Exploring Values of Science Through Classroom Practice

Rebecca Cooper and John Loughran

Introduction

> Science provides opportunities for students to develop an understanding of important science concepts and processes, the practices used to develop scientific knowledge, of science's contribution to our culture and society, and its applications in our lives. (ACARA, 2016)

Curriculum and policy documents often attempt to create opportunities for teachers to consider/reconsider their views of teaching and learning, and in science education, as the quote above suggests, there is always a need for teachers to think carefully about the way they portray science to their students. One implicit message in the statement is the importance of being conscious of how science is viewed and understood and, as a consequence, how teachers can connect science to everyday contexts in order to shape students' views of science. However, as even a scant read of the literature demonstrates, the need for science teaching and learning to be more relevant to students and to link what they are learning to the world beyond the classroom (Goodrum & Rennie, 2007) has been a high priority for science education. While there are individual examples of great work being done by science teachers and educators, large scale change has not been realised.

An abiding issue, then, is how to support teachers to think about their views of science and the ways they portray these to their students so that school science is not limited to interpretations of science as propositional knowledge, but an invitation to curiosity, interest, questioning and engagement, that is, a conduit to relevance to everyday life. This chapter uses the notion of *values of science* in order to consider how science is viewed (and valued) by teachers and how these views play out in practice. It does so by placing an emphasis on the role of science teacher education as a driver for purposeful consideration of views of science.

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Context

In the earlier version of this book, *The Re-emergence of Values in Science Education* (Corrigan, Dillon, & Gunstone, 2007), the first author of this chapter (Rebecca) wrote as a science teacher as reported in a vignette, describing her work (with a colleague) to illustrate how teachers wrestle with the ideas of values of science as part of their teaching. In particular, their journal entries around the nature of those struggles offered insights into the implications of those struggles and how the struggles impacted their practice.

Since that time, Rebecca has transitioned to being a science teacher educator. This, once again, provides her with an opportunity to consider the place of values associated with science in her teaching. Now her students are students of teaching, beginning their own journeys of thinking about what it means to consider values as part of their developing understanding of learning and teaching science. As a teacher educator, Rebecca has begun to ask: *How do I encourage students of teaching to see the importance of considering values of science as part of their teaching?* This question is significant because, for students of teaching, it is common for concerns to centre more on accumulating 'tips and tricks' of teaching rather than asking deeper philosophical questions about the nature of practice. Herein lies one of the challenges of being a science teacher educator—creating experiences for students of learning that will influence their practice in order to enhance the learning of science of their students. In other words, beginning to challenge the 'learning science as facts' approach to school science teaching.

Over time, as Rebecca began to experience changes in her own understanding of teaching through being a science teacher educator, she came to realise that teaching science in a way that promotes values of science is challenging. Although she thought she was addressing the link between values and practice, a change in practice that unsettled her led her to question what she was really doing and why. The implications for her students and their understanding of values of science came starkly to the fore.

It is through Rebecca's experience of the transition from science teacher to science teacher educator that this chapter explores the ways in which students of teaching think about and develop their own ideas about values of science while learning to teach. The link between how science is valued and science teaching practice is the main emphasis of the chapter (as opposed to a consideration of the values of science per se, which is addressed in other chapters of this volume, including the chapters by Rennie and Smith & Corrigan). Reflecting on this link between valuing science and science teaching practice, and the challenges associated with doing so in preservice teacher education is arguably a tangible beginning point for setting a foundation for science teachers' developing views of teaching and learning.

Values and Science Teaching

> … the term values is used 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)

The values a teacher holds can greatly influence what happens in a classroom (Hildebrand, 2007; Pajares, 1992; Ratcliffe, 2007). As Levinson and Turner (2001) suggested, teachers' value positions impact on the pedagogical approaches that they adopt and their interpretations of the "intended" curriculum. In other words, what teachers value has strong implications for what they teach, when, how and perhaps most importantly, why.

