Facilitating Change in Science Teachers' Perceptions About Learning and Teaching

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The Science Teaching and Learning (STaL) project is an in-service teacher professional learning programme constructed around two important design principles aimed at enhancing student learning. The first principle is based on the value of intensive pedagogical learning experiences for teachers of science. Guided by this principle, the programme aims to build participants' capacity to be reflective practitioners (Schön 1983) who seek to transform approaches to learning and teaching in science within their schools. The second design principle is to focus on assisting participating teachers to explicate personal understandings of that which constitutes effective school-based science education leadership as a mechanism to enhance the overall quality of science teaching and learning—with a clear expectation of impact on student learning (Lindsay 2013). These principles form the basis on which STaL is structured. In so doing, the programme genuinely supports a professional learning approach through which teacher participants are placed in the position of being learners of science and hopefully, then, initiators of change in their schools.

This chapter examines science teacher participants' developing knowledge of their students' learning about science as a consequence of changes in their practice catalyzed through the STaL programme. The data for that analysis is derived of the cases that participants write on the final day of the programme. Such cases are self-directed and driven by participants' needs, issues and concerns about their practice and their students' learning. As such, the cases document the pedagogical reasoning, actions and evidential base that matter for them in further developing their approaches to, and knowledge of, science teaching and learning.

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STaL Program Structure

STaL is a 5 day (2 + 2 + 1) intensive, residential course spaced across the school year with two explicit forms of support. The first is in terms of the residential programme itself (teaching and programme facilitation), in which a constant focus on facilitators' pedagogical purpose is explicitly linked to the learning approaches encouraged and teaching procedures adopted. The second is that of ongoing in-school support from a 'critical friend' (the second author of this chapter). The critical friend visits all schools (between 10 and 15 schools a year) at least three times throughout the programme. In these school-based meetings, discussions promote reflective thinking and support the trialing of alternative approaches to science teaching and learning. This ongoing contact ensures a supportive relationship is established which is important in encouraging and assisting participants throughout the programme, and, in particular, supporting them to better conceptualise problems of practice specific to their teaching and learning context.

The programme involves both primary and secondary teachers. There is an expectation that more than one teacher from each participating school attends with the intention that, through a shared experience of professional learning, participants might better be able to build on their learning experiences and support one another in meaningful ways in their school-based endeavours.

The formal outcome of the programme is that all participating teachers produce a written case (Barnett and Tyson 1999; Shulman 1992) capturing their professional learning as a result of their STaL experience. The cases are compiled, edited and formally published each year, producing a separate volume of work (e.g., Keast and Berry 2009). These cases explore a range of teaching and learning issues in science education and have provided useful insights into teacher thinking and a valuable set of data for analysis in relation to the impact of the programme. Each year the book is launched at a public event involving the teacher participants and celebrating their achievement as authors.

STaL was initiated in 2005 and in the seven times it has been conducted up to 2012, it has developed and been refined in accord with the expectations of the underlying design principles. All science teacher participants (N = 226) have been volunteers with annual cohorts of approximately 30. The purpose of the programme is to explore teachers' existing understandings of their practice and to introduce them to alternative ways of framing problems and reflecting on their science teaching and their students' learning of science—which is ultimately documented through their case writing.

The role of the critical friend has become a crucial part of the overall professional learning experience for all teachers participating in STaL. In the school-based meetings the critical friend encourages teachers to revisit their STaL programme experiences as a prompt for 'noticing' their teaching in new and different ways. Although, by design, these meetings are unscripted and informal, the discussions aim to purposefully promote critical reflection. Teachers are encouraged to take time to explore those moments in their teaching in which their routine thinking has

been interrupted or unexpectedly challenged. The critical friend listens, withholds judgment and responds to these teacher stories and concerns with the intention of drawing attention to aspects of these experiences that may have been overlooked, or to focus on particular reactions or responses to events in order to facilitate reflection. In this way the critical friend is actively developing teacher talk that goes beyond science content and teaching activities in order to encourage consideration of their personal perceptions of quality teaching and learning and their enacted role as a science teacher. In a similar manner, these discussions also create ways to explore students' perceived and enacted roles as learners.

The meetings are driven by issues that matter to teachers and it is through the lens of personal experience that they are encouraged to explore meaning and develop insights. The critical friend enables teachers to: comfortably discuss ideas about students' learning needs, identify that which is problematic in practice, and prepare to confront the challenges associated with considering and constructing new approaches to pedagogy. As a result, teachers begin to notice and attend to how their personal professional understandings shape and determine the ways in which they work and the nature of classroom events. This reflective thinking creates opportunities for teachers to begin to develop ways of focusing on experiences that (at the end of STaL) help to shape their case writing.

