Chapter 8
The Influence of Assessment on Moderating Science Teachers' Beliefs and Practices

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Introduction

This chapter will consider the moderating influence of assessment on secondary school science teachers' notions of what is important in science education and their practices. Six senior secondary science teachers from different states of Australia (Queensland and Victoria) were involved in this research as these two states represent very different policy approaches to assessment at senior years of schooling. This research highlights the influence such policies can have on moderating teachers' practices and the differences between what they think is important in science education and the reality of their classrooms.

Assessment Policies in Victoria and Queensland

In Victoria, teachers undertake assessment of student learning within their schools in all years with the exception of the final year. In this final year (Year 12, 17–18-year-old students), science students are assessed through two externally set and marked examinations (66 % of the weighting) as well as School Assessed Coursework (SACs) (34 % of the weighting) set by the classroom teacher. SACs can be in the form of a report on an experiment, a student-designed extended practical investigation, an

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analysis and response to media items, a PowerPoint presentation, an oral presentation or an analysis and response to a given set of data. SACs should be part of the regular classwork.

In Queensland an internal assessment system similar to the Victorian one operates up until the last three years of schooling. During these final 3 years, students are assessed on work that is set and assessed by their classroom teacher (100 % of the weighting). These school-based assessments fall into two main categories: externally moderated and quality assured. Externally moderated assessment is set by the teacher but is then taken to a panel of teachers of that subject for moderation of the task. The quality assured assessment is set and moderated only within the school and is similar in nature to the SACs in Victoria. The tasks set for either category of assessment could take the form of school-based exams, observation of practical performances, projects, assignments or fieldwork and often include a student-designed extended experimental investigation (EEI). As all of the assessment is school-based, it is often integrated into the classroom activities and used for both formative and summative purposes.

While there are many similarities in these two assessment contexts, Queensland's lack of an externally set examination and the emphasis on internally set assessment that is moderated by teachers has meant that this moderation process is often viewed as important, highly valued professional development for the teachers. The different demands made on Queensland and Victorian teachers in senior secondary school in terms of meeting assessment requirements place the teachers from these two states in different teaching environments that can often challenge their views of what is important for their students to learn in science.

This chapter will focus on looking at what science teachers see as important in science (their ideal view of science education) and the reality they experience in their classrooms. This reality includes the structural frames they work in, which importantly for senior secondary science teachers include the assessment of their students at exit levels of schooling, their interpretation and implementation of science curriculum as well as the nature of the specific students they teach. In this sense, this chapter will focus on an empirical study where researchers were working with teachers who use formative assessment in very different summative assessment systems as outlined above.

Values of Science

In exploring these teachers' ideal view of science education, the study attempted to establish what was important to the teachers through the lens of values that underpin the discipline of science. The examination of values is appropriate, as according to Halstead (1996), values are the

> … principles, fundamental convictions, ideas, 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 actions and which are closely connected to personal integrity and personal identity. (p. 5)

