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

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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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