Each of the 2-day components of the programme explores different approaches to science teaching and learning and places participants in the role of science learner. It is also in these workshops that participants are introduced to case writing as one way of conceptualising, documenting, sharing and learning about practice. The final day of the programme is a writing day in which participants develop drafts and share these with colleagues (STaL team members and participant teachers) in order to refine their ideas and writing, and to reflect further on their learning about science teaching and learning. Most participants report that the writing day offers, for the first time in their teaching careers, an organised and structured space outside of their teaching to write about their practice.

Spacing the programme across school terms 2–4 enables teachers to access new ideas and trial these in their school context and then to return to the programme and discuss their experiences further, and access the experiences and ideas of other participants in order to enhance their own thinking and practice. This format helps to diminish the 'one-off programme' view (that can easily dominate professional development (PD)) and purposefully aims to build relationships. Importantly, the programme is conducted in a non-school context (a city hotel, which comes at a high economic cost) but through that residential environment, the programme reflects STaL and the funding agency's (Catholic Education Office, Melbourne) concern to treat teachers as professionals and value their involvement in ways not common in more traditional PD programmes.

The STaL project is a vehicle for challenging existing science teaching and learning practices and encouraging the development of new knowledge of practice through experimenting with and sharing practice. The case writing acts as a formalised approach to reflection and knowledge development and dissemination. In

essence then, teacher participants are positioned as "producers, not just users, of sophisticated knowledge of teaching and learning" (Loughran et al. 2006, p. 15).

STaL sessions are designed to explore a number of specific areas of science education, in particular, exploring students' existing ideas and alternative conceptions, promoting rich discussion among teachers themselves about purposeful learning, unpacking student thinking to better access student understanding, the role of effective assessment, the role of personal values in science education, and scientific literacy.

Central to STaL is a re-imagining of traditional notions of PD as the supply of pre-packaged knowledge that is distributed to teachers in 'easily digestible pieces' (most commonly, mandated changes in policy and practices directed by education authorities), to a genuine focus on professional learning (PL), whereby teachers actively explore their individual experiences and contexts and become articulate about what they have learnt (Lieberman 1995). Conceptualised in this way, PL involves the sharing of insights about teaching and learning between teachers in order to gain a sense of professional control and ownership over their learning and, concomitantly, a responsibility for the learning and teaching environment that they actively create in their classes (Berry et al. 2009).

Cases as Data

Cases are a vehicle for eliciting teachers' knowledge of practice in ways that help to make the tacit explicit. The cases, which have been published as an outcome of each STaL programme, capture, portray and share participants' knowledge of practice and insights about science teaching and learning. The format is one in which teachers are encouraged to portray in rich detail the dilemmas, issues and concerns they face in their classrooms, resulting in a sense of credibility that tends to resonate easily with other teachers.

As the cases are written by teachers, the ways in which they choose to report their new understandings are idiosyncratic and are certainly not scripted to adhere to any particular or prescribed theme. Hence, links between teaching and learning are reported from participants' perspectives and reflect participants' new understandings.

The cases suggest that as a result of programme experiences teachers begin to think differently about their science teaching and trial alternative approaches to planning and teaching in an attempt to enhance student learning in science (the following brief extract from a case illustrates this point from a participant's perspective.)

> During my time in STaL I came to the conclusion that I really wasn't that great a teacher. On Day 1, we were presented with a teaching model that I loved and wanted to learn more about. The model (comprising ideas about prior knowledge, processing, translation, synthesis, etc.) made me realize that even though I teach content and throw in lots of hands-on

> (dare I say 'fun') activities, I am not always conscious of the entire learning process and what experiences my students (the learners) are going through.
> "I teach therefore they learn. Yeah right!"
> Being a learner again for 5 days was a real eye-opener. The strongest learning experience I had was when we spent 2 h creating our own Slowmations[1] … I was caught up in the process because creating a Slowmation was new for me; I already knew the scientific content knowledge. Because I had to get my head around the idea of creating a Slowmation I put all of my learning efforts into that. I couldn't give both tasks the same level of mental effort so I concentrated on one. It's like when you learn how to drive for the first time and you need to put all your effort into the clutch, gears and accelerator. However, as your learning progresses and you become more experienced, those separate tasks combine, become automatic and then you start to pay attention to the other things.
> As a result of my learning experiences I recognized that I needed to plan units of work more sequentially. This could be done using the ideas from the model from the first session, but I needed to think about separate learning tasks and activities so that students are not bombarded with too much new information all at once. This way my students will hopefully experience learning at a deeper level. It is also important to recognize the difference between content knowledge and the processes or skills that students need to learn those things.
> STaL enabled me to take a step back and become a learner again. That was the most powerful learning for me and has enabled me to shift my focus from, "What am I teaching?" to, "What are they learning?" (Speakman 2012, pp. 18–19)

Over the life of the programme more than 200 cases have been published. These cases have been analysed and categorised to develop an understanding of:

- the range of issues that are prominent among teachers,
- the prevalence of these issues across various cohorts of participants, and
- changes in teacher thinking about these issues as a result of experiences in STaL.

