

Capturing and Enhancing Science Teachers' Professional Knowledge

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Abstract This paper reports research from a three-year Australian science teacher professional learning project, the Science Teaching and Learning (STaL) Project, in which groups of science teacher participants (across years K – 12) worked with academics over a one-year period as teacher researchers. Through reflecting on their experiences within the STaL Project and collecting data from their classrooms related to specific science teaching concerns, teacher participants constructed cases around particular aspects of their professional learning. The cases that these participants developed elicited rich insights into their teaching and their students' learning of science. This paper discusses how the cases were developed by the teacher researcher participants and uses exemplars as a way of illustrating the nature of the professional knowledge developed.

Keywords Science teachers' professional knowledge · Professional learning · Knowledge base for teaching · Classroom cases · Teacher research

Background

Perceptions of what teaching is, how it is done and what it means to be a teacher abound; many of these perceptions are derived from observing teaching and are reminiscent of what Lortie (1975) described as resulting from the *Apprenticeship of Observation*. As a consequence of these perceptions of teaching, it is not uncommon to hear it said that if teachers are not in classrooms working with students (more often than not, at the front of the room, talking) then they are not seen to be 'doing' teaching. Yet teaching comprises so much more than what is obvious, on the surface, to an 'outside observer'. Less apparent is

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the knowledge that underpins teachers' practice, often described as the professional knowledge of teaching.

Munby et al. (2001) in their review of *Teachers' knowledge and how it develops* drew attention to the fact that the literature on teachers' knowledge is characterized by a "root tension [which] lies in the different views of what counts as professional knowledge and even how to conceptualize knowledge" (p. 878). For example, Fenstermacher (1994) highlighted the distinction between the formal knowledge of teaching (the knowledge created by educational researchers) and the practical knowledge of teaching (the knowledge created by teachers through their experiences of classroom teaching). Shulman's (1987) views of teacher knowledge focused attention on understanding not only what such knowledge might be but also how it might be developed. Shulman introduced the notion of Pedagogical Content Knowledge (PCK) into the literature which became a most attractive concept to educational researchers initiating a myriad of investigations into, and perspectives on, teachers' practice (Bullough 2001; Gess-Newsome and Lederman 1999; Loughran et al. 2006; Magnusson and Krajcik 1993). Grimmett and MacKinnon (1992) used the construct of craft knowledge as another way of considering teachers' professional knowledge describing it as being: "...a framework [that] would constitute a broadly conceived set of principles...[which] would provoke discussion and intellectual ferment; they would stimulate teachers to reflect on why they enact certain classroom practices and resist others" (p. 438). Cochran-Smith and Lytle (1999) offered another perspective through a recognition of knowledge *for* practice, knowledge *in* practice and knowledge *of* practice, while Clandinin and Connelly (1995, 2000) saw knowledge of practice as being framed through narrative inquiry.

Despite arguments about what constitutes knowledge of practice and how it might best be described, one common aspect of these conceptions is the fact that teachers' knowledge of practice is largely tacit (Korthagen 2001; Polanyi 1966). Some of the tacit features of teaching include such things as: the reasons for approaching teaching in a particular way; knowledge of teaching procedures and their influence on students' learning; the ability to interpret teaching situations in different ways; and, ways of recognising and responding to student learning difficulties; to list just a few. These (and many more) comprise aspects of teachers' professional knowledge of practice. However, because many of these features are tacit or implicit within practice they are not always central to the ways in which teachers talk about the complex work of teaching and learning. Therefore, that which is described as knowledge of practice is not always so obvious and recognizable to teachers themselves; in spite of the debates in the academic literature about what that knowledge might comprise.

One group of teachers who are familiar with the knowledge of practice and how it is developed and used in teaching is teacher researchers (those teachers who purposefully investigate and report their understandings of their teaching). Teacher researchers have helped to make many of the tacit understandings of teaching much more explicit (see for example the work of, Berry and Milroy 2002; Dusting 2002; Senese 2002, 2004). However, being a teacher researcher is not an easy role. It is typically an additional task taken on by teachers – it is not commonly afforded appropriate importance in the allocation of a teacher's workload – which always reverts back to the need for teachers to be 'doing teaching'.

Teacher researchers then can be seen as practitioners who offer one way of bridging the theory-practice divide as they actively engage in ways of exploring a knowledge of practice in their teaching (McGoey and Ross 1999; Pekarek et al. 1996). This view of teacher as researcher was important in shaping the structure and purpose of the Science Teaching and Learning (STaL) project described in this paper in which teachers were placed in situations

that were designed to challenge their existing views of practice and to encourage a teacher as researcher stance. In so doing, it was anticipated that these teachers would begin to frame and reframe (Schön 1983) their practice in ways that would lead them to unpack and articulate their knowledge of science teaching through writing cases (Shulman 1992).