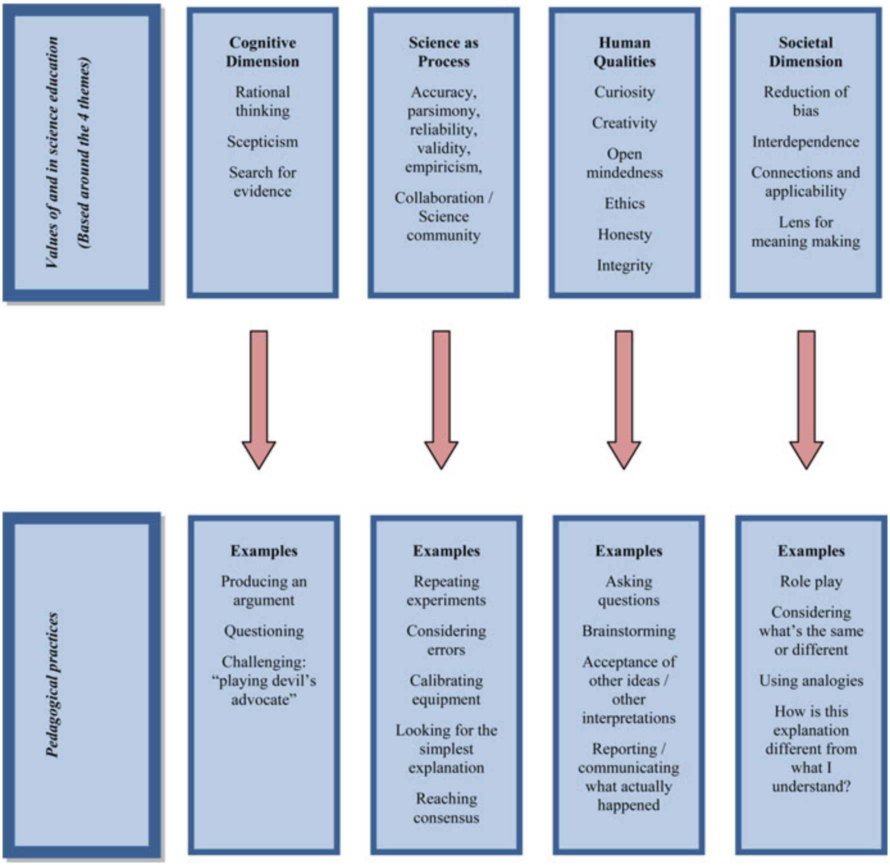

Fig. 8.1 Conceptual framework for the manifestation of values of science in teachers' practice (Adapted from Corrigan and Cooper 2011)

Values of science then should represent the nature of science including the epistemic and sociological values of science. Epistemic values of science include cognitive aspects, such as rational thinking and scepticism, as well as how such knowledge is generated, such as the following: is the data accurate, reliable, valid and empirical in nature? Sociological values of science include both external values such as reduction of bias and the lens chosen for meaning making, and internal values such as curiosity, creativity and open-mindedness. In studying science teachers in Victoria, Corrigan and Gunstone (2007) explored values of science under four broad themes—science as a process, human qualities, cognitive dimensions and societal dimensions—which are represented below in Fig. 8.1. The values represented here promote science as a way of thinking and acting and are consistent with the notion of values as "guides to behaviour" as defined by Halstead (1996, p. 5).

In Fig. 8.1 we have also included pedagogical practices as ways of observing the manifestations of the values within science classes. This is largely because in reality it is the pedagogical practices that can be observed, while the values need to be inferred or specifically sought through means such as interviews, as in the project discussed below.

It is interesting to consider what the arrows linking these two dimensions might represent. Perhaps they are events or things that are experienced in some way that alters a person's beliefs or attitudes, which may eventually accumulate to alter the values held. In this instance, the arrows may represent the interviews both before and after the observation of the pedagogical practices, the interviews having allowed teachers to articulate their beliefs about teaching science and their views of the values underpinning science, providing greater validity to the inferences being made with respect to the observations.

In considering pedagogical practices as what is being observed, it can often be difficult to understand what inferences are being made from these observations. For example, values, attitudes and beliefs, terms that are often used erroneously as interchangeable, comprise intellectual (or cognitive) as well as affective dimensions. Pajares (1992), in reviewing the literature in this field, considers Rokeach's (1968) perspective that "all beliefs have a cognitive component representing knowledge, an affective component capable of arousing emotion, and a behavioral component activated when action is required" (cited in Pajares 1992, p. 314). According to Pajares, Rokeach sees knowledge as a component of belief and relates beliefs to attitudes and values in the following way:

> When clusters of beliefs are organized around an object or situation and predisposed to action, this holistic organization becomes an attitude. Beliefs may also become values, which house the evaluative, comparative, and judgmental functions of beliefs and replace predisposition with an imperative to action. Beliefs, attitudes, and values form an individual's belief system.
>
> Understanding beliefs, Rokeach cautioned, requires making inferences about individuals' underlying states, inferences fraught with difficulty because individuals are often unable or unwilling, for many reasons, to accurately represent their beliefs. For this reason, beliefs cannot be directly observed or measured but must be inferred from what people say, intend, and do—fundamental prerequisites that educational researchers have seldom followed. (p. 314)

In the next section, we will examine an example of a science teacher and learning project and consider how the research being reported in this chapter utilised aspects of that project along with the frame represented in Fig. 8.1 to collect and analyse data.

