What can we as science teacher educators do to facilitate the type of critical analysis and reflection needed to help our preservice teachers begin teaching science in a style to which they are not accustomed?

Asking preservice teachers to reflect on their practice is not new. The Interstate New Teacher Assessment and Support Consortium (INTASC) and the National Council for the Accreditation of Teacher Education (NCATE) both include reflection in their standards for teacher preparation. Like others (Aubusson, Griffin, & Steele, 2010), it has been our experience that teacher candidate reflections tend to be of a general nature, focusing on issues such as classroom management, modifications, and appropriate time management (Morrell & Latz, 1992; Morrell, Latz, & Low, 1992; Morrell, Steinbock, & Casareno, 1999). We wanted to help our students prepare and conduct science lessons that incorporate reform-based teaching strategies identified as being necessary for effective science teaching. We teach preservice teachers the theories of reform-based science teaching, and we provide them with field experiences, but we do not provide them with a way to examine their own science teaching through the lens of reform-based practices. Before they can effectively analyze and reframe their experiences, students need to understand the issues associated with teaching and learning and look at the issues from the perspective of the teacher, the student, the curriculum, and the context (Casareno, 1994; Ciriello, Valli, & Taylor, 1992). Familiarizing preservice teachers with a reform-based observation protocol and asking them to use it to both plan and analyze lessons showed promise as a way to help our students become reflective practitioners of science teaching.

Methodology

The aim of all teacher preparation programs is to prepare exceptional professional educators. As science educators, the ultimate goal of our science methods courses is to prepare preservice teachers to teach science using the theories and pedagogies recommended by current research. We included a self-study component to see if our beliefs about what would be best for our students to do matched the practices we were using. Were we doing sufficient modeling and using the same techniques in our teaching that we wanted our preservice teachers to use in theirs? How could we improve our course to help better prepare our students?

We modeled our self-study using design-based methods from the Design-Based Research Collection (2003), a group that views an intervention broadly (to include

activity structures) and involves "anchored instruction" that is contextualized. We wanted to provide students with a viable tool to help them reflect critically on their science teaching in their practicum classrooms. There were multiple contexts: the methods classrooms and the teaching and modeling occurring in those settings, as well as the preservice teachers' field classrooms where practices are enacted. Additionally, there was the interplay among and between us, the preservice teachers, and their field experiences. Through a self-study design, we feel we are examining all three dimensions of teacher education, namely, knowledge-for-practice, knowledge-in-practice, and knowledge-of-practice (Cochran-Smith & Lytle, 1999). This study provided both a look at the usefulness of the intervention and a way for us to examine our courses and our teaching practices.

Although self-studies have been done that focus on improving preservice teacher reflection (e.g., McClanahan, 2008) and field experiences (e.g., Bates & Rosaen, 2010), our study most closely mirrors the study by Aubusson et al. (2010), who also looked at student reflections in science. Students were provided with instruction about reflection and then analyzed a 4-week practicum. The students were to employ a particular strategy (cooperative learning, problem-solving, teacher-directed, investigating, or performance) and analyze significant events during their practicum. The researchers concluded that preservice teachers' reflections were enriched by (a) having concrete field experiences on which to reflect, (b) having contextual anchors, that is, focusing attention on the specific strategies and their field experiences, (c) following a progression from a concrete description to a generalization about the situation to a plan for action, and (d) providing opportunities for "reflective conversations and collaborative reflection" (p. 214). Aubusson and his colleagues also suggested that providing conceptual anchors (educational theories, philosophies, principles, and ideas) can help bridge theory and practice. We took these findings and suggestions into account in our study.

Selection of a Protocol

Our first task was to select an observation protocol. A number of tools designed to evaluate different aspects of effective science teaching have been developed. One tool designed for that purpose is the Reform Teaching Observation Protocol (RTOP, Piburn et al., 2000; Sawada et al., 2002). The RTOP has 25 items focusing on three major categories: lesson design and implementation, content, and classroom culture. Another common protocol is the Local Systemic Change Observation Protocol (LSC) developed by Horizon Research, Inc. (2005) to evaluate the impact of a professional development model on science teacher effectiveness as measured through student achievement. Sampson (2004) developed the Science Management Observation Protocol (SMOP) to specifically assess how a teacher manages an inquiry-based classroom. The Oregon Teacher Observation Protocol (OTOP) (Wainwright, Flick, & Morrell, 2004) was also developed to measure reform-based strategies.

Most reform-based protocols have been used to document changes after in-service teachers have participated in reform-focused professional development (e.g., Benford & Gess-Newsome, 2006; Johnson, 2007; Johnson, Kahle, & Fargo, 2007; Martin & Hand, 2009; Wainwright, Flick, Morrell, & Schepige, 2004). The number of studies using reform-based observation protocols to examine preservice teachers' practices is small (e.g., MacIssac, Sawada, & Falconer, 2001; Morrell, Flick, & Wainwright, 2004). Smaller still is the number of studies that involve preservice teachers using the protocol strategies as a planning or reflective tool. Jackson (2009) reported limited success when she asked preservice teachers to use the RTOP to critique a video.

We chose to use the OTOP because it aligns with the topics we cover in our methods classes. It is also shorter and simpler to use than many of the other protocols we examined. We hoped that using this simpler tool would help our preservice teachers to engage with their teaching in their practicum classes, analyze their behaviors, and "make meaning" from these reflections so as to "enhance their understanding" of their choices and practice (Loughran, 2002, pp. 35–36). The OTOP is available from http://ret.fsu.edu/Files/Tools/Appendix.C.pdf. The OTOP includes ten broad reform-based practices scored on a scale of 0 (not observed) to 4 (characterizes the lesson).

Purpose and Methods

The purpose of this study was to determine the impact of introducing and using a teaching observation protocol, specifically the OTOP, on preservice teachers' abilities to effectively reflect on their own teaching in light of reform-based teaching practices. By discussing the protocol and then providing it to the students to use to reflect on their teaching, would the students have the contextual and conceptual anchors they needed to be a reflective practitioner?

This study involved 49 preservice teachers enrolled in elementary (23) or secondary (26) science methods classes at two universities. Both are small, primarily teaching institutions—one public, one private. The sample includes senior undergraduates and fifth year Master of Arts in Teaching preservice teachers; all were involved in student teaching placements while enrolled in their methods class. At both the private and public universities, students spent 15 h per week in the fall semester at their field placements, mostly in the morning, and attended university classes in the afternoon. In this student teaching placement, the preservice teachers take on increasing levels of responsibility and ultimately are responsible for a class for the entire time they are in the school (lesson planning, delivery, assessment). Subsequent to this part-time student teaching experience, the preservice teachers complete an all-day student teaching experience at a different level (early childhood, elementary, middle, or high school).

Prior to or concurrent with the methods class, the students at both universities attend courses in general education that cover topics such as lesson plan writing,

assessment, curriculum, classroom management, differentiation, and literacy. The purpose of the science methods classes is to provide opportunities for teacher candidates to explore trends, practices, materials, and resources specific to science teaching. We include topics such as conceptual change, engineering design, specific science assessment tools, inquiry learning, laboratory safety, and other topics specific to science teaching.

As part of the methods courses, preservice teachers were introduced to the OTOP and discussed the components of the protocol and the scoring. The OTOP has ten components focusing on habits of mind, metacognition, student discourse and collaboration, rigorously challenging ideas, student preconceptions and misconceptions, conceptual thinking, divergent thinking, interdisciplinary connections, pedagogical content knowledge, and using multiple representations. The class practiced using the protocol to rate a commercially available videotaped science lesson. After discussing the initial set of ratings, the class scored another lesson and discussed their scoring. By the end of the second round of scoring and discussion, the preservice teachers reported that they understood and felt comfortable using the OTOP.

Because the structure of the methods classes and student teaching experiences are slightly different at the two universities, the activity assigned to the classes differed. At both institutions, the preservice teachers complete a unit plan (work sample) as a requirement of the student teaching experience. The unit plan includes a description of the context, overview of the unit, individual lesson plans, pre-/post-assessments, analysis of the impact of the unit on student achievement, and an overall analysis of the instructional unit. This is in compliance with state licensing requirements. At the private institution, the preservice teachers are required to videotape a lesson as part of the work sample; however, all preservice teachers' work samples, regardless of grade level or content area, are evaluated using a single rubric. In the public university, videotaping is not a requirement at this stage, and while there is a universal scoring tool, individual methods instructors decide how they wish to evaluate the work samples of their student teachers. These differences affected how the preservice teachers used the OTOP as a tool for reflection.

At the private university, preservice teachers were to use the video record of one of their science lessons and critique its delivery in their field class using the OTOP. The preservice teachers were asked to identify any of the OTOP strategies used in their lessons and rate each as either a major (rating of 3–4) or a minor component (rating of 1–2) of the lesson or as one that was not observed. In addition, a specific reflection tool was completed by the preservice teachers. This tool consisted of a regrouping of the OTOP items into four main headings (student thinking, social skills and collaboration, content, and instruction). The preservice teachers responded to each of ten item statements using a Likert scale ranging from strongly disagree to strongly agree to indicate the extent that each item was evident in their lesson; they also provided written support for their ratings. The preservice teachers also shared a portion of the videotaped lessons with their classmates, discussing the OTOP ratings for that section. Preservice teachers submitted their OTOP rating sheet and their reflections to the instructors; submission of the plan and video recording was optional. While they were obviously encouraged to use the practices appropriate to

the lesson, preservice teachers were told they would be graded not on how many of the OTOP practices were incorporated in the lesson but on whether they could identify where and how any of the practices were being used in their teaching. The overall assignment was discussed with the preservice teachers after its completion. In addition, the two classes (one undergraduate and one graduate) were asked to complete a brief survey of their perceptions of the usefulness of the OTOP assignment and its impact on their planning and reflection.

At the public university, preservice teachers were teaching a unit of instruction ranging from 4 to 11 lessons. They documented the setting, planning, assessments and reflections for their unit in their teacher work sample. The methods instructor provided the scoring tool for all the science work samples. Originally, the preservice teachers were asked to video record a lesson and follow the same procedure as given at the private university. That requirement was removed when many reported obstacles that made recording lessons difficult. Instead of recording a lesson, the students' work samples served as the data source. These preservice teachers were asked to use the OTOP for both planning and reflective purposes. For each lesson, the preservice teachers identified in a table which OTOP elements were the major and minor focus in their unit plans. If an OTOP element was not present, it was left blank. They were also asked to write an analysis of each individual lesson that included their thoughts about the OTOP elements they had indicated were included in each lesson. Finally, for the overall unit reflection in their teacher work sample, they were asked to address elements of OTOP as well.