Teachers learn as they "construct new knowledge and understandings based on what they already know and believe" (Putnam & Borko, 1997, p. 1125). To do this requires teachers to reflect on their practice at a level that goes beyond retelling and moves into analysis (Davis, 2006). Loughran (2002) noted that "… one element of reflection that is common to many models is the notion of a *problem* (a puzzling, curious, or perplexing situation)" (p. 33). While the identification of a problem is clearly important, the way the problem is framed is also significant. In other words, it is not enough to simply point out the problem; the way it is recognised and described is important as this can shape what happens next: "there is little doubt that the initial framing inevitably impacts on what is seen, the nature of the risks taken, and the diversity in learning through action" (p. 35).

Teachers see problems as having different levels of significance. Some problems challenge a teacher's values, while others may not. Further, the values that a teacher holds can influence the way a problem is framed and may therefore influence the action taken. If we accept that there is a strong link between beliefs, values and behaviour in the classroom, then that which is valued can influence the nature of practice, and the teacher's disposition towards trying new things and/or taking risks in that practice:

> … teaching concerns coming to terms with one's intentions and values as well as one's view of knowing, being, and acting in a setting characterized by contradictory realities, negotiation, and dependency and struggles in sociocultural domains. (Britzman, 2003, p. 31)

From School Teaching to Teaching Teaching

As is clearly evident in the literature, the transition from school teacher to teacher educator has many challenges (e.g., Bullock & Ritter, 2011; Martinez, 2008; Murray & Male, 2005). The challenge to one's identity (Davey, 2013) often leads beginning teacher educators to see themselves as needing to bring the 'real world practice' of school teaching to the teacher education classroom (Dinkleman, Margolis, & Sikkenga, 2006).

As Rebecca made the transition from science teacher to science teacher educator, she carried a desire to build on the challenge of operationalising her views of science through her teaching as a science teacher educator. Hence, problematising her practice became important in helping her to better understand teaching and learning about teaching and thus begin to establish a pedagogy of teacher education (Korthagen, 2016; Loughran, 2006; Ritter, 2007). In seeking to make clear (through her own practice with her students of teaching) that values of science inevitably influence the nature of science teaching itself, she began to recognise the tensions of teaching about teaching (Berry, 2007) that can complicate what it means to model teaching and to make the tacit features of practice explicit (Bullock, 2009).

As the remainder of this chapter illustrates, by adopting a reflective stance (Cochran-Smith & Lytle, 2009) Rebecca became increasingly cognisant of the influence of values on her understanding of science and how these values impacted her practice as a science teacher educator.

Values and Science Teacher Education

Rosaen and Wilson (1995) observed that as teachers become teacher educators they often struggle to maintain a teacher education focus. Teachers new to teacher education are typically comfortable articulating their problems in the school classroom and reflecting on their teaching practice there, but when they move into teacher education they do not necessarily problematise their *teaching about teaching* in the same way. This may be because:

> While classroom teachers are expected to teach subject matter, university-based teacher educators are expected to teach about how to teach subject matter. Given this different emphasis for instruction, it seems obvious that the pedagogy used by a teacher educator would differ in some important ways from the pedagogy used by a classroom teacher. (Ritter, 2007, p. 5)

This quote highlights the difference in emphasis between the underlying purpose of school teaching and the development of a teacher educator's pedagogy of teacher education (Korthagen, Kessels, Koster, Langerwarf, & Wubbels, 2001; Loughran, 2006). As detailed time and time again in the literature, teacher educators tend to be school teachers who have made the move to teaching in higher education settings without any formal training in teacher education. Often this shift is based on a view that good teachers will make good teacher educators (Korthagen, Loughran, & Lunenberg, 2005) and the assumption that 'teaching' in teacher education is the same as the teaching in schools. Adding further complication to this scenario is that teacher educators often work in a specific subject area (e.g., Languages, Science, Maths, Music, and so on), each of which brings its own particular set of values and views that need be considered in the teaching about the teaching of that particular subject. If due consideration has not been given to the values related to teaching a specific subject area, then there is a risk that the true nature of the subject area will

not be acknowledged as part of pre-service teacher education, which may result in a generic delivery of the skills and characteristics required for developing expertise in teaching the specific subject area. Grimmett (1998) was of the view that teacher education requires an exploration of connections between subject specific materials and the minds of learners such that "detailed examination of both the structure of knowledge in each of the disciplines that make up the area, and also how the disciplines could combine to address real-world problems" (p. 258).