The Science Teacher and Learning Project

The Catholic Education Office (2005, 2006, Melbourne, Australia) in collaboration with researchers from the Centre for Science, Mathematics and Technology Education (CSTME), Monash University, has been developing ways of growing and supporting science teacher researchers for eight years (2004–2011). Science teacher research is catalysed through opportunities for science teachers to collaborate more closely with science education academic supporters through more systematic research into their practice and their students' learning and to reframe (Schön 1987) ideas about science education such that science teaching can be viewed as problematic and become a site for genuine inquiry. Reframing is, in part, facilitated through a consistent focus on the nature of quality in science teaching and learning. It creates a questioning stance in teachers and simultaneously creates new ways to inquire into the practice setting, which is critical in shaping the outcomes, and ultimate value, of science teacher research as a means for developing, articulating and sharing sophisticated knowledge of practice. With the clear articulation of such knowledge and with a documented evidence base underpinning such knowledge, science teacher researchers have the opportunity to close the gap between science education research and practice—and also science education policy—as the new knowledge becomes communicated and developed more broadly.

This chapter will utilise aspects of the project outlined above to investigate links between what the six teachers involved in this research articulate as being important in science education and the pedagogical practices that they use in their classrooms. In identifying what the teachers felt was important in science, it was essential to establish their personal stance on the view of science as a way of thinking and acting as well as their views on what their students need to learn. Many of these aspects were elicited through semi-structured in-depth interviews with teachers prior to and after observing their science classes. These insights into the teachers' beliefs about and attitudes towards teaching science allowed the researchers to observe the pedagogical practices with a clearer focus on what the teachers intended. This, in turn, allowed the researchers to match the practices and inferences with the values of science that the teachers were promoting.

Outlining the Research

Through peer recognition, six expert science teachers were identified with whom we explored their conceptions of science as a way of thinking and acting, what they felt it was important for their students to learn, what values of science underpinned these conceptions and how this matched with their teaching practice. The six teachers (three in Victoria and three in Queensland) teach both senior secondary (students aged 16–18 years) biology, chemistry and/or physics and middle secondary (students aged 12–15 years) science classes.

Initial exploration of their conceptions and values was conducted via a semi-structured interview (Robson 2002). This allowed the teachers to speak openly about their teaching experiences and to expand their thinking throughout the interview. The direction that the interviews took was therefore determined by the researchers and the teacher as the interview progressed. This approach provided rich, detailed stories about the teachers' practice that, when analysed, allowed us to identify examples of the values underpinning their teaching practice.

The six teachers were filmed teaching two lessons each: one senior science class and one class of Year 7–10 science. These videos again provided rich examples, this time of their actual practice in the classroom, and were an additional data source to the unstructured interviews where they verbalised their practices.

The next steps in the research included providing these teachers with an opportunity for exploring their own practices based on the frame outlined in Fig. 8.1. Teachers were able to use both their interview and video data to comment on the frame as they saw it in their practice. The teachers had the opportunity to discuss their beliefs about science and science education and the values of science that had been promoted in their practice. To conclude the process, teachers were asked to plan a lesson that would portray at least one specific value of science to their students.

The Ideal Versus the Reality

In their middle school science classes, the teachers from Victoria all value *human qualities* (see Fig. 8.1 above), paying particular attention to encouraging curiosity and open-mindedness in their students. They also value *science as a process*, emphasising accuracy, but with varying degrees of conviction. This suggests that in their middle school classes, the teachers are promoting values related to exploration, seeing what is possible and maintaining an appropriate level of accuracy.