Using the cases as a rich data set for secondary analysis has revealed evidence that STaL impacts teacher thinking and practice in three broad areas: the nature of science teaching, pedagogy and assessment. In the remainder of this chapter, indicative case quotations are used as data sources to illustrate the themes, issues and concerns being discussed. (The reference following each quote refers to the teacher author and the source from the appropriate case book from which the quote has been extracted.)

As cases are written from a teacher's perspective, they provide a way of seeing into the relationship between teachers' actions and students' learning behaviours. The analysis that follows highlights how the STaL cases illustrate ways in which the teacher participants think about student learning and how their teaching shifts in response to their insights. Importantly, the analysis revealed that as teachers begin to see their students' learning differently, it encourages them to continue to refine

[1]Slowmation is a simple form of digital animation used to create a 'slow-animation' (hence Slowmation) of a particular, theme, issue, concept or process which has great value in science teaching. For further details see Hoban et al. (2011).

their teaching. Therefore, as student learning develops it further reinforces the value of change in their teaching practice.

Student Learning

Concerns about students' learning in school science have been well documented, with issues of lack of interest and disengagement continually coming to the fore (Goodrum et al. 2000; Rennie et al. 2001). In response to these concerns, the STaL programme intentionally attempts to expose participants to teaching practices and curriculum designed to build on student interest, respond to student curiosity and questions, and make links to relevant real-life situations (for students).

During STaL, specific sessions explore ways to effectively develop understanding of content through student questions and open-ended discussions, and these sessions encourage teachers to think about their teaching differently, undertake new planning and teaching approaches, explore these in the classroom and share their experiences of science teaching and meaningful student learning. How these learnings are translated into teachers' practice and how those changes relate to perceptions of student learning can be explained through the idea of noticing.

Mason (2002, 2009) used the term 'noticing' to signal the need for teachers to see beyond that which is immediately obvious in their practice. He considered noticing to be integral to helping teachers approach teaching in a disciplined manner, with inquiry at the heart of practice. Mason argued that teachers cannot really understand practice if they cannot see it with fresh eyes and from alternative perspectives—something similar to that which Schön (1983, 1987) described as reframing. Therefore, in order for teachers to grasp the reality of students' learning experiences, there is a need to inquire into practice in order to better appreciate the relationship between teaching and learning. In so doing, a "teacher learns with and from the students about the ways in which teaching impacts their students' learning and how that learning helps further refine practice" (Loughran 2009, p. 12).

A number of cases captured the struggle that teachers experienced as they began to realise that their prevailing science teaching may not assist in the development of students' curiosity, skepticism and critical thinking skills. Rather, they saw that they may have been perpetuating a perception of science as a rigid body of absolute unchanging truths, consisting of isolated facts, and devoid of human imaginations and logical reasoning. Some participants saw a connection between the nature of school science and student disengagement; they began to notice different things in their daily practice:

> I saw that the students were almost drowning in class notes, and found myself drowning with them. I didn't see that I had a choice, but to get out there and try something different. What would have happened if the activity hadn't worked? No worse than could have happened if I didn't try the activity in the first place. (Solomon 2006, p. 22)

> But, good teaching requires us to promote thinking in our students, and this can only be done when staff are prepared to engage in reflecting about how they are teaching. Our

> profession is in a special situation where we are required to engage and help students to be ready to be involved in the workforce … [yet] many teachers have never worked outside an educational setting. The demands of a changing society in many ways require very different approaches than the schooling we experienced as teachers, including the ways we were taught to teach. (Goodridge-Kelly 2010, p. 82)

As the case extracts (above) illustrate, when teachers focus on student learning it has ramifications for their thinking about their own practice. In each of the sections that follow, case data is used to exemplify the theme under consideration in similar ways to that outlined above.