Thus, bringing together the skills and characteristics of quality teaching practice and the subject-specific knowledge around the nature and values of a subject area, matters. Further, Kim and Tan (2011) found that when decisions need to be made in the classroom, the beliefs students of teaching have about the nature of science and their science pedagogical values hold a greater influence than anything else on their decision making and the actions they take. Kim and Tan also noted: "They [students of teaching] struggled with the uneasiness of reconciling the desire for certainty and re-questioning their values of good teaching in their science classrooms" (p. 483).

So it seems reasonable to assert that science teacher educators should be aware of the need to support students of teaching to consider the influence of their values of science on their teaching. Further, science teacher educators should provide opportunities for students of teaching to incorporate aspects of the values of science into their thinking about their planning and in their reflection on their practice.

The knowledge of learning and teaching that students of science teaching develop is embedded in their perceived values of science, and so science teacher educators need to support their students to understand how their practice promotes science as a way of thinking about the world. Thus, it is important that science teacher educators pay attention to how they value science when developing their own understanding of teaching about science teaching.

As science teacher educators develop their pedagogy for teacher education, they need to maintain a focus on challenging students of teaching to examine their views of science and consider how these views might influence their practice and consequently their students' learning of science. Rebecca did this through her Big Picture Science unit.

Big Picture Science Unit

As noted earlier, this chapter emphasises the role of science teacher education as a driver for purposeful consideration of views of science and how these influence teaching. To do this, the chapter now follows Rebecca's transition from science teacher to science teacher educator and explores her consideration of values of science along with her attempts to promote similar thinking among her students of teaching.

This next section is based around insights into the pedagogical journey of two teachers (one of whom is Rebecca) as they created and taught their Big Picture Science unit (see Gunstone, Corrigan, & Dillon, 2007). Their experience is explored

further as an example of two teachers coming to terms with their values of science and their intentions for teaching science in ways that challenged and inspired them to take risks with their practice. In problematising their teaching and reflecting on their students' learning, they came to understand and value science in new and different ways.

Briefly, the Big Picture Science unit emerged from Rebecca's thinking about, and science challenges inherent in, an episode of the television series *Grey's Anatomy*. What sparked her thinking about Big Picture Science was the way in which the episode dealt with how decisions are made in life and death situations. The episode centred around a serious train accident. Two people arrive at the hospital and it quickly emerges that they have been harpooned: there is a pole running through the middle of them. The episode graphically displays them sitting facing each other, able to talk. After many tests and discussions, the doctors decide that they cannot save both of the people and so the decision is made that one must die in order to save the other.

The vignette below is designed to set the context for the Big Picture Science approach developed using the episode of Grey's Anatomy as the stimulus for the unit. To embrace the personal nature of this journey, the following is written from Rebecca's perspective on the situation.

Setting the Scene for Big Picture Science

Vojtech and I were teaching year 9 science together and attended a professional development session by academics from Monash University. The professional development session inspired us and was the catalyst for our collaboration in writing and delivering a unit called *Big Picture Science: Who Makes the Decision?* The unit became a long-term project that we combined with our teaching of a unit on body systems.

We used an episode of *Grey's Anatomy* called *Into you like a train* as a stimulus for the unit, and created an assessment task that required students to work cooperatively to use their science knowledge in creative ways. During the teaching of the unit, we each kept a reflective journal that documented our experiences. This journal became an outlet for us to explore our thinking about science and the way we were presenting it to our students. The intent of the journal was not to retell what had happened that day in the classroom but more to consider what had happened and to question what that showed us about students' understanding of science, as well as our own.

Reflecting on the Big Picture Science Experience

The Big Picture Science unit was a huge success but afterwards Vojtech and I were still caught up in what it is we have learnt and/or feel we need to change. Perhaps this was just our nature or maybe it was indicative of being part of a bigger project where you are constantly being asked to explain and explore and analyse, but nonetheless our headspace was not one of elation. It was, however, still positive; not what did we do wrong, but what did we do right and how can we do more of it? Our list of learnings at the end of the unit included:

- The way the teacher views science has a great impact on the way they present it to the students, which in turn influences how the students view science;
- Choice of stimulus material is vital; and
- Articulating publically and thus opening up your view of science for challenge is at the heart of the progress you make in teaching science.