Science Teaching and Learning (STaL) Project

The Catholic Education Commission of Victoria (CECV) identified Science as one of several key learning areas requiring improved school and student performance (CECV 2005). A Science Reference Group comprising teachers, academics and school principals was established to report on specific issues and concerns related to Science teaching and learning in schools, and to present possible future directions for improvement. Arising from their work, the Reference group noted five issues that required attention:

1. The nature of support from the school leadership team. This includes the time allocation for science coordinators to lead change, and the level of support for innovation and change in science teaching within schools.
2. The role of the science teacher/coordinator. Aspects include teachers' confidence in teaching science (particularly at the primary level) and the role and status of the science coordinator and its impact on professional learning, mentoring and extension opportunities for science staff.
3. The standard of science taught (both content and pedagogy). Science curricula may not incorporate up-to-date content and pedagogy and science teachers may not always be aware of the range of resources available and the science activities possible. When good science teaching is neither valued nor facilitated, the standard of the science taught is affected.
4. Student engagement in science, particularly in the middle years of schooling. Teaching practices and curriculum are not always engaging, nor do they necessarily make links to relevant real-life situations (for students) or cater to different learning styles.
5. The needs of high-performing/gifted students. An inability to engage students of high intellectual or creative ability in science in some schools contributes to the declining numbers who complete senior chemistry, physics and biology.

In responding to these issues from the Reference group, the Catholic Education Office Melbourne (CEOM) in conjunction with Monash University proposed an approach whereby the development of science teachers' practice, both individually and collectively, might be fostered through a Professional Learning program designed to challenge teachers' existing practice and culminate in participants constructing and sharing cases drawn from their resultant classroom experiences. Through the activity of case writing, it was anticipated that participants would have an opportunity to reflect on, and begin to articulate aspects of practice specific to their own needs and contexts, and through discussing cases with colleagues, new insights about practice might be generated and alternative perspectives and approaches explored that might lead to changed science teaching practices within their schools.

The STaL project therefore became a vehicle for challenging existing science teaching and learning practices and encouraging the development of new knowledge of practice through case writing and sharing. In so doing, STaL aimed to redress some of the issues raised by CECV about science education by focusing on the quality of science teaching within participants' own classrooms. In essence then, teachers were being positioned as

“producers of sophisticated knowledge of teaching and learning, not just users” (Loughran et al. 2006, p. 15).

Hence, the STaL project was built on a belief that knowledge of practice is generated through experience (individual and shared) and that collaboration between teachers affords valuable opportunities for their professional learning. As noted above, the STaL project embraced the idea that teachers are producers of specialised knowledge about teaching and learning, and that change in practice occurs most effectively when it is self-initiated and focused on individual needs and concerns. Teachers hold a rich knowledge about what they do, and this knowledge is continually being developed and refined within their classrooms but not necessarily recognized or shared in other than ad hoc ways (Loughran et al. 2006). This is due to issues of organisation (the busyness of teaching affords little time for teachers’ contemplation of practice and school structures are rarely set up to promote learning from practice), and teachers’ perceptions of their role (teachers rarely regard themselves as generators or holders of valuable knowledge about teaching beyond their individual classrooms, (Loughran and Northfield 1996). These aspects then influence how knowledge of practice is viewed and developed by teachers. Moreso, there is little expectation of teachers to engage in dialogue about teaching and learning or to move beyond sharing “activities that work” (Appleton 2002).

Central to the STaL project is a re-imagining of traditional notions of Professional Development 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, whereby teachers are actively involved in exploring their individual experiences and contexts and “becoming articulate about what they have learnt” (Lieberman 1995, p. 591). Conceptualised in this way, Professional Learning 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.

Professional Learning is concerned with empowering teachers through valuing their voices and perspectives (Gore and Gitlin 2004). This is not to say that teacher insights are the only effective form of educational knowledge – academic and other educational institutions also play pivotal roles in working with schools to offer different ways of knowing and looking at teaching practice (Jaworski 2004). However, through the STaL project case writing was seen as one approach for facilitating and capturing teachers’ insights about science teaching and learning in order to create opportunities for their Professional Learning in ways that would lead to enhanced student learning.