The lesson plans, video recordings (where available), student reflections, and OTOP scores were compared. We were specifically looking for whether the preservice teachers could reflect on and critique their lessons using the OTOP as a guide for whether they were actually using any reform-based practices in their teaching. Did they correctly identify examples of the OTOP items, could they support why a particular item might not be appropriate to employ, or whether a practice should have been or could be employed in a similar future lesson? The survey findings were analyzed using descriptive statistics.

Data Analysis and Findings: Use of the Protocol

At the private university, all preservice teachers were able to complete the assignment, although it had to be modified for some to include observation of a lesson other than a science lesson. A small number of preservice teachers (12) were not able to teach a science lesson in their practicum class. Some preservice elementary teachers were not in the school during science time or found that there was a school science specialist who did all the science teaching for all classes in the school. A few of the secondary preservice teachers were seeking an additional endorsement besides science and were in the field for their nonscience experience; typically, these were in a mathematics class. In all but one instance (a physical education class), the OTOP was useful regardless of the content the preservice teacher was responsible for.

Private University Findings

The Protocol. The data from the preservice teachers in the private university showed coherence among the scores on the OTOP, the reflections (scores and supporting statements), and the video recordings. Of course, some preservice teachers were better able to recognize when they were using reform-based strategies than others and not all strategies were used equally. When rating themselves, preservice teachers tended to shy away from the extremes, choosing "disagree" rather than "strongly disagree" on the reflection sheets and 3 s rather than 4 s on the OTOP. With few exceptions, the various pieces did match up, as the following examples illustrate:

> OTOP Item: This lesson encouraged students to seek and value various modes of investigation or problem-solving (Habits of mind).
> *Lesson A*: *Buoyancy, elementary class*
> OTOP rating (rating of 1–4 to characterize the lesson): 3
> Reflection (1–5 for strongly disagree to strongly agree): 4
> "This project did not have a lot of guidelines to follow, so the students could find their own route to the solutions. However, it did not require the students to find different methods of creating a float. Students were encouraged to compromise on designs."
> *Lesson B: Experimenting with stream tables, elementary class*
> OTOP rating: 3
> Reflection: 4
> "Although it is hard to see from the video, there was a lot of discussion with the students in their groups about what they were investigating with their tables. The students also asked a lot of higher-level questions about their tables' reactions."

> OTOP Item: Teacher encouraged students to be reflective about their own learning. (Metacognition)
> *Lesson A: Introduction to cell structure, middle level class*
> OTOP rating: 2
> Reflection: 3
> "Students put concepts in their own words, identified unclear concepts but I did not encourage reflection on their progress on what they learned or how."
> *Lesson B: Activity to have students practice making inferences, middle school class*
> OTOP rating: 4
> Reflection: 4
> "I questioned the students a lot in this lesson and asked them to think about why they believe things are the way they are. I actually think I went a little over board on all the questioning and reflective thought. I read an obscure statement and asked the students to make an inference about what they thought the object could be. I would then read another statement that further described the object and had the students revise their inferences."

Aside from the congruence of the ratings of the OTOP sheets and reflections, reading the students' analyses of the videos helped to reveal the depth of their reflection and analysis. Students often commented in retrospect on what they did not do and what they could or should have done, as the following three examples illustrate:

> The students did not discuss strategies for solving problems or pose investigative questions. The students did get the opportunity to share their ideas while they were learning through think-pair-share. However, the think-pair-share is more surface level thinking than investigative thinking. In retrospect, I wish I said, "now that we had our thinking and pair time, as we share let's decide what we want to investigate and learn more about as a class." I also

Table 10.1 Means and standard deviations of 32 student responses to survey items

Item	Mean	S.D.
OTOP helped me with planning	3.5	0.8
OTOP helped me in reflection	4.3	0.6
Sharing video clips was worthwhile	3.9	0.9
I will use OTOP in future planning	3.3	0.7
I will use OTOP in reflecting in the future	3.7	0.6
I recommend this assignment for future classes	4.1	0.7

Strongly disagree = 1, strongly agree = 5

> wish each station had two different ways to explore the station topic instead of just one way. This would have encouraged alternative modes of investigation. (OTOP 1, elementary)

> The learning goals were for students to be able to identify the parts of the tree during the activity and then to label the parts of the tree on a paper as the second part of the activity. The road-block I ran into was the students are still learning to write their letters and although they know the parts of the tree, the writing was a block for them. After a few students asked me how to spell certain parts of the tree, I made a word bank on the white easel which gave students a place to refer back to when trying to spell the word correctly. However, many of the students do not know how to read either, so writing words on the board was a bit counter-productive except it allowed me to simply point to a word when they asked how to spell a specific part. Looking back I would have made a word bank on each individual's paper and next to each word I would have a little picture of the part of the tree. The students would still have to draw their own tree and the parts of the tree would not be identical to their pictures so the images would not be a dead giveaway but may help with the confusion and struggle with labeling. (OTOP 6, elementary)

> The focus of the lesson was on the mechanics of converting improper fractions to mixed numbers and vice versa. Upon looking back over the lesson, I could have mixed in real world examples of how this might be used in areas like cooking (example: when to double or triple a recipe) or other examples the students might have related to. It wouldn't have been too difficult to find an example instead of strictly focusing on symbol manipulation skills in this instance. (OTOP 8, middle school)

The Surveys. All 32 preservice teachers returned the voluntary survey. The means and standard deviations for the six survey items are presented in Table 10.1. Because these preservice teachers were presented with the OTOP as a reflective tool, it is not surprising that the scores for its usefulness in reflection are higher than for its use as a planning aid. Interestingly, in the open-ended portion of the instrument, several preservice teachers commented that they would have liked to have been introduced to it earlier in the semester (instead of week 4 of 16 weeks) as they would have liked to have used it as a planning tool. A few preservice teachers commented on the videotaping, either complaining that the quality of the taping was poor or how good or bad it was to have to view themselves and really analyze what they were seeing. Twenty-four of the 26 preservice teachers who responded to the question about the usefulness of the OTOP assignment said it helped with reflection; these comments are illustrative:

- It allowed reflection that was meaningful.
- Makes you look at yourself in a different light.

Table 10.2 Number of OTOP strategies noted as a major or minor focus in 78 unit lessons

OTOP reform-based strategy	Number of lessons OTOP strategy identified as major focus	Number of lessons OTOP strategy identified as minor focus	Total number of times OTOP strategy identified
Habits of mind	9	7	16
Metacognition	4	18	22
Student discourse and collaboration	20	11	39
Rigorously challenged ideas	9	18	27
Student preconceptions and misconceptions	5	32	37
Conceptual thinking	10	36	46
Divergent thinking	5	12	17
Interdisciplinary connections	22	29	51
Pedagogical content knowledge	19	24	43
Multiple representations of concepts	24	20	45

- It prompted in-depth reflection.
- It made up think about the questions we ask our kids during our lessons.
- Structured my reflective practices in a very specific and productive manner.

Many preservice teachers felt it would be helpful to them in the future as a reflective tool (mean = 3.7). As one student teacher said, "Reflection and video helped so much. It also helped update and create better lessons out of our mediocre ones and make them more useful." On average, the preservice teachers agreed that the assignment was something to continue to use with future methods classes (mean = 4.1).

To summarize, for the students in the private university, the assignment seemed to accomplish its goal; the students were able to analyze their teaching in light of reform-based science instructional practices and identify where they felt positive about their teaching and where and how they might improve.

Public University Findings

At the public university, all but two preservice teachers completed the OTOP scoring and reflections (see Table 10.2). The 17 who completed it were able to use the OTOP successfully to identify and analyze their use of reform-based practices. However, there were some instances where preservice teachers thought an OTOP element was a major focus when it more likely was a minor focus or not observed. This happened most often regarding collaboration and group work.

For example, several identified a lesson for the entire class followed by a voluntary lesson extension that involved groups as being a major OTOP student discourse and collaboration focus rather than not observed or part of the lesson. The preservice teachers all recognized that there were some OTOP areas they used more than others. During a class discussion at the end of term, it was pointed out that this was

just one unit of instruction of about ten lessons. Their choices of reform-based strategies over a longer period of time should be more comprehensive.

The preservice teacher reflections revealed several patterns about the OTOP reform-based practices. First, there were four OTOP elements that were not identified often as a major or minor focus in the OTOP table: habits of mind, divergent thinking, metacognition, and rigorously challenging ideas. These four elements were mostly neglected in the reflections of those who identified them as a focus. A few preservice teachers noted having difficulty with those strategies. One preservice teacher who identified two lessons with a minor focus for habits of mind did comment that developing habits of mind was difficult without doing real work in a field of science. This preservice teacher intentionally tried to include labs with aspects of scientific inquiry to help students develop habits of mind. Another reported that he was unsuccessful at rigorously challenging ideas because of difficulty getting students to engage in discussions. Metacognition was identified as occurring only when students were being asked to explain how they got their answers when solving problems.

The theme in the comments about student discourse and collaboration was that this is difficult to do. The preservice teachers explained how their own lack of planning for group work made that part of the lesson less effective than they had hoped. Also, student dynamics such as who should be in the same group interfered with collaboration and group work in general. Several preservice teachers specifically stated that they wished they could do more with this but that too much socializing happens when students are placed in groups to work. Of the preservice teachers who tried to use small groups in their classroom, many indicated that it was done mostly as part of lab settings, which tend to be structured differently than other small-group activities.

All of the preservice teachers wrote about students' prior knowledge and misconceptions (student preconceptions and misconceptions), although four only wrote about these in terms of the pre- and postassessment comparison results. This is one of the required written criteria of the teacher work sample for all preservice teachers. In their analysis of their preassessment results, preservice teachers are asked to analyze the results including detecting student misconceptions. Their reflections show that the preservice teachers are concerned that their teaching, whether it is through lectures, demonstrations, laboratories, or some other instructional strategy, will lead to student misconceptions. Preservice teachers also wrote that some of their students still had misconceptions after lessons were completed or entire units were completed. They wondered what they could have done differently or how to better address the misconceptions the next time they teach that particular topic. Some preservice teachers believed they could eliminate student misconceptions if they had more time or if they could do a review—a belief that contradicts conceptual change theory.