A Teacher's View of Science

It became clear to us that the way the teacher views science has a significant impact on the way they present it to the students and therefore the way the students view it. If it is presented as a list of facts used to answer questions from textbooks and to be repeated on tests, then that is the way that most students will view it and operationalise it; they will just memorise and regurgitate facts and call it science.

The science as facts view was reinforced through this experience because there was actually a third year 9 teacher involved in Big Picture Science. However, that teacher was not able to be a part of the bigger project we developed and so did not attend the initial session that inspired the approach to the Big Picture Science unit. Although every effort was made to include this third teacher in all of the discussions about the unit, it quickly became clear that her views of science and teaching were more traditional in nature than that which was being pursued in the Big Picture Science unit and so she did not connect with the approach at the same level.

The Big Picture Science project was a year level project which created new and different demands from the more normal individualised classroom approach. For example, students worked on the Big Picture Science project until either the teachers or students saw a need for science content to be introduced. As the third teacher taught the content based on her planning of what she thought students would need and when, she became more isolated in terms of the intent and purpose of the project.

It seems reasonable to suggest that her different approach to teaching the Big Picture Science unit was in no small part a reflection of her view of science teaching and learning (i.e., that the students learn by working from the textbook—the source

of correct factual information—and learning is measured through achievement on a knowledge-based test); a view of science that the unit was actually designed to challenge.

Stimulus Material

Teaching the Big Picture Science unit highlighted the importance of stimulus material in the initial engagement of students in a topic. For example, in a previous unit a BBC documentary called *If drugs were legal* was used as the stimulus material. Although many students found it engaging and challenging, others found it difficult to follow as some of the issues were (to them) a little too complex to comprehend. Despite the fact that the programme drew some very obvious links to science curriculum content related to the nervous system and brain function (the topic being taught) it did not create a powerful need to know for all students.

In contrast to the BBC documentary, the *Grey's Anatomy* episode was accessible to students not only in terms of the issues but also the nature of the content, i.e., body systems. Students connected with the material in both an emotional and cognitive way. They could quite easily picture themselves, or someone they knew, in the situation; their thinking was challenged; and they raised questions that created opportunities for them to articulate their views on the situation. The use of *Grey's Anatomy* as stimulus material became the link between students' existing science knowledge and the world outside of the science classroom—the Big Picture of Science.

Challenging Views of Science

An important aspect of the Big Picture Science journey was built around collaboration. Having the opportunity to discuss and plan for teaching together, then writing about those experiences, provided 'data' that could be revisited and reflected upon, which in turn led to new learning and pedagogical change. The many layers of analysis led to great personal growth. Sharing and challenging views of science out of the classroom led to new developments in the classroom for both teachers and students and fostered an understanding of science that was qualitatively different to that experienced before embarking on the Big Picture Science adventure.

Ongoing Reflections on the Big Picture Science Unit

Post the Big Picture Science experience, I spent a great deal of time reflecting with Vojtech about our shared experience of developing the pedagogical experience together. What quickly emerged was an articulation of what we valued about teaching science (such as making science authentic, emphasising problem solving and usefulness, and contextualising content). However, as we considered our planning an interaction with the third teacher highlighted that these values were not always shared. Although we did not necessarily recognise this at the time, it later occurred to us that the discussions we had engaged in as a duo in planning their Big Picture Science unit had been based around shared values.

When our values (such as contextualising content and others listed above) were challenged by the third teacher, the importance of those values became clearer, stronger and more articulable. Further, the differences in practice highlighted the significance of values in shaping students' science experiences. We shared particular values that supported our pedagogical approach; the third teacher's views of science (and thus the values underpinning them) led her to create different pedagogical experiences for her students that did not necessarily align with the intent of our notion of Big Picture Science.