Challenging Assumptions

Seeking to find and challenge taken-for-granted assumptions (Brandenburg 2008; Brookfield 1995) in practice is one way in which the act of noticing can lead to new insights into student learning. A common assumption many teachers raised was related to the perceived importance of teacher control in relation to effective learning. The assumption that students learnt what a teacher prescribed was challenged and led to a recognition that disengagement and underachievement could not simply be blamed on the students themselves. Transmissive teaching (Barnes 1976) can too easily prevail as a default approach to school science. However, through their case writing, some participants noted the need for such approaches to teaching to be seriously confronted:

> A sense of disquiet was growing in me about my classes. It was not so much from the students—they seemed to be engaged in my lessons, enjoying the practical work and not complaining that they had a science lesson. It was something else. I was not happy. I was slowly coming to the realization that my teaching was gradually becoming monotonous. My method of 'getting the content across' involved standing at the front and reading the content to them, and occasionally picking on a student to read out loud; usually the one that had been talking. This was becoming my 'easy default' option. (McGrath 2008, p. 69)

> I was suddenly faced with the realization that my desire to impart scientific content and get them to absorb it may actually be the wrong approach. "How much of the knowledge we are exposed to at school do we retain and are able to use in our daily living?" I asked myself. I know that when I work something out for myself I understand it at a much deeper level than if I learn it "parrot fashion". There seems to be something missing when I do it that way. (Goodman 2008, p. 55)

As evidenced in the case extracts above, when teachers begin to question their approach to teaching, they see the classroom and their actions anew. In preparing for STaL, the critical friend (second author) visits all of the participants to discuss their existing practice and issues/ideas/challenges they might see for themselves and what they might hope to gain from the programme. She typically finds that prior to participating in STaL, many teachers describe predictable and familiar approaches to science teaching that reflect their own rather, than their students', understandings of science ideas. One outcome of STaL is that these views are challenged in

productive ways by the teachers themselves as they see their practice and their students' learning differently. For example:

> I found creating ways for students to be independent learners changed my teaching and their learning. I had struggled to develop a conversation with this group all year and had found that just posing questions was not enough. These students needed visual cues. Through this approach to my science teaching I have consciously started to delay judgement and to refrain from simply praising students publicly. As a consequence, they appear much more confident to write what they think and to make contributions to discussions in ways that are new for me and much more meaningful for them. (Laba 2012, p. 4)

Passive Learning

The cases provide evidence that as a result of their learning experiences in STaL, participants began to question why they taught science in a particular way, that is, they controlled decisions about what content was to be learnt, and when and how students learnt best. They also began to question the value of the inevitably predictable classroom routines which flowed from these decisions—routines which failed to engage students intellectually. They started to confront the situation, recognising that they employed some approaches to teaching science that allowed students to disconnect from both the content and the rigours of learning. The data suggest that some teachers began to notice how their thinking and actions shaped what and how their students learned and that the teaching behaviours that made them feel in control and confident as 'good' science teachers, in reality, reinforced passive student learning behaviours.

Many instances of passive student learning were observed and cited in teachers' cases, all within a context of noticing their practice differently. The data suggest that students expected, and perhaps even relied on, teachers to maintain classroom conditions in such a way that learning was routine, familiar and comfortable. The following extracts demonstrate teachers' heightened awareness of the interconnectedness between teaching and learning, and in particular the impact of their teaching on student learning:

> "Miss, you actually have to teach us this stuff, we can't learn it by ourselves."
> "Can you please explain, like, the whole thing."
> "I'm dumb at chemistry, you need to teach me."
> "You weren't here to teach us yesterday so we didn't do anything."
> It was comments like these that made me realise that perhaps my class were too reliant on me teaching them new concepts.
> The problem I faced was thinking about what I might do to change this. For the next few weeks I reflected at the end of every lesson on what learning had occurred; something I hadn't done since teaching rounds. (Monds 2008, p. 88)

> It is a matter of concern, not just to me but several members of the Science staff that the students seem to be like sponges. They want to soak up facts presented by their teachers but don't really seek to be active in their own learning and all they care about is the mark they get at the end. (Bliss 2007, p. 63)

Changing Conditions for Learning

In acknowledging passive learning, many teachers made a deliberate decision to attempt to change their students' learning behaviours—which ultimately meant changing the prevailing classroom conditions. Some of the cases captured teachers' reflections about what changing the learning conditions meant for their teaching, particularly in terms of the accepted approaches they used in the classroom and the skills and actions which they needed to reconsider. Changing the conditions meant there was a need to build respect and trust between themselves and their students. This was something that stood out as being crucial when taking risks and trialing alternative teaching approaches.