The preservice teachers reported using conceptual thinking in their lessons. The reflections on conceptual thinking centered on how they, as teachers, were able to ask higher-order questions. The preservice teachers did not mention if their students asked higher-order questions. Preservice teachers' focus on higher-level

questions for their reflections may have been reinforced in other courses, such as assessment, and by prompts in the teacher work sample guidelines that ask preservice teachers to pinpoint their use of higher-, intermediate-, and lower-level questions, tasks, and assignments.

The OTOP element that was cited most frequently was interdisciplinary connections. The preservice teachers recognized that their students needed to have real world, relevant examples for learning and for interest purposes. For example, one person wrote that students are not really interested in wrinkled or smooth peas in genetics, but the students are interested in genetically transmitted human diseases. Another person wrote that including real life examples goes beyond the goals and objectives and is what makes helps makes lessons diverse.

This theme overlapped with pedagogical content knowledge and multiple representations. These preservice teachers wrote about their own strengths and weaknesses in their knowledge of content they were teaching. A few gave specific examples of having incomplete content knowledge and linked that to their ability or inability to make real life, relevant connections and to use different teaching strategies. For the most part, the preservice teachers felt positive about their ability to include several different ways to teach concepts without lecturing. Their comments related to the 90-min block period, generating interest or motivation to learn, multiple intelligences, and/or trying to reach different learning styles. One preservice teacher wrote that, although she had these elements as a minor focus, this in no way diminished the role they played in her lessons. In fact, she felt that these needed to be in every lesson for greater student learning to occur.

Finally, it is important to note a conspicuous omission in the reflections by preservice teachers. Throughout the OTOP reflections, the preservice teachers mostly focused on the teacher actions part of the OTOP and neglected the student actions portion. Perhaps this omission is due to the nature of beginning teachers. They did write about students in their analyses, but many of these reflections focused on classroom management and motivation. In summary, for the students at the public university, using the OTOP seemed to help them learn what reform-based strategies were, how they could implement them, and what prevented them from implementing the strategies.

Influence of the Protocol on Preservice Teachers' Reflections

The data from both universities indicate that the incorporating the OTOP into the methods courses was useful in providing our preservice teachers with a contextually anchored tool to examine their own teaching in light of reform-based teaching practices. It was interesting to see the differences in student reflection based on the two different ways the tool was used with the groups. In the private institution, the preservice teachers were reflecting on a video recording of their own teaching using the OTOP indicators, and they tended to support their OTOP ratings with both teacher and student behaviors. These preservice teachers also do a written reflection on each

lesson they teach, and this tends to focus on their perceptions of the quality of their teaching based on students' reactions and feedback. Thus, these preservice teachers actually had two sources for their OTOP reflection: their video recording and their own written reflection. Because the video recording itself focused more on the teacher than on the students, the preservice teachers were able to look at their teaching while recalling their perceptions of how their students reacted to the lesson.

In contrast, at the public university, the OTOP tool was used for planning and analyzing unit lessons. Without the benefit of recordings of their lessons, the preservice teachers' analyses were based solely on their perceptions and recollections. This may help to explain the fact that these preservice teachers tended to focus on their own behaviors rather than on their students' behaviors. Teachers' basis for reflection was teacher lesson plans, which are teacher performance. However, reflecting over ten lessons provided these preservice teachers with a broader and more realistic look at how reform-based teaching strategies play out in a classroom. Not every lesson will have every strategy represented or present to the same extent. Viewing a unit of instruction allows for greater depth of reflection. Both methods of using the OTOP appear to have merit. The single-lesson reflection helped preservice teachers to examine more closely the types of strategies they used in a class period, taking into account both their own and their students' behaviors. The unit reflection helped preservice teachers to think more long term and to use the tool for planning as well as for analysis. It prompted the preservice teachers to realize what strategies they used more frequently and the factors influencing their instructional choices. The OTOP appears to have value both for planning and for analysis.

Regardless of the context, the preservice teachers were able to look at their teaching through the lens of reform-based teaching. Their comments were focused on instructional pedagogies, how effective they were in using them, whether the method was appropriate for a particular lesson with particular students, and how they might be able to strengthen their use of the reform-based strategies in the future. Thus, the use of the OTOP appears to help the preservice teachers to develop as reflective practitioners. These results support the findings of Aubusson et al. (2010) and Morrell et al. (2004): providing contextual anchors on which student teachers can reflect seems to improve the quality of reflection, both in terms of focus and depth.

Influence of Self-Study on Our Practice as Science Teacher Educators

This study was designed to determine if we could help our preservice teachers reflect on the reform-based science practices they were using in their teaching. As we planned and began to work through the OTOP assignment with our students, we realized that we were making changes to our own teaching to support the students' OTOP use. For example, if we expected our students to teach in a way that promotes habits of mind, then we also had to teach in ways that promoted the development of

their habits of mind. We engaged in reflective dialog periodically throughout the semester and while analyzing the data to explain to each other what we were observing in our students and in ourselves. At the conclusion of the analysis, we identified areas where we needed to develop our own teaching.

While education students tend to be more critical of how they are taught than students elsewhere in a university, we found that our methods students would often raise questions specifically linked to the protocol in our modeling of reform-based practices in their methods classes (e.g., Would that be an example of how to promote metacognition?). This made us more aware of the need to be explicit in our instruction and to identify for the preservice teachers both the practices we were using and the reasons for our instructional choices. We often overlook the fact that what is tacit to us is often not apparent to our students, and this was a good reminder. We have been including more time-out voice-overs in our teaching. For example, if we are doing a demonstration or leading an activity and we recognize a teachable moment outside of our original intent, we put the lesson on hold and move to the side to do a sideline discussion and then resume our lesson. We have also been doing more detailed analyses of our presentations with our students. We engage them in a lesson, discussion, or activity and then go back to analyze what methods we used, why those methods might have been chosen, and the effects of those methods on the quality of their learning. As with the work of McClanahan (2008), these discussions in the teacher education course demonstrate to preservice teachers that it is important to analyze our teaching and to provide guided practice for talking about issues of teaching and learning.

From our analysis of the preservice teachers' assignments and comments, we learned that we need to emphasize explicitly some of the reform-based practices in our teaching. For example, in the past, we have often glossed over the topic of cooperative learning because it is discussed at length before the teacher candidates arrive in our course. Comments from the preservice teachers showed that, while they understood the concept of cooperative learning, they needed more guidance in how to use this practice with their students. We also need to identify situations other than laboratory activities in which grouping students would be beneficial.

We also realized that preservice teachers need to be able to view modeling of effective teaching strategies. We cannot expect that they will be able to view and process all that they and their cooperating teachers do during their field experiences or that what they see during their field experiences will be the type of teaching we would like them to emulate. More short videos of science teaching have been incorporated into our courses for illustrative purposes and discussion. We have added illustrations of teachers differentiating instruction, using techniques such as Sheltered Instruction Observation Protocol methodologies and strong questioning strategies. We have also identified vignettes of students (e.g., younger students showing classic stages of Piagetian cognitive development) and discussed what we might do if these were students in our own classes.

Conducting this self-study has also made us aware of the need to incorporate more of the preservice teachers' field experiences into our courses. We often link our pedagogy with the school, but we do not invite preservice teachers to bring their

experiences back to our classrooms. This came to light in the private university setting. While circulating around the room while the students were viewing videos in small groups, it was obvious that they were engaging on a personal level with each other's classes. We overheard comments such as "that's what your room looks like" or "now I see what you mean about that student." From these observations, we realized that, although we talk explicitly about field experiences in a course such as the student teaching seminar, we often fail to have the students bring personal field placement experiences into methods courses, except when asking for examples of specific concepts or applications. Finding ways to incorporate more of the preservice teachers' field placement experiences into the methods class should make our courses more relevant and build more connections between theory and practice.

Both of us plan to continue to use the OTOP with our students. In the private university, it will be introduced much earlier in the course so the students can use it for planning as well as for analysis. In the public university, the institutional barriers to the use of video recording have been overcome, and the students in that methods class will also be using the OTOP to critique their actual teaching. We have discussed whether we should remove the existing rating system for characterizing the use of the OTOP items in the lesson. We could simply change the ratings to *observed* or *not observed*, which is similar to many of the in-service teacher evaluation forms used in the area. In the next implementation, we will also remove the two iterations of rating used in the private institution. The students will be given the original OTOP with the descriptors but will only be asked to complete the reflection form. This should reduce redundancy and a possible source of confusion.

Conclusions

Reform-based science teaching approaches have been shown to increase student achievement. Observation protocols for identifying these strategies may help teachers to examine their own teaching. To date, these observation protocols have tended to be used primarily with in-service teachers and by researchers. Based on the findings of this study and student comments, the OTOP appears to be useful in enabling preservice teachers to identify reform-based teaching practices and to plan instruction accordingly. Significantly, the OTOP may also provide a means for preservice teachers to analyze their own pedagogical approaches. Using reform-based observation protocols with preservice teachers may prove to be a step that allows them not only to learn about reform-based teaching practices in methods classes but also to incorporate specific strategies into their planning and instruction with the support of their methods instructors and student teaching supervisor. Such protocols can be a conceptual anchor for self-reflection during their field experience placements. They can also provide a basis for examining the concepts on which the practices were based. Grounding preservice teachers' reflections in specific practices in their field experiences allows them to examine both where they were being successful and where they needed to focus more attention. It can also help them to think critically

about how they might accomplish their goals. When the preservice teachers become full-time teachers, they will already have experienced designing and implementing reform-based science teaching lessons. Whether these preservice teachers will use the OTOP when entering the profession is unclear, but they will have a coherent perspective to aid them in analyzing their practice.