We wanted our students to experience science in a way that would lead them to value science as meaningful, useful and authentic. Thus, our practice was designed to emphasise our values and encourage students to experience science as contextualised and that linked content with real life. It also revolved around encouraging students to collaborate, and assessments valued the very creativity and problem solving that we saw as crucial to challenging science as simply restating facts and information.

Vojtech and I also came to recognise that through our approach to the unit, our students' values were similarly brought to the surface as a consequence of the discussions about the situation depicted in the *Grey's Anatomy* episode. After viewing the episode, our students were asked to write a journal style response to the episode and to include some indication as to whether or not they agreed with what happened. Of course, there were a multitude of views expressed, but some common (paraphrased) concerns included:

> "The younger person should live because they have their whole life ahead of them."
>
> "The older person should live because they probably have people (partner, children) that they are responsible for and need to look after."
>
> "The doctors should have tried to save them both; irrespective of what the tests are telling them, they should have tried."
>
> "The doctors made the right decision based on the data they had."

Another interesting aspect of the episode, and one which became a major point of concern for the year 9 students, was a scene in which a doctor was running neurological tests on both patients, specifically, testing to see if they could wiggle their

toes. Due to the positioning of the patients and the fact that they were both wearing neck braces, neither patient was able to see their toes or the toes of the other patient. One patient was able to wiggle their toes, the other patient was not. In the scene, the doctor told both patients that they were able to wiggle their toes. The majority of students were not happy about that response and suggested that it was entirely inappropriate of the doctor to lie; something they saw as a breach of trust. Again, through the Big Picture Science unit the class was delving into values rather than content per se.

Vojtech and I recognised opportunities in the episode as ways to talk about decision making and the skills required to evaluate data and the place of evidence in decision making. In so doing, we were able to use the material as a way of discussing ethical conduct, not just for doctors but also for researchers. That allowed a deeper consideration of what could be involved in conducting experiments and how researchers may not always know what the outcome might be (unlike most of the experiments that students tend to experience in school through recipe-type practicals). Subsequent discussion about the need to consider the consequences of not only carrying out an experiment but also of the outcome and how the knowledge gained might be used once again went to the heart of values of science (consider the Manhattan Project).

The Big Picture Science unit created a new way into having our students learn science as something broader, richer and more meaningful than simply memorising facts. The unit purposefully sought to push students to think much more about how the content (e.g., knowledge of the skeletal and nervous system) could be used to inform decision making. The Big Picture Science unit became an impetus for shifting students' thinking—or perhaps surfacing that thinking—about the value of science.

From Science Teacher to Science Teacher Educator

The following vignette continues to explore Rebecca's journey as she transitioned from school science teacher to science teacher educator and begins to consider how she came to portray science and science teaching with her students of teaching. The vignette is made up reflective notes from the time of teaching, reflections post teaching, and more current reflections. The account illustrates how a focus on values influenced her understanding of being a science teacher educator as she attempted to make visible the multitude of issues inherent in teaching and learning about teaching science that she now deemed required significant attention as a teacher of prospective science teachers. Her experience with Big Picture Science had helped her to realise that the values inherent in a teacher's understanding of science education, such as making science authentic, emphasising problem solving and usefulness, and contextualising content, should be a significant focus of teacher education: these values had had such a strong impact on not only the learning of content for her

secondary school science students, but also their views of science and how science knowledge could be used.

Vignette: The transition from science teacher to science teacher educator

During my transition from science teacher to science teacher educator I was teaching general science method [a unit for students of teaching who wish to teach science at Years 7–10]. I was in the privileged position to be team teaching this unit with two other colleagues. Initially, we found this fantastic handout called "The day we made pancakes at school" (Doig & Adams, 1993, see Fig. 1 at the end of the chapter, a sample page from the handout), which we began using in our class simply as a handout. However, what we soon came to realise was that the real value of the handout lay in actually making the pancakes.