If valuing teachers’ knowledge of practice matters, then ways of capturing it are crucial. STaL drew on the notion of Cases (Shulman 1992), since Cases were seen as a way of offering real possibilities for capturing, portraying and sharing participants’ knowledge of practice because the format is ‘real’, i.e., teachers readily identify with cases as the dilemmas, issues and concerns on which they are based, resonate with others in meaningful ways. Cases can therefore be seen as a vehicle for eliciting teachers’ knowledge of practice in ways that help to make the tacit explicit; not only for oneself, but also others.

Cases include the rich detail crucial to looking into practice in ways that are genuine for teachers. They capture what has happened, how and why in particular teaching and learning experiences. Hence, case writing and sharing – as developed and used in the STaL project – offered what Richert (1992) described as a means of promoting teachers’ understanding of their experiences of teaching and learning. Therefore, the STaL project (culminating in case writing) was ultimately designed to support participant teachers’ Professional Learning; and

subsequent sharing of that learning within the profession through the resultant cases, with the aim of beginning to address the issues raised by the CECV Reference group about science teaching and learning in schools.

Participants

A total of 107 science teachers participated in the STaL program, from 2005–2007. All science teacher participants are volunteers with a premium placed on attracting (wherever possible) pairs of teachers who can work together in the same school – although some individual teachers are also enrolled in the program. In year 1 (2005), there were 33 participants from 17 different Catholic schools (four primary schools and 13 secondary schools), in year 2 (2006), there were 33 participants from 21 different Catholic schools (nine primary schools and 12 secondary schools) and in year 3 (2007), 31 participants came from 16 Catholic schools (seven primary schools and nine secondary schools). (At the time of writing, a fourth cohort is preparing to start the program).

The program involves 5 days of formal workshops (2×2 days and 1×1 day) spread over a school year. As noted above, the purpose of the program 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 practice and their students' learning of science – which is ultimately documented through their case writing. In addition to the five workshop days, each teacher is supported by a member of the STaL academic team during the year. This support occurs in the form of individual school visits (approximately two per year for each participating school) and ongoing electronic contact. Hence, a supportive relationship between STaL team members and participants is created which is important in encouraging and assisting participants throughout the program, and, in particular, supporting them to better conceptualize problems of practice specific to their teaching and learning context.

Each of the two-day components of the program explores different approaches to science teaching and learning and places participants in the role of science learner. Also, in these workshops participants are introduced to case writing as one way of conceptualizing, documenting, sharing and learning about practice. The final day of the program is a case writing day in which participants develop case 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 case 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.

For each of the three years of the program, STaL has published the teacher developed cases as a book (Loughran and Berry 2006, 2007, 2008). Copies of these books are given to all participants and shared within the Catholic Education schooling system.

Cases: Thematic Analysis

The sets of cases developed and published as books elicit rich understandings about science teachers' knowledge and the types of issues and concerns that prompted their reflection on practice. In order to determine the range of aspects of practice that teachers were writing about over the three years of the program, and how they were thinking about these issues through their writing, each volume of cases was examined for broad themes, by the third author of this paper. (Note that the first three researchers are facilitators in the STaL

program, and the fourth is an administrator of the program). Through this initial stage of analysis, three major categories of topics were revealed: teaching, learning and pedagogy.

A second stage of analysis involved close reading of each case by two of the researchers independently (first author and third author), to ascertain the explicit concern/issue/practice underlying the major category that was the central theme of the case. Clearly, such analysis is subjective as a “good” case purposely elicits a range of sometimes contradictory messages in an attempt to draw the reader in to the experience. However, the process of analysis employed was not designed in order to correctly and absolutely assign labels to every aspect of each case but rather to seek to ‘notice’ (Mason 2002, an idea that will be elaborated later in the paper) the more obvious bigger picture issues (allocated as sub-themes) that combined to create a sense of the author’s thinking about her/his situation. The final list of sub-themes emerged through discussion between the two authors from their independent analysis, and is documented in Table 1. Typically, across each case, four to five obvious sub-themes emerged, although interestingly, there was little cross over between the three major categories to which the case as a whole was allocated (see Table 1).

The cases attest to a significant level of impact in terms of teachers’ understanding of teaching, and of learning, as separate entities. Interestingly though, there was much less attention given by the teacher authors to the combination of these terms, as pedagogy (category 3), in the European roots of the term (i.e., that teaching and learning are inextricably linked and that each influences the other in a symbiotic relationship, see for example, Van Manen 1991, 1994, 1999). In fact, the cases prepared in 2007 are the only ones identified as addressing the notion of pedagogy. This point is taken up later in the paper.