For science teacher educators, reading and analyzing students' analyses of their teaching may be helpful in judging the quality of preservice teachers' learning. In the self-study component of this study, we realized that our assumptions about what preservice teachers know are not always accurate. We identified the areas in which we need to provide more explicit modeling and discussion as well as the areas where we are successfully introducing these concepts and practices to our students in a way that helps them use them in their own teaching. Using the OTOP as a tool for analysis not only benefitted our students by having them view their science teaching through a specific set of lenses but also served as a catalyst for us to analyze our own teaching. As noted earlier, teachers tend to teach as they have been taught. Designing an assignment to help preservice teachers learn to analyze their practice and studying our own teaching in the process helped us to reexamine our pedagogies of teacher education and change our practices to teach in ways that we hope our preservice teachers will adopt.

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Chapter 11
Developing a Model for a Self-Study Professional Learning Community

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The field of self-study of teacher education practices (S-STEP) has evolved rapidly since its origins as a Special Interest Group of the American Educational Research Association in 1993 (Loughran, Hamilton, LaBoskey, & Russell, 2004). Although the term *self-study* might suggest an individual teacher educator studying his or her own practice, this is rarely the case, as most self-studies involve pairs or small groups of teacher educators working together. Collaboration can happen in an ad hoc way with sporadic meetings whenever a time is mutually suitable or in a systematic way with regular meeting times and a structured format to guide the collaboration. A systematic approach to self-study can be viewed as professional learning for teacher educators (Hoban, 2007). This form of professional learning involves a group of teacher educators/academics making a deliberate decision to participate in a planned professional learning program to initiate and sustain the self-study research.

Framing self-study as professional learning is a positive development for teacher educators. If teacher educators cannot model reflection and initiate efforts to improve their own teaching, then perhaps they should not be in the profession. Thankfully, some long-term efforts are now being studied. For example, Lunenberg and Samaras (2011) studied two instances of self-study as professional learning (in the USA and in the Netherlands) and identified six guidelines for a pedagogy for teaching self-study: (1) starting point the "I," (2) emphasize the learning side of self-study research, (3) knowledge generation and presentation, (4) critical collaborative inquiry, (5) transparent and systematic research practices, and (6) teachers' modeling (pp. 175–192). While these guidelines are valuable because they identify some of the key principles of self-study research, we sense a need for greater focus on

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point (2), the learning side of self-study research, especially if self-study is to be seen as professional learning for teacher educators. Another report of self-study as professional development (Gallagher, Griffin, Parker, Kitchen, & Figg, 2011) highlights the importance of a self-study community of practice for a group of teacher educators. While we agree that a community of practice is an important goal, its existence as such cannot be assumed, and so it needs to be a goal that the group hopes to achieve. The purpose of this chapter is to provide greater detail about the nature of the academic learning involved in establishing and maintaining self-study as professional learning, especially if the group is to recognize itself as a community. This chapter summarizes our group's experience by developing a model for a self-study professional learning community.

We report here a study of 12 academics, mostly teacher educators, who embarked in 2010 on a 12-month professional learning program specifically focused at developing their skills in self-study research. The design of the professional learning model originates from extensive research on the professional learning of school teachers and published in a book entitled *Action Learning in Schools: Reframing Teachers' Professional Learning and Development* (Aubusson, Ewing, & Hoban, 2009). Although this model for teachers' professional learning guided the initial design of the model for the academic professional learning, it evolved over the 12 months to be more specific for teacher educators' self-study. Key to the changes in the model was making the notion of community a centerpiece of the model rather than a learning process. This chapter draws specifically on an interpretation of community by Grossman, Wineburg, and Woolworth (2001), who maintain that a community is much more than a group of teachers or teacher educators who gather regularly to discuss practice. Moreover, it develops through stages and only becomes a mature community when a group develops enough trust to share tensions and dilemmas of personal practice involving participants who speak honestly and personally. These characteristics of a mature community are particularly suitable for self-study groups, as discussions should focus on sharing of tensions and dilemmas that become evident when unraveling the complexity of teaching (Berry, 2007; Berry, 2004a, b; Britzman, 1991/2003).

Origins of the Teachers' Professional Learning Model

The model for designing the professional learning program for self-study is based on a professional learning model for teachers, as shown in Fig. 11.1 (Aubusson et al., 2009). This model is an adaptation of a professional learning framework in business education called *action learning* (McGill & Beaty, 1995; Revans, 1981; Inglis, 1994). The teachers' professional learning model, which was developed over 5 years from studies of over 100 professional development programs incorporating action learning, has three interrelated principles: content, processes, and conditions. It is the interplay of the three that produces and sustains teachers' professional learning. We saw this model as suitable for adaptation to self-study, as it is always

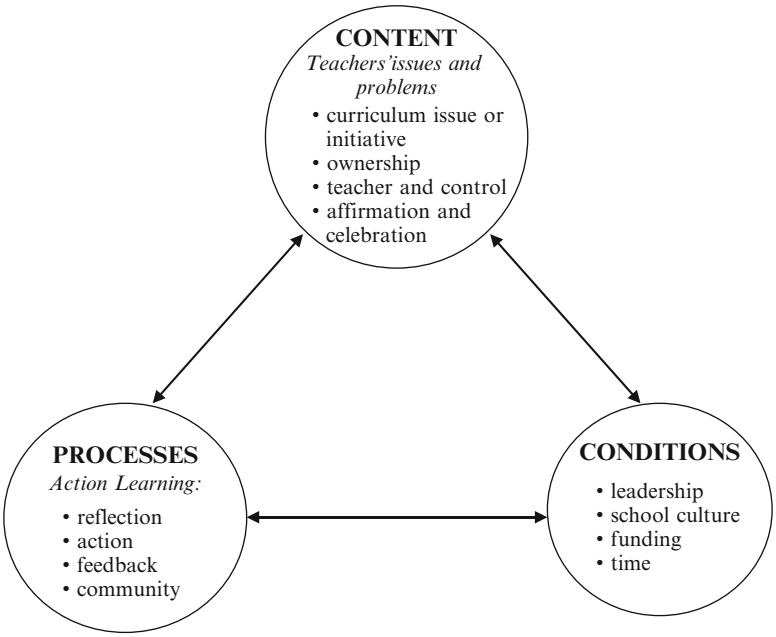

Fig. 11.1 Teachers' professional learning model (Adapted from Aubusson et al., 2009, p. 110)

done in a small group (usually 6–8 people), and the discussions are scaffolded and guided by a facilitator. The centerpiece of action learning is the group discussions in which individuals share and analyze their experiences about a workplace issue or problem, with the expectation that others in the group will provide inputs. It is on the basis of these contributions that action plans are devised to resolve the workplace issue. Plans are enacted after the meetings and then reconsidered at subsequent meetings in a recursive manner. Figure 11.1 shows the three principles and demonstrates their interrelationships.

The three main professional learning principles are described as follows:

1. *Content*
   The focus or content of the professional learning is teachers' own classroom practice. The focus could be ways to scaffold children's learning, assessment, or different instructional strategies.
2. *Conditions*
   There are several conditions that are key to initiate and sustain teachers' professional learning. Some important conditions include leadership, in terms of a principal or executive support to initiate change; a supportive culture in the school in which teachers are encouraged to try something new; and a culture that celebrates rather than criticizes new initiatives. Key to teachers trying new ideas is time to reflect, discuss, and share ideas. It is therefore important that teachers who are attempting long-term change have some time provided especially to share ideas with different people in the group.

3. *Processes*

There are four key processes that underpin teachers' professional learning. The first process, *reflection*, involves participants rethinking about something problematic to make meaning of their experiences to help them to cope with similar situations in the future. Initially proposed by Dewey (1933) as a particular form of thinking, it was argued that reflection is a way of rethinking and learning from experience: "The function of reflective thought is, therefore, to transform a situation in which there is experienced obscurity, doubt, conflict, disturbance of some sort, into a situation that is clear, coherent, settled, harmonious" (Dewey 1933, pp. 100–101). This notion of learning from reflection was elaborated by Schön (1983), who introduced the concepts of *reflection-in-action* and *reflection-on-action*.

The second process, *action*, means that participants try out ideas that have been generated from personal reflection. Learning by doing, or experimenting with ideas, is certainly not a new concept, as it was one of the main tenets of Dewey's (1938) theory of learning through experience. The implication is that trying ideas out as actions gives ideas more meaning because of the understanding gained from knowing the consequences of the actions. The idea for the action may be part of a team project that is the focus of the action learning, or it may be something unique to the specific team member. The result of this action becomes the topic for subsequent reflection and discussion at the next action learning meeting. The teacher then analyzes the action and shares the result with the team, and the cycle of reflection, sharing, action, and change continues in a recursive manner.

The third process, *feedback*, provides ideas on the efforts for change in the classroom, and this feedback can come from several sources. One source can be members of the action learning set who might observe each other teach in their classrooms. For this to occur, a level of trust needs to have developed within the group. It sometimes helps if the team member doing the observing has been asked to provide feedback on a particular aspect of teaching nominated by the teacher being observed. A second source of feedback can come from the facilitator, who may be invited by the teachers to provide comment on a particular aspect of their teaching. A third source of feedback can be the students in the classroom. This is a very powerful form of feedback, especially if the students are provided with a language to articulate particular aspects of teaching and learning that may be the focus of the action learning (Hoban, 2002).

The fourth process, *community*, relates to group members of the team sharing personal anecdotes to gain a deeper understanding of the meaning of their personal experiences. This social influence on learning was also first highlighted by Dewey who defined the *community* as "sharing in each other's activities and in each other's experiences because they have common ends and purposes" (Dewey, 1916, p. 16). This recognition of the importance of social interactions for children's learning is also applicable to teachers' professional learning. Grossman et al. (2001) argue that forming a community is not an automatic process for any group. They distinguish between a *gathering* and a *community* suggesting that a community goes through several phases as a beginning, evolving, and mature

community. A key sign of a beginning community is that the group can share sensitive issues and discuss tensions that exist within the group. It is negotiating the tensions and moving forward for the benefit of the group that is the sign of maturity, which may take many months and in some cases years to develop. They suggest that initially a group will be convivial in order to get on as a pseudo-community, in which members of the group tend to suppress conflict. A mature community, however, encourages multiple perspectives and encourages the discussion of alternative opinions. Finally, it is in the discussion of conflict and tensions that groups grow into a community and have a moral commitment to the professional growth of the whole group rather than each individual.