When we first used the handout …

Upon discovering this handout, we simply used it as a handout, setting it as a homework task at the conclusion of the first week. These student teachers had considered their current notions of science by exploring specific topics, such as states of matter, and come up with ideas about how they might go about teaching a topic to a given year level. Essentially, they had to plan the topic as a unit of work to run over four weeks, including assessment strategies and monitoring the development of students' conceptual understanding. The task was designed to elicit the current understanding of the nature of science held by our student teachers and what they felt good learning and teaching looked like in a classroom. At the conclusion of the lesson, we gave them the handout and asked them to complete it for homework as if they were secondary school students in year 8. Upon returning to class the following week, the student teachers switched handouts and marked each other's work. Initially, the marking was done individually, but later in the class it was analysed through class discussion about what would be deemed acceptable as an answer, how much detail might be required to get full marks for an answer, what would constitute a correct answer

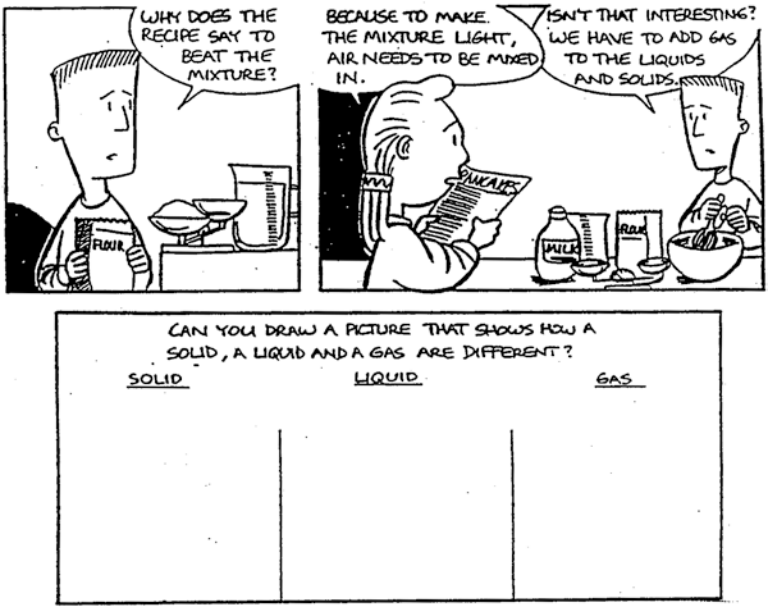

Fig. 1 Sample page from "the day we made pancakes at school". (Doig & Adams, 1993)

at different year levels, what might the teaching look like if this was the assessment task, and how they felt students would react to a task such as this.

What happens now …

After a few years of using the handout as described above, we decided to make a change. As the name of the handout suggests, it is all about making pancakes, and so we decided to get the students of teaching to actually make pancakes in class. A great deal of time was spent considering the purpose of doing this as it was going to take up a considerable amount of class time. We came to the conclusion that we should give it a try and see if this would further challenge their ideas about the nature and values of teaching science. The handout was still set as a homework task, but now that the student teachers had actually made pancakes, we felt that it somewhat changed the nature of the task from being totally theory and content driven to incorporating a memorable learning experience (i.e., what White (1989) described as an episode, a common science teaching anchor for learning). We found that this greatly changed the conversation in the following lesson from being about the answers on the handout in front of them to being more about how they connected the experience they had had with the handout and, further, whether this was what they expected science learning and teaching to be like. That provided us (the science teacher educators) with a great "way in" to challenging their notions of science, learning and teaching science and of course, their values of science.

Lesson 1: Making pancakes

This lesson felt a bit shaky to start with and even a little uncertain as we ran it. I suppose this was mostly because we were trying something new and actually cooking the pancakes for the first time as opposed to just having the students of teaching complete the handout. I was conscious of ensuring that our students of teaching were not thinking that we were just making pancakes for fun and therefore wasting their time. What would happen if they didn't see the point or make the link? Was it up to us to make this explicit or would this actually defeat the purpose of challenging their views of science? During the class, a couple of the girls said they saw no science in it! "What?!" I thought. "Perhaps completing the handout as homework would help to focus their thinking and begin to establish some links."