In their senior school classes, the teachers from Victoria all emphasised *science as process* with their classes, along with *cognitive dimensions*. It appears that teachers are promoting values of science in their senior classes that are more related to responding to questions and understanding content. The teachers felt that the higher stakes of Year 12 (the final year of secondary school) meant that they could not take as many risks with their teaching and that the purpose of teaching science shifted to focus on the external examination as a major driver of what and how to teach. Mark, a secondary school science teacher in Victoria who teaches middle school science and senior school Biology, summed up this thinking:

> So for me at Year 10 level, the example for Year 10 level is driver safety and relating that to forces and motion. Fifty years ago no one thought about crash investigation, why crashes happen and the science involved, and now it's everywhere. So that's an example of how science has come into an area of society where it has relevance in a lot of different areas. How we build roads, how we educate drivers, laws that are made and how we treat people with injuries who experience these sorts of things. So I think that's an area of science that I think has become… relevant to this time in their lives at Year 10 because they are probably getting behind the wheel of a car for the first time. So that's one example that's probably been around since I've started teaching [and] I've made it a priority of teaching motion and forces at Year 10. I just couldn't do it without relating it to driving and driver safety.
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> … It's Year 12, different views, the pressure of an exam at the end. I would like to think that I'm enthusing them to understand biology rather than just sitting the exam, but I can't avoid the content, I have to teach it. So for me, it [the exam] has to be a big part of where I need to get their understanding to… if I don't want parents ringing up or a principal or head of campus coming to me.

In an effort to emphasise some of the values of science that he believes are important, Mark created a Year 10 (16-year-old students) subject called Creative

Science that explored the links between art (visual, aural and dramatic) and science. The links considered were wide ranging and could include considering the work of Jackson Pollock and the effect of drip rate and hole size on the end result, looking for shapes that are naturally formed within the work of artists, or considering the inspiration that art can provide to science and vice versa. During the lesson that was filmed, the students were experimenting with dripping and flicking paint and analysing the patterns formed:

> Mark is quietly moving around the classroom having put some background music on. He goes over to assist a student who is investigating the difference that height makes when using the drip method for painting. He assists her to take measurements but then continues to move around the room. Mark moves towards a student who has stopped what she is doing as the music dramatically changes. She remarks that this music no longer suits her work and he engages in quite an in-depth discussion with her about the effect of music on his own work, particularly his work as a research scientist. (Researcher field notes)

Contrasted with this is Mark's Year 12 biology class that was filmed:

> The day before this class was filmed the students used a computer simulation to collect data to answer several questions set for homework. Mark begins the lesson with a brief class discussion about the similarities and differences between two of the questions. He then moves on to another activity that is explained as being a way of consolidating their understanding and use of the terms autosomal dominant, autosomal recessive, X-linked dominant and X-linked recessive. The students are given four pedigree charts to discuss in pairs. They are asked to decide which type of inheritance is affecting each pedigree and to justify their selection. The pairs then join up to make groups of four and the groups of four then have to come to consensus about the type of inheritance in each pedigree. Each group records their answer on the board and the group's selections are discussed. The class agreed on 3 out of the 4 pedigrees and Mark facilitates a long and in-depth discussion of the possibilities for the fourth pedigree that culminates in the class discovering that there are actually two correct answers. Mark concludes the discussion by asking the students to consider what they would do if this had been an examination question, which results in one answer being suggested as more correct. (Researcher field notes)

While it is understandable that Mark would certainly want to draw links to the examination at some stage, it is interesting to note that he does this at the end of the class, in a sense displaying it as the final pinnacle that the students are working towards.

In Mark's own words, taken from interview:

> The dilemma I have and you're right that content is a killer. I succumbed to it even though it's not the way I would necessarily like to teach a Year 12 year. But I've always felt that we're doing that [working with the content] now, and I've been fortunate that I've been able to introduce another subject in Year 10 called creative science, where I do exactly what you've just explained [work in a more exploratory and open style].... And I guess for me the key here is to develop that in the Year 10 and Year 11 classes so that in Year 12 it is already part of their thinking. And then I feel that there is an opportunity to be able to do what I like to do in Year 12 given the rigours of Year 12 and the situation.