Across a range of cases, it was evident that making changes involved:

- giving students more opportunities for decision making;
- trusting students' judgements about their personal learning needs and interests;
- encouraging more flexible teaching and learning discussions and interactions;
- utilising real world events to exemplify and contextualise student learning;
- recognising the power of language in building meaningful understanding;
- the importance of attending to student interest and curiosity by valuing student questions; and
- actively debriefing with students and promoting student reflection on their own learning.

The following extract illustrates one teacher's thinking about these types of changes and the challenges such changes present.

> I looked at the teaching in my Science classes. One of the most challenging and enlightening realizations that I learnt through the Science Teaching and Learning Teacher Research project was just how powerful the relationship between the teacher and their own class of students is.
> I realized that I needed to know my students much better if I was to teach them well. However, that is some challenge when I regularly see 170 students each week.
> I decided to see every Year 9 Science student at the Parent-Teacher-Student interviews and to discuss their learning instead of talking about marks and behaviour. I also began to recognize the importance of helping students to make a real connection with their own world. I also wondered whether that was really possible to achieve. I have started to do this by asking students questions about what they have previously covered in science and other subjects and how that connects with their everyday life. In making changes to my practice, my greatest fear has been to lose control of both my students' learning and behaviour. I was also worried about what my colleagues or parents might say.
> "What would students think of me when I showed doubt, confusion and mistakes in trying out new approaches that I wasn't yet expert in?" That's hard; the first couple of times anyway.
> It has been hard going. There is so much preparation necessary because of the various changes that have to be done: rearranging the classes; giving different explanations; spending the entire class wandering around and dealing with more questions than in the past; and, dealing with students who are stuck and just want to be told what to do.
> Often I reach the end of the class that I think has been engaging for my students but am not sure what to do next:

> "How will I follow through in the next lesson to build on the learning?"
> These are all challenges that I am now learning to deal with.
> "So where to from here?"
> Well, I can honestly say that now I feel more confident to start to offer a range of learning approaches, to talk with each student to say for example:
> "Do you like this method John?"
> "What have you learnt today?"
> "What can we do together to improve learning?"
> I found it useful to regularly conduct a review of my own and my students' progress. In this way I am beginning to see that the effort is worth it and the gains, although slow, are real. I am enjoying my teaching more and now I feel as though I can see how my students are learning. It's hard work, but it's worth it. (Butler 2007, pp. 106–107)

As teachers elected to change their teaching, students found themselves in unfamiliar territory in their science classes. What had previously been predictable landmarks and signposts had shifted. No longer were they encouraged to sit passively and listen; the teacher wasn't telling them what they needed to know. There was more to science than doing experiments, responding to closed questions and completing standard written reports.

These changes had a significant impact on teacher expectations of students' learning and behaviour. Teachers were more accepting of students' thoughts and ideas and encouraged them to take part in open discussions. In response, students were expected to take risks and share a variety of ideas. This, in the students' eyes, meant that there were fewer cues to what might be 'right', and more opportunity to be seen publically as being 'wrong'. Learning was not defined by the expected routines and students were now being required to play an active part in decision making, to see how ideas linked together, to take responsibility for finding ways to demonstrate their understandings and to pay attention to how they were thinking and learning. This is exemplified in the following extract:

> "Why haven't you started, girls?" I asked.
> "We don't know what to do," Sally replied.
> "What questions are you investigating?" I inquired.
> "Does looking at an eclipse really send you blind and what effect would it have on eclipses if the moon were a different distance from the Earth?" she answered.
> "Well how do you think you could find that out?" I asked, trying my best to push them forward in a positive way.
> "Can't you just tell us the answer?" Michelle retorted.
> "Are you going to mark us on this?" Sally added.
> "No, I can't just tell you the answer and no I am not going to mark you on this," I said with a hint of frustration.
> "Well, will it be on the test at the end?" Sally asked.
> I must admit that at this stage I was feeling rather frustrated. I was trying to create this wonderful learning experience and all they were interested in was how I was going to mark them …
> By now Sally, probably the academically weakest student in the group, seemed to be getting the idea but Michelle, who regularly achieved high marks on the tests, still seemed dubious.
> "Do you understand what you need to do Michelle?" I asked.
> "I think so but why can't you just tell us the answer?" she replied.