It needs to be noted that teachers' professional learning will not be sustained if these three principles of content, processes, and conditions act in isolation. In other words, the processes can be established and the content may be engaging for the teachers, but if the conditions are not there in terms of leadership support and time for the teachers to reflect, act, and get feedback, then the synergy will not work. In essence, the principles need to act *synergistically* for the professional learning community to interact so that there is interplay between the content, processes, and conditions to initiate and sustain teacher learning. According to Hoban (2002, p. 69), "this interplay is dynamic and provides a deeper understanding of why we teach the way we do by encouraging the testing out of new ideas in conjunction with staff discussions and student feedback."

Toward a Model for a Self-Study Professional Learning Community

The model for teachers' professional learning that had been developed over several years was adapted for academic professional learning in a series of meetings from November 2009 to November 2010. The framework to initiate and sustain long-term professional learning about self-study is based on the interplay of the same three influences for teacher learning, but with one key difference: the content was self-study. The three principles were adapted as follows for academics collaborating in self-study of their teaching practices:

1. *Content*
   To initiate the project, an invitation was sent out to all members of the university. By changing from a focus on teachers' professional learning to a focus on academic professional learning, the content of the project needed to change from focusing on classroom practice to focusing on aspects of teaching about teaching that are relevant to a teacher educator. The content or focus of each self-study group member is shown in Table 11.1.
2. *Conditions*
   Several conditions for sustaining professional learning were identified and put in place for the self-study program: (1) a 1-day workshop at the beginning of the

Table 11.1 Content of the self-studies

Academic's name	Academic role	Self-study focus
Garry	Group facilitator	Indigenous thinking
Amanda	External expert	Facilitator
Tricia	Math educator	Being a "crank"
Gordon	Science educator	Learning environments
Celeste	Learning developer	Risky business
Wendy	Science educator	Identity
Peter	Commerce academic	Teaching ethically
Christine	Academic developer	Supporting academics
Irina	Teacher educator	Being a Vygotskian Teacher educator
Lisa	Teacher educator	Changing roles
Jessica	Teacher educator	Beginning academic
Barbara	Teacher educator	Reflective teaching
Jillian	Teacher educator	Personal history

course to initiate the program, (2) meetings every 6 weeks as a whole group, (3) smaller subgroups of pairs or threes for more regular meetings and to assist in data collection, (4) involving a group facilitator to organize the program, (5) having a 2-day writing retreat at the end of the 12-month program, and (6) involving an external expert in self-study for the initial 1-day course and the writing retreat.

3. *Processes*
   As with teacher learning, there are several key processes that must be in place to support academics to analyze their personal practices, including reflection, action, feedback, and community. The time for each meeting was divided into two parts: half of the meeting would involve general discussions about self-study, possibly based on a reading, and half of the meeting would involve each academic sharing reflections on their study and seeking advice and feedback on the ideas being attempted.

Data Collection

Two forms of data were collected to explore the evolving model of an academic's professional learning focused on self-study. First, at every second meeting, we discussed how the program was unfolding and asked if there was anything particularly influential to encourage self-study. These discussions were recorded. Second, each participant was encouraged to keep a journal and write a draft paper about his or her journey while also commenting on the professional learning model. Data from the group discussions of professional learning are presented next, followed by two case studies that summarize the results of self-study projects and personal analyses of the model.

The following quotation is from a recording of our discussion near the end of the 12 months, at the 2-day writing retreat at which participants discussed the

model of professional learning and refined their manuscripts. One of the members stated that the self-study group had become a safe place for her to share her problems about teaching:

> Particularly as an early career researcher, there have been real benefits here. It's been like a counselling session, saved some money at the psychologists, that's how I feel. I feel like I just belong in the group and it's essential to self-study, to uncover dilemmas and problems and we have to have a safe place to talk about them. If we don't, well it's just another group and that's what attracted me, that I can speak and change myself you know. I thought that was good but then I thought, "Oh, I have some problems" and then I went about it instead of doing nothing. I tried to do much more, rather go that way and if I didn't have a group, I perhaps never would have gone there, But sitting as a group there is an opportunity to be in a community within the larger university community where you're supposed to be expert and the whole thing is about self-promotion and presenting yourself in that light where you can actually let that one go for a while.

Being comfortable in sharing personal experiences and being vulnerable are essential characteristics of a self-study community. We turn now to data from the first case study by Peter, an academic from the Faculty of Commerce. We found that it was a positive influence on the group to have Peter as a member, as he provided a different perspective, which is a feature of a mature community (Grossman et al., 2001). The second case study is from Wendy, a science educator from the Faculty of Education.

Peter's Case Study: Promoting Socially Responsible Behavior in International Human Resource Management

I joined the self-study group as a management educator from the Faculty of Commerce. Although I initially felt quite awkward being part of a group in which most members came from the Faculty of Education, my discomfort was soon eased by the common interest we shared in desiring to develop and enhance our teaching practice. I joined the group because I was becoming increasingly dissatisfied with the conflicting demands on my time. University teaching was indeed a "complex and messy terrain" (Berry, 2004a, p. 1312), and I felt that I needed fresh ideas and some collegial support. What better way than to join a group of professionals from the Faculty of Education and learn from the experts? I soon realized that my newfound colleagues were wrestling with very similar dilemmas and tensions. The self-study group encouraged open reflection on a teaching dilemma that each of us was facing. This process gave me permission to discuss with the group my feelings of dissatisfaction with one of my courses. In the wake of the global financial crisis, corporate scandals, and corruption, serious questions were being asked about the apparent failure of business schools to instill values, ethics, and corporate social responsibility in their graduates. I felt that my management courses needed to focus more explicitly on preparing our graduates for the moral dilemmas they would be facing in the corporate world. In my conscience, I felt that I needed to engage

students more explicitly with critical thinking about their responsibility toward people and planet, not just toward profit.

The research issue for me was *how to engage students in value-laden concepts such as societal well-being without appearing to be preaching or moralizing*. I struggled to embed such notions in my courses for fear of imposing my personal values on my students. As an academic, I had been trained to avoid value-laden judgments and statements. There was a tacit fear that discussion of issues such as personal behavior and corporate greed would be perceived as meddling or moralizing by my students. With the support of the self-study group, I began to examine what I could do in my management courses to embed principles of responsible management education. More importantly, the group challenged me to analyze what I was learning about myself as an educator through the journey to resolve this dilemma. The clarification of my own moral and ethical values in the area of international human resource management gave me the framework through which to change my teaching practice in this area. In the past, I had tried to address socially responsible business practices as a stand-alone lecture late in my course. However, there was no evidence in any of the student assessment tasks or during discussions in tutorials that students had experienced any serious engagement with these concepts.

In the first iteration of my international human resource management course after joining the self-study group in 2009, I embedded questions regarding developing socially responsible solutions to management problems in three of the assessment tasks. For example, in the first task, which was a brief survey of literature relevant to an issue of their choice in international human resource management, I asked students to demonstrate "the application of socially innovative solutions to your chosen topic to meet the needs of staff in the international employment relationship".

Generally, this first task was handled poorly. Most students struggled to make the link between the mechanics of expatriation decisions and the social impact of moving people internationally, both on the sending community and the social groups with whom international employees would be working. The second assessment task, a consultant's report for a company sending Australian employees to work in a city in Southeast Asia, built upon feedback from the first assessment task and required groups of student consultants to consider, among other things, "what social innovations could the multinational enterprise (MNE) adopt to benefit the MNE's stakeholders in that community?".

Encouraged by the support of my self-study colleagues, I was able to reframe the entire course around the quest for responsible management behavior in international human resource management in the next offering of the course. The assignment questions were also fine-tuned, based on student responses in 2009. For example, the literature review task in 2010 contained this question: "What ideas do these [journal] articles generate in your search for socially innovative solutions to an international human resource management issue?" . The question regarding social responsibility for the 2010 consultants' report was scaffolded to help students consider their recommendations more realistically: "What initiatives could the

multinational enterprise employ to be socially innovative? Describe the likely impact of the social innovations upon the local community" (Course Outline).

The evidence from student assessment tasks, responses to questions on the final exam, and unsolicited feedback from students suggests a much more powerful learning experience on social responsibility for the 2010 cohort of students. In 2010, lectures scaffolded the key ethical behavior assessment themes and stimulated critical thinking about managerial responsibility toward the environment and the societies in which multinational enterprises operate. One clear improvement was evident in the way the 2010 cohort of students was able to articulate their socially responsible ideas during their group consultants' reports in their tutorials. Because the notion of responsible management had been woven throughout the lectures, students possessed a common language through which to express their emerging thoughts and values. Final marks for the 2010 cohort were slightly higher than those for the 2009 cohort. There were also comparatively more distinctions and high distinctions in 2010. While these marks are indicative of more student engagement in 2010, it is acknowledged that there are multiple factors that affect overall student results; this initiative was but one of a number of continuous improvements in the course.

What Did I Learn About Myself?

The self-study project challenged me to reconsider judgments I was making about what was acceptable and appropriate content in my courses. Was the dilemma really more to do with my self-identity? Was I afraid of being seen as less competent than a more scientific academic? What if I delivered the material on ethics clumsily? Would I be seen as moralizing to students? In order to live with myself, I had to clarify what values I held regarding society and what my responsibility was toward the global community. If my self-identity was robust, I determined, it would not really matter if some individuals disparaged the social agenda in the curriculum. Certainly, the move away from the known and familiar way of teaching the course was accompanied by uncertainty and self-doubt, but out of this discomfort has grown an awareness of new possibilities that, I believe, has reinvigorated this course.

As I resolved questions of self-identity through reflection and honest discussion with colleagues in my faculty and in the self-study group, I noticed that critical questions regarding corporate social responsibility seemed to fit more naturally in the lecture topics. Rather than ethics being bolted on to a lecture, consideration for people and planet became an integral part of the lecture structure. In resolving tensions regarding my responsibility as an academic to engage in ethical debates, I have actually gained an additional critical lens through which to view the business world.