This dilemma was found to be common among Victorian teachers. For Victorian teachers teaching Year 12, preparing students well for the external examinations is more important than the values of science they want to promote in their science classrooms.

This research process has allowed us to explore the degree of connectedness between what teachers say they believe is important in science and science education (teacher's ideal) and their practice in the classroom (the reality). The data indicates that for these Victorian teachers, with these classes, the level they are teaching makes a difference to the values of science that they promote with their students. The teachers from Victoria clearly articulate that they believe that certain values of science are important (i.e. human qualities) but feel that at the senior levels they are unable to emphasise these due to the pressures of external assessment and, in particular, the examinations. The teachers feel that they are not doing the right thing for the students unless they focus on the external assessments and provide the students with what they believe they need in order to be able to perform at their best.

In Queensland the teachers, within a set of guidelines, determine the assessment at all levels of secondary science education. Greg, a secondary school science teacher in Queensland who teaches middle school science and senior school biology, describes the assessment process he implements across his teaching in secondary school:

Greg	… So if they're honest with their experimenting—especially in Year 10 and Year 9—it transfers in Year 12 where they do work as if it was on the outside [of school]. Like a SAL[inity] test, you don't make up the results for a SAL[inity] test. You just do it and you sign off on it [be]cause it's your name you're putting to the results so to speak.
Interviewer 1	Yeah, building that sense of reputation… so people have faith.
Greg	Yeah, faith in your results.
Interviewer 2	So are there opportunities for you to assess that sort of thing as you go through the years?
Greg	The Year 12 kids now I had in Year 10. And it's good because the ones I did teach…it's like as they get older, the boys that I've had before know how I sort of work. So they're always looking for stuff on the net and always coming up to me and saying, "Hey Sir have you seen this?" and "What do you reckon?" You know, just discuss things, where the other boys…I've started trying to get them into that sort of thinking process, but it's hard when you have a different class every year. It changes. That's how I sort of gauge it.
Interviewer 1	So your Year 12 was pretty similar to Year 10…or Year 9. We saw your Year 9 class. Is that just because you think that's the important way to teach? I mean the fact that it's Year 12....
Greg	Yeah, it doesn't matter the age because they're still kids. They're still 17 and they're boys and they still want to do hands on stuff and they still want to do fun things but obviously to a bit of a higher level. So I'll try to still do the same things throughout all the years, like you know the same values throughout the Year 9s, just so if they had me in Year 12, they'd know what to expect.
Interviewer 1	So you don't seem to shift in your teaching and what you think is important just because it's Year 12… So that whole notion… I mean you want them to do well… But that's not the driver? It doesn't appear to be the driver for you.

Greg The driver for that is the parents and for them [the students] to do well. But I think more of the drive is.... Well for me, I think you learn a lot more of the science at the university level, and if you enjoy science then you're going to study it. So if you enjoy something, then you're going to pick up science at university and study it and that's when you sort of get the real nitty-gritty concepts. I was speaking to the careers counsellor years ago and science is going backwards. There's hardly anybody doing it now in the university level. So if you get kids to scientifically think, then it's fine…. Ah well, the parents don't know that I think like that [be]cause you know, it's all about the boys at the end of Year 12. And I try and tell the boys it's not the be-all [and] end-all of Grade 12 getting that O.P. [overall position, the final result for students completing secondary school in Queensland, Australia]. No one looks at an O.P. after Grade 12 anyhow.

Considering the differences between the responses from these two teachers who teach the same thing but in different states of Australia, it is clear that the different assessment procedures imposed are having an impact on the teachers. Where Mark feels compelled to work with his students to prepare them for the end of year exam, Greg is more concerned with promoting values of science related to enjoying science and encouraging his students to discuss issues related to science in order to get them thinking. This trend was observed between all the Victorian and Queensland teachers.