> I ignored the last question and left to check the group working in the computer pod. They had discovered what an eclipse looked like but had not had much luck with their second question. I suggested that it might be better if they found that out by doing an experiment. However, once again I found myself up against a culture of "Just tell me the answer!" If I don't tell them they will look on the internet to find someone who will.
> I shoo them out of the pod to get some equipment and see if they can work out for themselves what might happen if the moon was a different size.
> I visit each group to see what they are doing and how well they are getting on with answering their questions. As I move around I am asked, several times, variations of "Can't you just tell me the answer?", "Will we marked on this?" and, "Will this be on the test?" I can tell several of the students are annoyed or frustrated by my refusal to give what they consider to be satisfactory answers to these questions …
> On the whole I was happy with how this activity went but there were several hurdles to jump, most important of which seemed to be an entrenched mind set in the students.
> It seemed that some of the "brightest" students had struggled most with the task. These students are so focused on marks that an unmarked task seems to lack relevance to them …
> It is perhaps important to accept as a teacher that a single activity is unlikely to result in wholesale change in the mind set and attitudes of my students. Such changes of culture are going to take a long time and may be made more difficult by what is happening in other classes. Helping students learn for understanding is hard work. (Bliss 2007, pp. 64–66)

Changes in Learning

Because STaL is an ongoing programme over the course of a year, changes in both student learning behaviours and the quality of student learning were raised verbally on different workshop days and through the school visits with the critical friend, as well as being more formally reported through cases.

Case data provided evidence that some teachers could see that their students were asking questions and sharing personal thinking and ideas in new ways. Teachers drew attention to how students began to demonstrate high levels of personal interest through their willingness to:

- initiate research and personal investigations;
- engage in discussions;
- utilise a range of communication strategies;
- link science to real world experiences;
- talk together about science ideas; justify thinking;
- talk together about learning; and
- question and interrogate information.

In many of the cases it was noted how these changes began to emerge as students experienced a greater sense of trust and acceptance of their ideas. However, it was also clear that teachers had to work hard to consistently maintain high personal expectations of student learning and develop the skills and strategies to ensure a learning environment in which conditions for promoting interactive and personal learning were present. A major challenge appeared to be that this process of change

was slow; it took time and was often inconsistent in terms of sustained student behaviour.

> "Will you give us proper notes for this stuff though?"
> "What? You've got good notes," I thought.
> Apparently if the notes are not from me they are not "proper notes".
> At this point I realised that some of the girls had missed the point. They were totally capable of taking control of their own learning. They had just been doing it. I had seen it for myself. These girls, and so many others like them at our school, are spoon fed information and don't think they have accomplished anything unless they have pages of writing to prove it.
> "Am I going to be able to change their thinking overnight?" I thought to myself. "No way."
> "Could I chip away at it using activities such as this one to try and make them see their learning from a different angle? Sure!" I told myself with a sense of satisfaction and confidence … However, I've demonstrated to myself that I am capable of 'letting go' and giving them a bit of freedom. And, on most accounts, it has been a worthwhile thing to do. Although the girls may not have seen the benefits immediately as I did, it had been a positive learning experience; for both myself and the girls.
> "Now to get them to see it more themselves. That's what I need to do. Yep, I'm not the only one who has to learn to let go." (Rowe 2008, pp. 94–95)

Science also seemed to be changing. The characteristic 'definitive answer' became less prevalent. Science was becoming more dynamic and open to conjecture (see also Fensham's chapter, this volume). Views of science learning were changing, albeit slowly.

> What their responses taught me was that for many of the students, science remains 'fuzzy' as they are in a state of review or reflection. They no longer think that science is just made up of experiments and are now coming to understand that science is a method of study and an opportunity for discovery. Although it was perhaps a small shift in their thinking, they made a giant leap towards where they can move in the future. (Walsh 2010, p. 91)

Overview

STaL appeared to function well as a genuine professional learning experience through the manner in which it actively encouraged and supported participating teachers to begin to recognise and respond to indicators of effective student engagement, the nature of teacher talk, the value of listening to students, and noticing and reflecting on critical incidents (Tripp 1993), often the trigger for their case writing. However, cases also demonstrated that many teachers were concerned about taking risks and letting go, responding to student thinking, linking science to real life contexts, and shifting students' perceptions of science learning.

The ongoing tension for teachers was that these challenges were interconnected with student perceptions about their own role in science classes, that is, students maintained persistent beliefs about that which constituted valuable learning and what teachers should be doing to support such learning. The evidence in the cases suggests that changing teaching approaches was not on its own a solution; students

also had to find a reason for change and a motivation to accept an alternative role in school science.

What was clear was that through a focus on pedagogy, the essential conditions for building trust and interactive, respectful relationships led to valuing student thinking in different ways. As a consequence, a clear purpose for learning emerged which challenged transmissive views of practice in ways that supported more sustainable and achievable change in the longer term. This change was apparent not only in teachers working with their students, but also in teachers accepting a leadership role in working with colleagues.