On further analysis, I was rather dismayed that I had not embedded notions of responsible management more explicitly in the lectures, tutorials, and assessment tasks from the first instance of this course. Intellectually, I acknowledge the need to move away from a transmission model of teaching and learning, but I had too

easily fallen into the trap of just *telling* students about ethics rather than seriously considering how to *engage* them creatively in the learning process in this crucial area. My self-study has led me to question the values I knowingly or unknowingly convey to my students. For example, by not addressing the social impact of various business practices in the past, what message was I sending to my students? This study has also reminded me of the need to question my taken-for-granted assumptions about what content should be covered in a university subject. Do I have discipline-specific blind spots? The self-study prompted me to ask questions such as these: What am I missing in this course, and what changes can I yet make in my teaching practice to provide students with opportunities to engage more fully in their own learning journeys in the context of sustainable social innovation? Success in raising student awareness of ways to demonstrate ethical behavior in one subject has had a reframing effect in my teaching practice. I now feel confident in challenging students to think about responsible management behavior in the whole range of courses that I coordinate. As a consequence, I have perhaps learned more about responsible reflection on subject content than my students have about responsible management behavior! The self-study has thus informed my teaching to be richer in stories, more engaging in critical reflection on usefulness to society, and more carefully structured to assess graduate learning outcomes related to social responsibility.

The Model for a Self-Study Professional Learning Community

The self-study group had several robust (and some fun) discussions about the model for a self-study professional learning community. The model helped us to make sense of what we were doing and to clarify our intended outcomes. From my experience, the model elegantly captures the following elements: The learning process of the group can be conceptualized as action learning (Revans, 1981), especially as extended by Delahaye (2011), where the emphasis is on taking risks and resolving uncertainties through questioning, implementing, and reviewing a real problem in the real world. We were encouraged to collect data, keep journals, record evidence, and plan interventions in our teaching practices. Both Amanda and Garry challenged us to go beyond description of what happened to a more profound analysis of what we learned about ourselves through the experience. In several meetings, we broke into subgroups to share our ideas and reflections in a more personal environment. The capstone of the journey, from my perspective, was the writing retreat. Here we workshopped our ideas, read aloud to the group, received constructive feedback, and spent quiet time reworking our drafts and receiving expert advice from the facilitators and other colleagues, all in a beautiful location physically removed from the distractions of daily interruptions on campus.

Content. We were encouraged to "be clear and honest about dilemmas and difficulties" (Amanda, personal communication, 2010) and to approach the issues in a scholarly way. Garry reminded us of the need to focus on what we learned about

ourselves and how this changed our teaching practice. We read widely in the self-study literature, we discussed relevant conferences, we had guest speakers, and we discussed the nexus between teaching and identity. We helped each other make sense of the complexities and contradictions we were facing in our teaching practice, and we discussed what value our reflections could be to others and how to position our writing in the extant literature.

Conditions. Garry and Amanda were excellent facilitators who created a supportive and safe environment in which we could explore our doubts and difficulties. Different perspectives were welcomed and affirmed. Our self-doubts and difficulties were received by colleagues with an empathy born of shared experience. Disclosure led to increased trust. Humility led to mutual respect. By the end of our writing retreat, we had shared good food, great discussions, wonderful collaborations, and a renewed sense of direction from the theoretical clarifications made possible by Amanda and Garry.

Outcomes. My experience of the self-study group was both inspirational and transformational. From the first meeting, moderated by Garry and Amanda, a community began to develop from the common desire for better understanding of the complexities and dilemmas of teaching practice, from the desire for personal growth, and from the aspirations for improved student learning outcomes. As we workshopped our self-study ideas, I found that my doubts and difficulties were received by the group with an empathy born of shared experience. As we discussed our teaching dilemmas, I experienced a refreshing sense of community and support. In recognizing the need to make public the knowledge gained from the process, we committed ourselves to sharing publication ideas. A growing knowledge of the self-study of teacher education practices literature has helped me articulate "a knowledge of practice" (Loughran, 2010, p. 50) in ways that other educators can understand. Other outcomes of the group process included renewed confidence in our role as teachers and inspiration from the support of respected colleagues. My teaching practice has been transformed by reflecting on teaching innovations and sharing these observations with trusted friends. The outcomes we experienced—deeper understanding of our teaching practices, renewed confidence, and reinvigorated classes—occurred, I believe, because of the combination of the elements in this model. While we had differences of opinion regarding the terminology of various components in the categories, there was broad consensus that our group had been so mutually beneficial because of the complex interplay of the features captured in the model for a self-study professional learning community.

Wendy's Case Study: Self-Study of a Science Teacher Educator

Working with the self-study group gave me a chance to step back from my day-to-day life as a junior academic and look back on my teaching pathways over the last 20 years. The progression included a previous life as a science teacher who became a science educator who now teaches preservice teachers about teaching

(Russell & Korthagen, 1995). These different issues of identity were my focus of the self-study group at the University of Wollongong (UOW), which provided the context for me to consider my own relationships to Britzman's (1991/2003) four cultural myths: *teacher as expert*, *teacher as self-made*, *teacher as sole bearer of power*, and *teacher as a product of experience.* In my self-study, I used these cultural myths to explore how they have influenced or been implicated in the development of my various science teacher selves. I aim to surface aspects of my socialized teacher identity as developed through my career transitions: preservice teacher in California, early teaching jobs in small high schools in British Columbia, graduate studies at the University of British Columbia (UBC), and now early-career academic at the University of Wollongong in Australia.

This case study therefore asks the following research question: *How can Britzman's (*1991/2003*) cultural myths help me to understand how my teacher educator identity has developed?* Data sources used in the self-study include records from our self-study group meetings (both audio recordings and written records), recollections from meetings with colleagues and mentors, student evaluations from both UBC and UOW, and an essay written in 2007 about "Becoming a Teacher Educator" as part of my earlier participation in a teacher education research group in Canada (Pitt et al., 2008).

Each of Britzman's (1991/2003) myths serves as a focal point for examining my socialized identity, opening awareness of my developing science teacher and teacher educator selves through a window into how I have changed my teaching practice through these explorations. Through the self-study, I revisited the data sources, in particular the essay written in 2007 that was used as a starting point in the UOW self-study group. Excerpts from the essay are included here as reflections of the particular point in time when I was immersed in the transition from science teacher to science teacher educator. My current position as a newly tenured junior academic is the vantage point for these explorations. I summarize what I learned about myself using Britzman's four myths as headings.

The Myth of Teacher as Expert

The myth of teacher as expert is widely held, perhaps even by teachers, and, in practical terms, feeds an "ends-as-means" discourse. In other words, "expert" knowledge reduces to a "best way" to teach a particular topic, which diminishes the complexity of expert knowledge of content or pedagogy. I noticed this as a science teacher when students and community members brought me injured animals or asked technical questions about the village water supply. But I became more keenly aware of this perception of science teacher as expert when the students in my very first science methods class did *not* see me as an expert.

Student evaluations from that first class made it clear that expectations they held of me (that I should be an expert) were not realized when I failed to provide

"recipes" for successful science lessons. An excerpt from the 2007 essay includes my reaction to my students' expectations:

> I felt a dis-ease with the idea that my own lessons, planning strategies, decision-making processes or management protocols could be adopted directly or applied in another setting, at least not without a deep understanding of my own philosophical and theoretical leanings, along with the contextual knowledge that went into the planning in the first place. Translating my own understanding into the environment where the student teacher would eventually teach seemed simplistic at best, and pedagogically and ethically inappropriate at worst. And yet, this is what the students seemed to want, even demand.

What my students experienced as a failed expectation was an indicator of my own identity in transition: from science teacher to science teacher educator. This transition was underway, but my awareness of its implications developed more slowly.

The Myth of Teacher as Self-made

As a high school teacher, I spent periods of 2–3 years in several small high schools around British Columbia. I was commonly asked to teach many subjects both within science and in other areas, only some of which I was formally qualified to teach. I often taught mathematics courses, but I was also asked to teach in such areas as physical education, information technology, or home economics. The schools typically had 100–200 students in grades 8–12, so there were not enough science subjects to fill my workload. I earned a reputation as someone who could teach a variety of subjects, and it is fair to say I was shaped by this experience. As I began graduate studies, I began to reshape my future.

As a teacher transitioning to full-time graduate student, I wanted to explore how teachers' learned-on-the-job expertise impacted student learning. The research question for my masters work arose out of my own experience, and so my experience of being a teacher had a significant influence on how I made the transition to graduate student. My research found that in other areas of British Columbia, it was also common for high school teachers to teach outside of their specialty teaching areas at least in terms of their undergraduate and teaching qualifications (Nielsen, 2004; Nielsen & Nashon, 2007).

The Myth of Teacher as Sole Bearer of Power

The third of Britzman's (1991/2003) myths points to the danger of oversimplifying discourses of power. As a preservice teacher, I was absorbed in a power struggle between my "master teacher" and my university supervisor. The three-way relationship among us operated as both a functional and institutional triad

(Veal & Rickard, 1998), but when my university supervisor emphasized her own position of power (even over my master teacher), I critically judged her ability and motivation. Although he did not need to be defended by me, for he was a highly regarded biology teacher, I felt my university supervisor's role as a retired English teacher did not justify positioning herself as having power over him to evaluate or criticize him. But, as a student teacher, I lacked a stance from which to challenge her position of power. I was witness to how the power of the institution could be imposed through the actions of the university supervisor. The result was that both my master teacher and I were disempowered as individuals. Perhaps because the institutional triad was not a mutualistic relationship, the functional pairing of my master teacher and I became a stronger locus of power. While risky, especially to me as a preservice teacher, I am now keenly aware of these three-way relationships and the vulnerability of the preservice teacher to impositions by either of the other members of the triad.

The Myth of the Teacher as a Product of Experience

For teachers and those learning to teach, the last of the cultural myths suggests a need to explore contradictions in one's own personal biography. The aim of these explorations is to develop understanding of the authority and extent of cultural forces. As I was drafting chapters of my doctoral thesis, I felt far-removed from my earlier life as a high school teacher. There was a bit of nervous energy when September rolled around, yet again, and I was not returning to my classroom. I felt even farther removed from my own teacher education program and the choices I had made in moving between the various transitions in my teaching career. In the reflective essay written in 2007, I was beginning to position myself as an academic:

> As I continue to study in the field of teacher education and engage in research in the field, I learn more about what kinds of program elements are key to a rich experience for teacher candidates. What I still find difficult is the reality that teaching is as much art as it is science, for the moves and decisions that are made minute-to-minute by teachers in classrooms are responding to the particularities of the individuals in that classroom at that moment in time. A disposition toward awareness and acceptance of this reality is what a teacher education program needs to create in order for it (and its students) to be successful. As I see it now, knowing more broadly about the field of educational research, but teacher education more particularly, I too, am engaged in a life-long pursuit of understanding of the always-pressured and always-changing role of teacher educators.