Promoting Values of Science and Links to Pedagogical Practices

A little while after Greg had participated in the interviews and classroom observations, the researchers asked him to try to plan a lesson that would promote one of the values of science that he felt was important. What he found when he sat down to plan was the set of values we presented him with (see Fig. 8.1) matched his thinking about this unit with respect to the progression of the learning that he wanted the students to experience. The results, presented in Table 8.1, include a selection of the values of science that Greg selected, Greg's lesson descriptions with a pedagogical practice highlighted and the further explanation of the lessons that he gave during a semi-structured interview with the researchers.

In focusing on Greg in this section, we are able to highlight the evaluations he has made about his pedagogical practices in his science class as he uses his beliefs about science teaching to promote the values of science that he sees as important in teaching and learning science. From his interview and also from his lessons that were filmed, it was clear Greg had a firm belief about the importance of the values of science as an intrinsic aspect of his teaching. He was able to evaluate how his lessons promoted the values of science, based on what he believed was important for students to learn. He did not seem compelled to use all of them or use them evenly, and when interviewed

Table 8.1 Greg's selected values, his lesson's focus and further explanation of the lessons from the interview

Values	Lesson description	Further explanation from interview
Human qualities *Curiosity*	Lesson 1: Urban myths. Class discussion about stories or movies about infectious disease, fact or fiction. Responses recorded o n the board *Pedagogical practice:* Using myths, stories, movies to generate a desire to know	"Yeah, the process in which I'd teach. You know, to value… to engage students initially is **curiosity**. Like for Year 10 science, they're doing diseases and stuff so we do have a discussion about urban myths and stories and movies about infectious diseases. We just talk about that. You know, what diseases they've heard of or what's in the media at the moment about diseases and stuff like that"
Cognitive dimension *Scepticism*	Lessons 2–4: Movie*, what do you believe?* Watch a popular movie (I Am Legend, Outbreak, etc.) and ask students to construct a list of fictional and factual references to infectious diseases throughout the movie *Pedagogical practice:* Generating what is not reasonable—fic- tional as opposed to factual	"But with **scepticism**, we watch a movie, either *I am Legend* or *Outbreak* or *Infectious Disease,* and then they ask…yeah *Outbreak* is great. And then I actually get kids… so **scepticism**, they construct a list of fictional and factual references they use in the movie… like that, and then they have to… whatever is fictional they write down, say why it was fictional and then turn it around to make it factual"

Cognitive dimension *Rational thinking*	Lesson 5: Write a letter *Pedagogical practice:* "Myth bust" the movie using research and logic to improve the scientific credibility for the movie producer/director. This culminates in the students writing a letter to the movie producer/director suggesting corrections for the scientific inaccuracies	"So they came in with their…the **rationality** one… so after the movie I got the kids to write a letter to the director or producer saying, "You need to change this to fix the movie"
Science as process *Accuracy, reliability* **Human qualities** *Integrity*	Lessons 6–7: Experiment *Pedagogical practice:* Engage students in the science process	"After that we do an experiment with the old agar and swab so that covers a lot I think. That covers **integrity**, and **searching for evidence**, and **accuracy**, and **reliability** when they do an experiment. And then they did an experiment, basically an experiment from the book"
Cognitive dimension *Search for evidence*	Experiment: growth and control of pathogens. Swab surfaces on agar plates. Variables for controlling pathogens include different household disinfectants added to the agar—observe colony growth, identify colonies, infer best/worst disinfectant for different pathogens	

(continued)

Table 8.1 (continued)