> Simply because I have changed in how I think about my pedagogy does not mean that I should expect that all staff will, or should, be like me. Importantly, teachers, just like students, also need to have a reason to introduce new ways of working and to experience success with new strategies to gain the confidence to try further new things and to integrate these changes into their teaching. As a leader, I have also learnt that I need to have clear expectations, provide resources and engage my teachers at every opportunity over an extended period of time to allow them to have success and gradually change their practice. (Brasher 2010, p. 84)

Science teaching is often criticised for being preoccupied with knowledge acquisition rather than engaging and enabling students to become more effective learners of science. When teachers begin to notice the inconsistencies between what they say, what they value, and what they actually attend to in their practice, we have found that rich personal learning opportunities begin to emerge. We see STaL as encouraging us in our role as programme facilitators to effectively capitalise on these 'teachable moments'. Such teachable moments do not occur by simply immersing teachers in more science content. We have learnt that it is about building relationships from which supportive learning environments emerge.

Teachers need opportunities to construct their professional knowledge from purposeful interactions through both the uncertainty and empowerment of the learning process. This experience of learning supports and challenges teachers to strategise how they might better align their teaching intents with the learning outcomes they value for their students. As we trust this chapter illustrates, the evidence of such a learning process resides in participants' cases.

Conclusion

This chapter highlights that in order to enable substantive changes in the teaching and learning of school science, the nature of PD needs to be seriously reconsidered. As the cases data illustrate, when teachers are supported to contextualise their learning and write about it in a structured (but not restrictive) form, opportunities for individual learning are able to be capitalised on and shared in meaningful ways, which then supports teachers' professional learning.

As the data illustrate, STaL facilitated teachers' development of an articulable purpose and vision for their science teaching which was closely linked to their expectations for change in student learning. For those changes to be realised, it therefore seems reasonable to assert that professional learning must enable teachers to reconceptualise learning in science—and student engagement provides a powerful focus for this process. An interesting finding from the analysis of the cases has been that as teachers attempt to reframe their practice there is a 'flow-on' effect in relation to the role of students as learners.

The cases powerfully capture not only the complexity of the challenges teachers face as they attempt to reframe practice but also the challenges that students face as the science teaching and learning landscape is reconfigured. This flow-on effect suggests that students are confronted by a shift from a position of relative clarity about themselves as passive, dependent learners to a far more tentative position embodied by what it means to be more autonomous learners.

The well-documented concerns with school science that typically emerge in the research literature (e.g., that success is about having the 'right' answers, science is about note-taking, the teacher is the font of all science knowledge in the classroom, science as it is taught is often not relevant to everyday life, and so on) cannot simply be addressed by a change in teaching approach. Traditional PD is often characterised as a mandated system based on superficial views of change as linear and straightforward. This chapter suggests that teachers profit from professional learning opportunities that help them explore the conditions needed in their classrooms to influence students' perceptions of learning. When that situation prevails, students' learning of science is more likely to be substantive, real and long lasting.

References

Barnes, D. (1976). *From communication to curriculum*. Harmondsworth: Penguin.

Barnett, C. S., & Tyson, P. A. (1999). Case methods and teacher change: Shifting authority to build autonomy. In M. A. Lundeberg, B. B. Levin, & H. L. Harrington (Eds.), *Who learns what from cases and how? The research base for teaching and learning with cases* (pp. 53–70). Mahwah, NJ: Lawrence Erlbaum and Associates.

Berry, A., Loughran, J. J., Smith, K., & Lindsay, S. (2009). Capturing and enhancing science teachers' professional knowledge. *Research in Science Education, 39*(4), 575–594.

Bliss, C. (2007). No, I won't just tell you the answer! In J. Loughran & A. Berry (Eds.), *Looking into practice: Cases of science teaching and learning* (Vol. 3, pp. 63–65). Melbourne: Monash University/Catholic Education Office (Melbourne).

Brandenburg, R. (2008). *Powerful pedagogy: Self-study of a teacher educator's practice*. Dordrecht: Springer.

Brasher, B. (2010). On the road to change: What's wrong with elephant steps? In A. Berry & S. Keast (Eds.), *Looking into practice: cases of science teachers' professional growth* (pp. 82–84). Melbourne: Monash University/Catholic Education Office (Melbourne).

Brookfield, S. D. (1995). *Becoming a critically reflective teacher*. San Francisco: Jossey-Bass.

Butler, I. (2007). The dilemmas of change. In J. Loughran & A. Berry (Eds.), *Looking into practice: Cases of science teaching and learning* (Vol. 3, pp. 105–107). Melbourne: Monash University/Catholic Education Office (Melbourne).