Lesson 2: Discussing the 'pancake' handout

The lesson today also feels a little shaky, but more from the students' perspective than mine. Even though they swapped handouts and responded to our questions as if they had written the handout in front of them (so not replying as themselves in an effort to create a sense of distance from what they were saying), there was still a sense of pressure and uncertainty in the room. We have been really pushing and challenging their understanding of some concepts, which I think is a good thing, especially for those who think they know it all, but sometimes I worry about those who are a bit nervous about their level of content knowledge ... just something for me to be aware of and perhaps attempt to counter.

We asked them how they approached making the pancakes last week and more specifically if they approached it with a science lens. Their responses included:

"We tried to be strategic about it, started small and moved from there, but we didn't treat it like a serious experiment because we didn't think it was science."

"It's a chemical reaction and physical change, its structure has changed and it has now become cooked batter … I know to explain it like this now but I didn't think like that last week."

"… taste the batter, it's floury, but taste the pancake and it tastes different because a chemical reaction has occurred and we have a new substance … I never thought of this as putting science into practice … (student then mutters to self) why don't I?"

Their responses made me think that perhaps we'd made a dent in their thinking, or at the very least, started them thinking. We decided to capitalise on the dent and slowly turn it into something that could be reshaped rather than repaired.

I don't think that our students of teaching hold views or thinking that requires complete remodelling, but it would be nice to think that they are up for a challenge and open to new possibilities about what science is, how it can be learned and how it can be taught. But where are we in all of this?

As science teacher educators we are standing in the eye of the storm; there is a sense of messiness, chaos and complexity all around as we try to untangle science, science learning and science teaching—and yet we have to remain calm and focused on our own teaching of science teaching so that our students actually have a sense that our practice is worth noticing and responding to if our teaching and our notions of science are to be accessible and able to be critiqued, unpacked and examined. In other words, we have to help our pre-service teacher students reflect on their experiences of our teaching and their learning in order to learn about their teaching of science and their students' learning.

Ongoing Reflections on My Teaching: A Focus on Values

Through the experience outlined in the vignette above, I came to recognise that my view of the nature and value of science was firmly situated in emphasising the usefulness of science in and for the everyday. However, I also recognised that pursuing this through my teaching of science teaching is significantly challenged when my students of teaching do not value science in a similar way. For example, in the cooking pancakes activity, I quickly recognised that many of my students of teaching did not see the science in this everyday action. While the pancake cooking activity was established as a way of challenging the views of science of the students of teaching, I did not anticipate how challenging it would be to make the links between cooking pancakes and science not only obvious but also meaningful.

Reflecting on the Big Picture Science experience reminded me of the impact of the way I thought about and valued science in my practice, and thus the views of the nature and value of science held by my students of teaching. Consequently, I recognised a need to continue to challenge what my students of teaching valued in science in order to help them think carefully about how they presented science to their students in schools, and how they assessed their students' learning in science. Thus, a focus on values in my role as a science teacher educator became an essential aspect of my developing pedagogy of teacher education.

I found the experience of shifting context from science teacher to science teacher educator an educative one, in that it made me recognise that knowing what good science teaching 'looked like' in school did not necessarily translate in the same way in the science teacher education setting. In moving into the science teacher education space, I was confronted by the need to unpack my thinking and to be able to articulate my pedagogical reasoning. The need to be able to 'give reasons' for my practice reminded me once again of my experience with Big Picture Science. By engaging with values in the teaching of science teaching, I began to make explicit

for myself and my students of teaching why values matter and how considering them more carefully impacts one's practice.

My teacher education experience is increasingly shaped by one of my values of science; I value the way science is dynamic and responsive to the complex problems in the world. Thus, my teaching of science teaching attempts to acknowledge the complexity of science, but in so doing illustrates the importance of authenticity; again, the stimulus material for the Big Picture Science unit captures this point.

A focus on values, such as the way science can be dynamic and responsive to complex problems matters because it shifts thinking from the "what" (content) to the "why" (why this content?) and "how" (how can it be useful?). Through an emphasis on the "why" and "how" I have been able to recognise more easily how they influence the focus of assessment, i.e., from tests and recipe style practical reports (mostly encouraging the restating of the "what") to assessment that is centred around creative problem solving of more authentic problems (which requires decisions to be made around "why" this content and "how" it can be useful to solve the problem). Raising these ideas and showing them as a contrasting pair is one effective way of challenging students of teaching to appreciate the place of values of science in the development of their own knowledge and practice of teaching.