Values	Lesson description	Further explanation from interview
Societal dimension *Interdependence*	Lesson 9: Investigation *Pedagogical practice:* Applying what you know and making decisions Investigation topic: Global warming and the spread of disease are there links?	"Ah yeah, so **interdependence**…I had just an investigation topic. Sometimes I just throw this in, with nature and science and human beings and interactions in nature. I sometimes do that if the kids are an advanced group. I try and get them to write what's the link between global warming and the spread of diseases, like sort of what the humans do and stuff like that"
Human qualities *Creativity*	Lesson 10: Design *Pedagogical practice:* Make your own design Students design their own disease in a group. They should consider: transmission, symptoms, mortality, treatment/control, creative microscopic drawing and name of disease. Students are to present their disease to the class (gallery walk). This could be viewed as **valuing the science community**	"And then **creativity**—I get the kids to design their own disease. So they get a piece of paper. It's like a Venn diagram but sort of a little bit different. They've got to say the transmission, symptoms, mortality, treatment, and they have to draw it microscopically. Like say if it's a bacteria, like what type of bacterial shape it is. And then you put them around the class, and they do a gallery walk so they look at all the other diseases"

he commented that he used them when they fit (which was frequently) with what he believed it was important for his students to understand.

For Greg, the values of science in Fig. 8.1 have meaning because they represent what science means for him. His prior experience as an environmental scientist assists him to see science beyond his own classroom and he is able to help his students consider the implications of what happens if one works in science. For example, Greg commented: "Students should always measure and record accurately. They [the students] know they need three results for an average but they don't want to do it. What they don't realise is that in industry accuracy equals dollars". Greg's experience in industry has strongly influenced the way he thinks about and uses science and this has manifested in the values of science that he promotes with his students through his teaching; this he does in ways he believes represent science more authentically for his students.

Formative Assessment in a Summative System

Promoting particular values of science in their classrooms sees teachers assessing different things throughout their lessons. These assessments are often formative and take place as an integrated part of the teaching. They may involve the entire class, a small group of students or an individual student, and the feedback is usually provided immediately as a discussion. For example, we filmed Larry, a senior physics and middle school science teacher in Queensland, teaching a Year 9 class (15-year-old students) that had just completed a series of experiments to investigate chemical and physical change:

> Towards the conclusion of the lesson, Larry brought the class together and asked the students, "Why is it a chemical change? What's the clue?" This was followed by asking the students, "Can you get me back to where we started?" The students replied that they couldn't because they were chemical changes but Larry, clearly not satisfied with this response, pushes them for more and asks again, "What's the clue for that?" The students' hands shoot up and Larry is shown the actual test tubes, beakers and petri dishes containing the results of the several experiments. Larry moves around the room to each group and has them explain what they have observed as the clue for a chemical change. (Researcher field notes)

Larry's assessment of their explanation, although informal and brief, does assist the students to concisely explain what they have observed during the experiment. Through assessing their explanations of the chemical changes in the experiment, he is promoting cognitive aspects of science, challenging the students to produce a stronger argument by referring to evidence.

Larry also taught a Year 12 physics class that was filmed and that also involved a student investigation. In this case, Larry had set up several demonstrations that used magnetism, electricity or both and progressed through them to help students explore electromagnetism:

> Larry has worked through all of the demonstrations and a pair of students asks if they can have another look at the demonstrations and have a go themselves. Larry excitedly replies,

> "Go for it" and leaves them to explore on their own. This prompts other members of the class to do the same with the other demonstrations. While this is happening, Larry begins to tell the students about the Maglev train as an example of where an electro-magnet is used in real life and talks about the friction being reduced and the speed of the train increasing. A student then asks, "So, how does the train stop?" This takes the discussion in a whole different direction as Larry facilitates a brainstorming session on what you could do or need to know in order to stop the train. Larry concludes the discussion with a captivating thought about how science can solve a problem (make a train go faster) and create a problem (make the train difficult to stop). (Researcher field notes)

Larry is pushing his students to think well beyond remembering basic facts and to think more about ways they can use what they know to help them solve problems. Larry is assessing his students' abilities to make links between the work they are doing in class and what they see outside of the classroom (i.e. valuing the societal dimension), which is very important to him. He comments during an interview, "It's definitely about making links and… I don't know why, they don't seem to be able to see a connection between doing changing colours in a test tube and what's happening down in the creek".