During the years of my doctoral program, I began to think like a teacher educator. This thinking was perhaps promoted by my involvement with the group of Canadian teacher educators, but it was also assisted by virtue of the particular place where I did my graduate studies and by having been given opportunities to start to develop an identity as a teacher educator. I acknowledge now that this is bumpy terrain, and ongoing engagement with my own biography allows a depth to the reflections that continues to inform my teaching and research as a junior academic.

Aspects of the Model

To this point, I have described some of my explorations with Britzman's (1991/2003) cultural myths as part of my self-study. I turn now to consider the context of the explorations in the self-study professional learning community.

Content. I saw the explorations made possible through my involvement with the self-study community as possible because of the group's focus. At a very busy point of making a major career move to Australia, the group provided a place to focus on the self, in this case, the transition to my first tenure-track academic position. Through the group, I was helped to shape the nature of the content of my own self-study and motivated to continue working on the study. Exploring my own transition points between the various locations of my pedagogical self served to illuminate some interesting contrasts and revealed some of my own subjectivities within the teaching contexts in which I have worked. Belonging to a professional learning community of engaged professionals continues to be a fruitful venue for this aspect of my work and professional growth.

Conditions. Through the self-study and the impetus provided by the self-study professional learning community, I explored my personal transitions among and between various positionings as student, student teacher, novice teacher, experienced teacher, teacher-turned-teacher educator, and academic. These were shared and recorded among a group of respectful colleagues, under the guidance of a group facilitator (Garry) and an external expert (Amanda Berry), all of whom provided a sense of accountability. Our group met bimonthly, starting with a workshop led by Amanda. A year later, Amanda returned to join us for a writing retreat where we workshopped our papers in progress. Discussions at each meeting and at the retreat were very fruitful, drawing attention to both the content and process of conducting and writing a self-study paper. We offered each other ideas, feedback, and encouragement but, most importantly, critical conversations where individual attention was focused on the content of the self-study. Self-study offers opportunity to become more deeply knowledgeable about individual practices as teachers and researchers, and I believe that this is work we must do together as critical friends and colleagues. I have come to realize that these are also important facets of the work for me. I had considered self-study to be an individual activity, but being part of the group was a regular reminder and an incentive for me to continue to make progress on an academic paper that is now in the review process for publication.

Processes. Through participation in the self-study professional learning community, I engaged with the question of my developing identity as a science teacher educator through action learning cycles. Meeting regularly was both a condition and a process that enabled sharing work in progress, questions being explored, ideas for what might count as evidence, and thus clarity, opening the self to colleagues where respectful engagement with each other promoted the kinds of reflections that foster change. For me, I revisited places along my own teacher developmental path, which continues to inspire me to consider how the influences along the way shape me now

as a teacher educator and academic. The implications of my own learning have thus become consequential for my own students.

Self-Study outcomes. While aspects of the myths ring true, particularly for my teacher self, the popular notions embodied in the myths exist in tension with the underlying power discourses that are everyday issues for teachers. This is also the case for teacher educators like me, many of whom have come to the role from previous work as classroom teachers (e.g., Berry, 2007; Bullock, 2007). Through the self-study, I analyzed my own transitions between parts of the teaching triad—student, teacher, university supervisor (Veal & Rickard, 1998)—and how I had been positioned in these roles by institutional structures, societal perceptions, and assumptions about roles for science teachers and teacher educators. These positions shaped me in ways I could only interpret by looking back in time, analyzing how the various teaching contexts have shaped me. I have also been implicated in shaping those contexts. This is as a key value for me of participating in the self-study professional learning community.

Discussion and Conclusion

This chapter describes how a model for teachers' professional learning was adapted to become a model for academics in a self-study professional learning community. Data collected to inform the adaptation included recorded discussions at team meetings, participants' individual journals, and case studies written by the participants. The evolution of the model was discussed explicitly on several occasions during the 12 months, and the model was modified in light of feedback from the group.

As a result, the group decided to keep the triadic nature of the model with its three interdependent principles concerning content, processes, and conditions. We believed that the program would not endure without each of the three principles because each principle is fundamental to sustaining professional learning. However, it was clear that the content was each person in the group and his or her teaching practices, and so this term was included as the focus for the self-study. The conditions to initiate and establish self-study research were also important and included having time to analyze and having access to facilitators to provide guidance in terms of literature and methodology. The learning processes were also important as these kept the conversation going, yet there was one major change that arose as a result of this project.

The concept of community is central to the professional learning process for academics studying their own teaching practices, and we have come to believe that it is the most valuable result of our study because such a group comes together on a regular basis to share openly and honestly their ideas about personal teaching. It was noticeable, especially after several months, that as trust developed, people in the group became more honest in sharing personal experiences. The trust was evident in discussions of personal uncertainties about teaching and in our highlighting tensions in our practice. Some participants also shared aspects of their personal histories. We felt that this was a sign that the group was emerging into a mature community

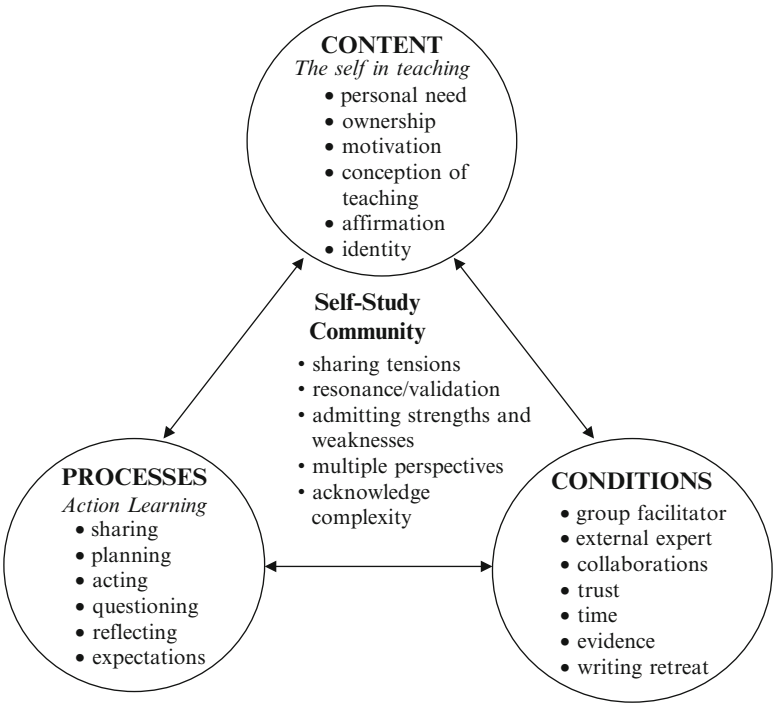

Fig. 11.2 Self-study professional learning community model

(Grossman et al., 2001). Moreover, there was resonance within the group when someone shared a personal dilemma or tension because many of us could identify with the experiences and feelings being expressed. We felt that this was so important that it should become the centerpiece of the model, as a sign that we were developing into a mature professional learning self-study community. Figure 11.2 illustrates this shift in our thinking.

Over time, we hope to revisit this model with another self-study group and refine it further. We believe that it is important for different self-study groups not only to document the products of their research as new insights for self-study but also to document the process of academic learning. Publishing such efforts will inform future efforts at developing self-study professional learning communities.

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Chapter 12
Science Teacher Education, Self-Study of Teacher Education Practices, and the Reflective Turn

Tom Russell

The disciplines of science are often perceived as a quest for right answers, a perception generated unintentionally by the school classroom focus on right answers in the assessment of one's success in learning science. In contrast, the profession of teaching has very few right answers and frequently involves the management of conflicting tensions (Berry, 2007). As a result, the science educator often faces a significant dilemma: there are few right answers for teaching science or for teaching others how to teach science, yet those who are learning to teach science are often predisposed to expect right answers by virtue of their own education in science. Thus, the education of science teachers often involves the challenge of shifting prior expectations from the right answers associated with science to the many perspectives required to make sense of the realities of teaching in a science classroom.

The Tension Between Transmission and Interpretation

Barnes (1975) called attention to the issue of right answers in an interesting way. Teachers in 11 secondary schools were surveyed about their attitudes toward written work by students. When the responses were analyzed, the teachers could be ordered in the following sequence according to the subject they taught: science, languages, domestic science, geography and history, religious education, and English (p. 143). From the teachers' responses, a scale was constructed that contrasted two distinct views of teaching and learning: transmission and interpretation (p. 140). Teachers at the transmission end of the scale indicated that writing served the purpose of recording and acquiring information; the marking of writing served the purposes of assessment

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and correcting errors. Teachers at the interpretation end of the scale indicated that writing served the purpose of fostering cognitive and personal development; the marking of writing served the purposes of making replies and comments and creating a basis for future teaching (pp. 140–141). "What Transmission teachers value is the memorizing of established knowledge" (p. 145). Barnes's analysis of the teachers' responses resulted in his "hypothesizing a relationship between (1) the teacher's view of knowledge, (2) what he values in the pupils, (3) his view of his own role, and (4) his evaluation of his pupils' participation" (p. 144).

If it is correct to assume that science is frequently taught from a transmission perspective while the teaching of science is taught from an interpretation perspective, then the transmission-interpretation scale outlined by Barnes suggests that the shift from student and teacher of science to educator of science teachers is particularly complex and difficult. Some of the chapters in this book speak directly to the complexity of that transition. Self-study of teacher education practices has the potential to address the science educator's challenge of competing perspectives by offering a methodology (LaBoskey, 2004) that can be used to study what and how prospective teachers are actually learning in science education classes. Bullock (2011) provides an excellent illustration of this methodology.

The Concept of a Reflective Turn

An additional perspective on the chapters in this collection is provided by Schön's (1991) idea of a "reflective turn," which he introduced to describe a particular stance toward the analysis of professional practice: "giving practitioners reason" (p. 5).