Goodman, R. (2008). It's me, not you. In J. Loughran & A. Berry (Eds.), *Looking into practice: Cases of science teaching and learning* (Vol. 3, pp. 54–56). Melbourne: Monash University/Catholic Education Office (Melbourne).

Goodridge-Kelly, M. (2010). Changing the pitch, not the goal post. In A. Berry & S. Keast (Eds.), *Looking into practice: Cases of science teachers' professional growth* (Vol. 2, pp. 79–82). Melbourne: Monash University/Catholic Education Office (Melbourne).

Goodrum, D., Hackling, M., & Rennie, L. (2000). *The status and quality of teaching and learning of science in Australian schools*. Canberra: DETYA http://intranet.onec.go.th/world_ed/sciencereport.pdf.

Hoban, G., Loughran, J., & Nielsen, W. (2011). Slowmation: Preservice elementary teachers presenting science knowledge through creating multimodal digital animations. *Journal of Research in Science Teaching, 48*(9), 985–1009.

Keast, S., & Berry, A. (2009). Looking into practice, sharing professional wisdom: Introduction to this volume. In A. Berry & S. Keast (Eds.), *Looking into practice: Cases of science teachers' professional growth* (Vol. 1, pp. 5–7). Melbourne: Monash University/Catholic Education Office (Melbourne).

Laba, A. (2012). Developing conversations in science. In S. Keast & J. Loughran (Eds.), *Exploring scientific literacy through cases of teaching and learning* (pp. 3–4). Melbourne: Monash University/Catholic Education Office (Melbourne).

Lieberman, A. (1995). Practices that support teacher development. *Phi Delta Kappan, 76*(8), 591–597.

Lindsay, S. (2013). The case for focusing on student learning. In S. Keast, G. Lancaster, J. J. Loughran, & D. Panazzon (Eds.), *Understanding teaching and learning science through cases* (pp. 4–5). Melbourne: Monash University/Catholic Education Office (Melbourne).

Loughran, J. J. (2009). *Perspectives on science teaching and learning in Melbourne Archdiocesan Catholic Schools: A report prepared for the Catholic Education Office Melbourne*. Catholic Education Office (Melbourne): Melbourne.

Loughran, J. J., Berry, A., & Mulhall, P. (2006). *Understanding and developing science teachers' pedagogical content knowledge*. Rotterdam: Sense.

Mason, J. (2002). *Researching your own practice: The discipline of noticing*. London: RoutledgeFalmer.

Mason, J. (2009). Teaching as disciplined enquiry. *Teachers and Teaching: Theory and Practice, 15*(2), 205–223.

McGrath, K. (2008). What! Is this science? In J. Loughran & A. Berry (Eds.), *Looking into practice: Cases of science teaching and learning* (Vol. 3, pp. 69–72). Melbourne: Monash Print Services/Catholic Education Office (Melbourne).

Monds, S. (2008). Thinking about change. In J. Loughran & A. Berry (Eds.), *Looking into practice: Cases of science teaching and learning* (Vol. 3, pp. 88–90). Melbourne: Monash University/Catholic Education Office (Melbourne).

Rennie, L., Goodrum, D., & Hackling, M. (2001). Science teaching and learning in Australian schools: Results of a national study. *Research in Science Education, 31*, 455–498.

Rowe, E. (2008). Letting go. In J. Loughran & A. Berry (Eds.), *Looking into practice: Cases of science teaching and learning* (Vol. 3, pp. 93–95). Melbourne: Monash University/Catholic Education Office (Melbourne).

Schön, D. A. (1983). *The reflective practitioner: How professionals think in action*. New York: Basic Books.

Schön, D. A. (1987). *Educating the reflective practitioner*. San Francisco: Jossey-Bass.

Shulman, J. H. (1992). *Case methods in teacher education*. New York: Teachers College.

Solomon, T. (2006). Marching through solids, liquids and gases. In J. Loughran & A. Berry (Eds.), *Looking into practice: Cases of science teaching and learning* (pp. 20–22). Melbourne: Monash University/Catholic Education Office (Melbourne).

Speakman, J. (2012). What are we really trying to teach? In S. Keast & J. Loughran (Eds.), *Exploring scientific literacy through cases of teaching and learning* (pp. 18–19). Melbourne: Monash University/Catholic Education Office Melbourne.

Tripp, D. (1993). *Critical incidents in teaching: Developing professional judgement*. London: RoutledgeFalmer.

Walsh, S. (2010). Science is fuzzy. In A. Berry & S. Keast (Eds.), *Looking into practice: Cases of science teachers' professional growth* (pp. 91–93). Melbourne: Monash University/Catholic Education Office (Melbourne).