My experiences have highlighted for me how, through science teacher education, challenging students of teaching to reimagine science goes hand in hand with questioning their underlying views of learning and teaching science, and the practice inherent in those views. In reflecting on the purpose of their teaching in light of their understanding of the values they associate with science, meaningful links can be made to the science curriculum, authentic assessment and classroom practice—all key components to helping students of teaching begin to make sense of the complex nature of science teaching and learning.

My experiences suggest that in coming to make sense of teaching about teaching science through the lens of values, I have reconsidered and learnt more about what it means as a teacher to place emphasis on values. Reflecting deeply on my understanding of learners of science and how they experience science—both as students and students of teaching—and continually reflecting on, and drawing together the richness of both experiences of practice (school and teacher education), has encouraged me to purposefully challenge students of teaching to think more deeply about the values they associate with science and the nature of learning and teaching science.

Reflecting on the Role of Values of Science

Reflecting on the time since the first values book (Corrigan et al., 2007) was published I am conscious of the shift in my own thinking about values of science and, in particular, I note my ability to better articulate these values and to incorporate them into my teaching about science teaching. However, I also note that during this

time, my students of teaching have not changed much in the sense that they still consistently hold views of science that are quite traditional—perhaps even perceived by some to be 'value free'. Yet there is significant research (some of which is referred to in this volume) that would suggest that science is value-laden and that this is an important point to highlight with both school students and students of teaching. As a consequence, two issues come to mind.

Firstly, during my time as a science teacher I was privileged to work with incredibly supportive and innovative colleagues and a school management team that was not only supportive but willing to take risks. An idea raised at the beginning of this chapter—that the values a teacher holds can greatly influence what happens in a classroom—becomes operationalised in an environment where the teacher's values are welcomed and viewed as a priority. Without this support, perhaps teachers are more likely to become enculturated into practice that carries different (perhaps hidden) values which may run counter to one's implicit intentions. Teaching in ways that explicitly emphasise that which is valued requires time, effort and thoughtfulness. Clearly, then, such an approach requires support and an openness to questioning the values inherent in particular practices. Such support allowed me to collaboratively develop and work on the Big Picture Science unit.

Secondly, students of teaching tend to (initially) have very clear expectations of what it is they are going to do as a science teacher and, thus, what they expect of their science teacher education experience. It seems fair to suggest that cooking pancakes in lesson one is not what they might expect.

Discussing values of science can be a challenge, but what my science teacher education experience has increasingly taught me through these experiences is that asking my students of teaching to consider *their* values of science can be a little uncomfortable for some. However, as "an uncomfortable learning experience can be a constructive learning experience" (Berry & Loughran, 2002, p. 20), it is important not to avoid such situations but to pedagogically engage in constructive ways.

My journey has shown me (and hopefully through sharing it, it has shown others too) that values really do influence the way a teacher teaches. Bringing them to the fore in practice is essential—and all the more so in science teacher education—because values influence not only what is taught, but also how and why, and crucially how those intentions are interpreted in students' learning.

Conclusion

This chapter aimed to highlight the importance of recognising and responding to notions of the values of science and how doing so can influence a science teacher educator's pedagogy of teacher education. The vignettes and experiences detailed in this chapter illustrate how science teacher educators can explicitly support students of teaching in ways that both challenge and embrace a wider view of the science curriculum, including a reconsideration of the nature and place of values associated

with science, in order to encourage and improve the quality of science learning and teaching in teacher education and in schools.

As the vignettes and their discussion sought to make clear, purposefully reflecting on the messages, intent and purposes underpinning approaches to science teaching and the teaching of science teaching requires a shift in thinking and teaching that goes to the heart of science values and how they are portrayed through practice. Ultimately, science learning is shaped by the values inherent in science teaching. Therefore, opening up to scrutiny the dynamic interplay between both in what comprises the complex work of teaching science teaching must be fundamental to quality science teacher education.

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