> Whenever these patterns [of spontaneous professional activity] appear strange or puzzling, [those who have taken a reflective turn] assume that there is an underlying *sense* to be discovered and that it is their business as researchers to discover it. As a consequence, they are sometimes led to reflect on their own understandings of their subjects' understandings; in order to discover the sense in someone else's practice, they question their own. (Schön, 1991, p. 5)

> The reflective turn is … a kind of revolution. It turns on its head the problem of constructing an epistemology of practice. It offers, as a first-order answer to the question, What do practitioners need to know?, reflection on the understandings already built into the skillful actions of everyday practice. Even when the [coach] wants to help practitioners acquire a new set of skills or insights … his or her primary concern is to discover and help practitioners discover what they already understand and know how to do. (Schön, 1991, p. 5)

In the context of teacher education generally and of science teacher education in particular, there can be two types of reflective turn for the teacher educator. The first is a *reflective content turn*, which may occur when the teaching of the content of science and the content of science teacher education are seen less as transmission and more as interpretation. The second is a *reflective pedagogical turn*, which may occur when one realizes that how we teach teachers is less a matter of transmission and more a matter of interpretation (Russell, 1997, pp. 44–45). Taking a reflective turn is, in part, the move required to acknowledge that the beginning teacher already knows a great deal about teaching, even if she or he cannot tell us that knowledge

because it was learned tacitly, not explicitly (Lortie, 1975). Similarly, the science teacher educator must acknowledge that his or her personal views of teaching and learning were learned tacitly, not explicitly, and thus constitute professional knowledge that cannot be described easily but must be explored carefully in the process of moving from a transmission perspective to an interpretation perspective on learning to teach science. Self-study of one's own teacher education practices can be a powerful methodology for making reflective turns with respect to both content and pedagogy. Being able to identify a reflective turn is thus a possible criterion for concluding that a self-study of teacher education practices has been successful.

The application of self-study methodology to science teaching and teacher education seems particularly appropriate because the least complex approach to science teaching is one based on transmission, with the apparently straightforward goal of transferring right answers from teacher to student. It seems almost inevitable that listening to one's students will initiate a reflective pedagogical turn that results in seeing how much more complex science teaching can be. The science teacher turned science teacher educator may, by default, begin with a similar transmission view with respect to pedagogical content knowledge for science teaching. Again, using self-study methodology to listen to those learning to teach is a strong stimulus for making the reflective pedagogical turn with respect to science teacher education. As Loughran and Russell (2007) suggest, these reflective turns can ultimately support the view that teaching itself can and should be disciplined. Pedagogy matters, and self-study of teaching practices can encourage us to view teaching as a discipline.

Analyzing the Move from Science Teacher Candidate to Science Teacher

Liam Brown and Tom Russell demonstrate the power of self-study in the development of a science teacher's first 2 years of teaching. They also illustrate the role of a critical friend who has a commitment to seeing that new teacher succeed. Here we also see the value of blogging as a methodology for self-study. When blogging entries are made frequently and regularly and when responses are received soon after entries are posted, a permanent record is created that can be revisited easily by both individuals. Learning from experience is not automatic. Writing to oneself and others about one's earliest teaching experiences can improve learning from experience dramatically, and responses from a critical friend can further support the self-study process. Liam began his preparation for a teaching career with a strong commitment to active learning, and thus, he appears to have made a reflective pedagogical turn even before beginning the teacher education program. Tom's teaching and contributions to the blog appear to have helped to sustain that turn as Liam faced the daily challenge of students who saw learning as a passive rather than an active process. As Tom participated in the blog, he was encouraged to revisit his own self-study experiences. It was very easy to give reason to Liam, and he tried to support Liam when he found it challenging to give reason to some of his students.

Transforming Oneself from Expert Science Teacher to Science Teacher Educator

Dawn Garbett provides a revealing account of her many changes in perspective as she moved from the science classroom to the science education classroom. The details of her transformation can easily be interpreted as a shift from a transmission perspective to one of interpretation. Gone is that comforting sense of right answers, as Dawn declares her confidence in her uncertainty and her new comfort in not knowing exactly what she is doing. Clearly, self-study has inspired Dawn to make a reflective pedagogical turn. Her students expect that science content is their greatest need; self-study has moved Dawn to reframe her students as needing to understand how they are teaching and how teaching influences the resulting learning. Dawn speaks of self-study as a destabilizing influence, and this response is typical of many who adopt self-study methodology. By attending to her students' levels of confidence with respect to science teaching, Dawn came to realize that she could be more productive by modeling productive teaching strategies than by transmitting accurate science content.

Moving from the Science Laboratory to the Science Teacher Education Classroom

Alexandra Santau also focuses on the transformation to a science teacher educator, but from the unusual starting point of experience in a science laboratory rather than in a science classroom. Her self-study focuses on the gap between the experiences of her preparation for the role of science teacher educator in a doctoral program and the experiences she needed to prepare for that role. She assumed that the doctoral program would provide all the elements of preparation but eventually concluded that pedagogical preparation was lacking but sorely needed. Her analysis of her experiences may inspire those who design doctoral programs to make reflective turns that will stimulate new and realigned elements in such programs.

Using Pedagogical Practices to Develop Pedagogical Reasoning

Stephen Keast and Rebecca Cooper jointly teach future science teachers in a way that demonstrates an ongoing commitment to and a structure for self-study of their teacher education practices. While it is common to invite a critical friend to comment on the data of one's self-study, Stephen and Rebecca invited their critical friend to review videotape recordings of their teaching and then make inferences about what messages their students might be taking from their classes. This approach gives reason to both their students and to their critical friend, resulting in data that provided them with fresh perspectives on their teaching.

Moving from Elementary Teacher to Elementary Teacher Educator

Tim Fletcher reports how self-study of his personal development as a physical education teacher educator inspired him to take a fresh perspective on whether elementary teachers of physical education or science should be specialist or generalists. His efforts to respect and identify the prior experiences of his students, who tended to have had negative reactions to their elementary-school physical education experiences, led him to abandon the notion that participating and having a good time are indicators of positive physical education experiences. Here we see another reflective pedagogical turn achieved through self-study of the personal development of teacher education practices.

Constructing a Distinct Pedagogy for Teaching Physics Teachers

Shawn Bullock is no stranger to the self-study of teacher education practices. His self-study experiences while completing his Ph.D. studies naturally created a sense of confidence about his preparation to begin his teaching as a science educator. As he continued his self-study of his teacher education practices as he began his academic career, he soon discovered that unique problems of practice in the context of a new university and program were generating puzzles and surprises that required further reframing of his pedagogical values. He names his reflective pedagogical turns as turning points in his efforts to sustain attention to the big picture of his educational and pedagogical values.

Listening to Student Teachers to Develop a Pedagogy of Science Teacher Education

Pernilla Nilsson and her critical friend, John Loughran, provide an excellent example of giving students reason. By listening carefully to her students in a course on teaching elementary science, Pernilla was able to identify more clearly the tensions in her teaching. The result is four assertions that can be seen as reflective pedagogical turns in her understanding of her teaching. Virtually every science teacher educator lives the tension between teaching for teacher candidates' short-term need to do well in their practicum placements and their longer-term need to see the bigger pedagogical picture of the relationship between how a teacher teaches and how students learn.

Changing a Teacher Educator's Perspectives by Following New Teachers into Their Classrooms

Deborah Trumbull prepares science teachers in New York State, where there is a very long tradition of standardized examinations at the end of most secondary school subjects. Her case study of "Wendy" reveals her efforts to identify and understand the reasoning behind apparent inconsistencies in Wendy's work as a teacher candidate. As she succeeded in her efforts to understand the logic in Wendy's responses and then followed Wendy into her third year of teaching, what she learned forced her to make a reflective pedagogical turn. As Deborah put her personal negative reactions to high-stakes testing into the context of their effects on her students' overall learning about assessment, she realized that there was much to be gained by developing the importance of formative assessment.

Inspiring Teacher Educators to Analyze Practices as Teacher Candidates Do the Same

Patricia Morrell and Adele Schepige provide an excellent illustration of Schön's (1991, p. 5) observation that it is not unusual to find that "in order to discover the sense in someone else's practice, they question their own." Patricia and Adele set out to encourage greater use of reform-based science teaching practices by selecting an appropriate protocol, teaching their students to use it, and then analyzing the results for influences on preservice science teachers' practice teaching actions and their analyses of those actions. They made a reflective pedagogical turn when they realized that they needed to model the same reform-based practices in their own university classrooms. This turn inspired their self-study that generated a series of changes to their practices, including the practice of making explicit their own thinking, which had previously been largely hidden from their students.

Creating a Model for a Professional Learning Community in Self-Study

Garry Hoban and 11 colleagues at the University of Wollongong conclude this collection not with a self-study but with a yearlong study of a professional learning community focused on self-study of academic teaching practices. Case studies by two members of the community illustrate individual members of the group making reflective pedagogical turns. Then, as the group adapted a model of teachers' professional learning in an effort to capture the essential characteristics of their experience, members of the group made a collective reflective turn to conclude that the concept of community needed to be the central feature of their model for academics collaborating to study their personal teaching practices.

The Reflective Pedagogical Turn in Self-Study of Teacher Education Practices

The experience of constructing an edited collection from the ten manuscripts that now appear as Chapters 2 through 11 has in many ways reminded us of our earlier experiences of collaborative self-studies of our teacher education practices, initially in the same classroom at Queen's University during Shawn's Ph.D. studies and more recently in our separate classrooms at Queen's and UOIT. It is impossible to read, edit, and refine ten chapters without being influenced by the central points of each; doing this work collaboratively provided each of us with a critical friend as we took turns reviewing each chapter and suggesting additions and refinements. I was intrigued when I realized that each chapter illustrates in some way the authors' making a reflective pedagogical turn. After all, what is the point of a self-study of one's teacher education practices if no new insights arise? To conduct a self-study of one's teaching practices is to give oneself reason, seeking out the sense in one's existing practices and in the responses of our students to those practices. As we seek to understand more fully our practices and what our students make of them, it is almost inevitable that puzzles and uncertainties will arise, and these often lead to a reflective turn. If this collection of self-studies of science teacher education practices inspires others to make reflective pedagogical turns that generate readers' own self-studies of teaching practices, the editors and contributors will rejoice.

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