As can be seen from these examples, Larry consistently promotes his values of science through his pedagogical practices, where the formative assessment practices during his classes build student competency for summative assessment practices. The opportunities he affords his Year 9 students to clarify their explanations of chemical change and his Year 12 students to utilise their knowledge and articulate their links will be useful, he believes, to them during summative assessment tasks.

Contrasted with Larry is a lesson we filmed of Shona, a senior chemistry and middle school science teacher from Victoria, teaching a Year 12 Chemistry class (18-year-old students). During the lesson Shona has been working through some questions from previous Year 12 chemistry exams to try to get students to consider the process of answering the question as opposed to just answering it.

> Shona has a question from a previous exam question projected on the board and she says, "Let's look at this question, what topic is this from?" The students respond and she continues, "Ok, this is an equilibrium question. Right, now, let's write down what are the main things we need to know about equilibrium." The students brainstorm ideas about equilibrium and write them down. "Ok, now let's look at this question, what is it trying to target here?" Shona refers her students back to the ideas they have just written down and some students begin circling a couple of the words on the page. In an interview, Shona explains that she does this in class "so they [the students] can make more of a link between this knowledge that they've got in their head and then see what part of equilibrium is it wanting you to demonstrate? This helps them make links, but it also helps them understand how a question is constructed, how they might go about solving it and encourages them to question the validity of the actual question before they even attempt it." (Researcher field notes)

In contrast to Larry's lesson, this lesson is focused on the summative assessment of this subject, the examination. Shona is making an effort to have her students look beyond getting the correct answer in that she trying to make them think more carefully about the process of answering the question. The formative assessment that is taking place during this class is focussed on the students' ability to structure a response to a question, rather the response itself. While there is certainly not a sense that Shona is promoting science as a set of facts to be recalled, there is a sense that her teaching during this lesson is driven by the impending examination and her responsibility to her students to prepare them for it.

Conclusion

There are multiple ways for teachers to utilise formative assessment in their classrooms while still giving consideration to summative assessment. The teachers in this research who teach in Victoria, while for the most part promoting the values of science that they felt were important, tended to allow these values of science to be pushed aside and somewhat overrun by the requirements of the summative assessment practices that are applied during the final year of secondary school. These teachers felt that unless they allowed the summative assessment practices to drive their pedagogical practices when teaching students in their final year of secondary school, they would not be doing the right thing by their students. Thus, when considering the pedagogical practices of the teachers from Victoria, there was, at times, a discrepancy between what they said were important values of science during the interview and what they actually did in the classroom.

In contrast, the teachers from Queensland had a great deal of connectivity between the values of science they espoused as important during the interview and their observed pedagogical practices, regardless of the level of secondary education. These teachers were able to embed their assessment practices far more fluidly within their pedagogical practices and therefore create opportunities for formative assessment during their classes that better matched the summative assessment tasks that the students were to undertake, regardless of the year level. In this sense, the formative assessment was seen as integral in building student competency for the summative assessment practices.

Teachers' articulation of the values of science that they feel students should know in conjunction with their articulation of their beliefs about teaching science provides a powerful notion of what the teachers hold as their ideal view of teaching and learning science. Unfortunately, the reality does not always align with the ideal. While the values of science may provide enduring principles and life stances for teachers' pedagogical practices, they can be challenged by the environment in which the teacher is working and even be sidelined in the face of enforced structures such summative assessment practices.

This chapter has attempted to provide some explanation around the links (arrows) between the different components within the frame provided in Fig. 8.1 above. These links need to be modified to show the interdependence between each of these elements rather than the one-directional representation in Fig. 8.1. Beliefs about teaching science are an important aspect of the links as they challenge the nature of the values of science held by teachers and at times override the promotion of such values and strongly influence the teacher's pedagogical practices. Examination of the assessment practices that teachers employ in a classroom, or are bound by due to the environment they work in—particularly the formative assessment practices and how they related to the summative assessment practices—can help teachers identify the values of science they are promoting in their science classrooms and consider the impact of both values and beliefs on their pedagogical practices.

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