Table 1 Themes emerging in each of the volumes of the cases books

Major category	Sub-theme	Volume 1 (year 1 cohort)	Volume 2 (year 2 cohort)	Volume 3 (year 3 cohort)
Focus on teaching: Developing practice	Translating theory into action	6	2	3
	Learning experiences: different perspectives of teachers and students	6	8	2
	Open ended activities: providing intellectual space and challenge	6	10	1
	Taking risks in teaching	8	15	15
	Changing the teacher’s role	12	11	12
	Investing time in student learning	1	4	6
Focus on learning: Developing student understanding	Shifting students’ views of learning (What matters? What is ‘real work’?)	3	8	5
	Assessing student knowledge	5	7	4
	Valuing & building on student interest, questions and ideas	7	7	12
	Discussion: promoting trust and decision making	7	9	5
	Students linking learning experiences	10	6	5
	Planning for learning	11	18	11
	Promoting deeper thinking	11	4	4
	Student engagement	15	16	14
Focus on teaching <i>and</i> learning: Pedagogical development	Unpacking student understanding	0	0	8
	Sharing intellectual control	0	0	15
	Linking science to the real world	0	0	7

Analysis of the Cases books (see Table 1) highlights how the 3 major categories and sub-themes emerged in and across the cases over each of the three cohorts involved in the STaL project for the three years of the program (2005–2007). Because each case touches on a range of issues (beyond that which is the central category of the case itself), the collection of cases offers interesting insights, both individually and collectively, into the nature of these science teachers' attention to their knowledge of practice, concern for student learning and the way the two might be integrated. Therefore, it seems reasonable to suggest that the case writing approach has been helpful in creating conditions for the teacher participants to begin to articulate their knowledge of professional practice in ways that extend beyond just the 'do-ing' of teaching. (This aspect is highlighted further through the exemplar cases offered in the next section of the paper).

In the following sections, exemplars of each of the major categories listed above are offered following a brief analysis of the data from Table 1. Each case demonstrates how the particular author came to frame and reframe (Schön 1983) a particular aspect of their practice. The cases that have been selected offer a glimpse into aspects of the professional knowledge of practice that underpin the particular situation described therein and are indicative of case writing within the major category being discussed.

Focus on Teaching: Developing Practice

The sub-themes of this category highlight some of the issues and ideas that attracted the STaL participants' attention in terms of their approaches to, and thinking about, teaching. It is important to be reminded that the cases were developed as a consequence of a range of experiences throughout the STaL program. The manner in which participants then worked with these ideas back in their own classrooms (or not) was their choice – it was neither mandated nor directed. Participants were encouraged to pursue any issue, practice or concern that captured their attention, or in the Deweyan sense (Dewey 1933), a 'problem' that might initiate reflection.

In relation to teaching, the STaL program emphasised the need to experiment with teaching procedures, but not for the sake of simply accumulating a range of new teaching procedures or strategies, but rather for participants to experience new ways of thinking about their teaching and how it might be constructed, i.e., a consideration of purpose and the ways in which that purpose might be played out in practice. Over the three volumes of the cases books (Loughran and Berry 2006, 2007, 2008), the data illustrates a relative consistency in terms of participants moving beyond teaching procedures per se [e.g., experimenting with POE's (White and Gunstone 1992), slowmation (Hoban 2005), interpretive discussions, etc.] and into a consideration of the nature of learning about teaching from such experimentation – as per *taking risks* and *changes in the teacher's role*.

This result draws attention to the ways in which participants were moving beyond a technical-rationalist approach (Schön 1983) to practice and adopting a more critically reflective stance (Brookfield 1995) toward their construction of knowledge of, and for, practice. To demonstrate this interpretation, an exemplar case from this category (Focus on teaching: Developing practice) follows.

Letting Go

Walking into the lab I was feeling confident that today's lesson was going to be different and the girls were going to like it.

No notes today (at least not written by me). Today I was going to stand back and let the girls take control.

We were starting our new topic Mixtures, and as the girls settled I said:

“Ok ladies today you are going to teach each other. In groups of four you are going to take one of the sub-topics from the board, research it and then present it to the class.”

Think, Pair, Share

As I was going through exactly how a Think Pair Share works, the hands started to go up.

“Can we pick our own groups?”

“Are we going to get marked on this?”

“Are we presenting them today?”

Not the response I was looking for. Since beginning teaching this year I have gotten into a routine of real chalk and talk type lessons. Although the learning styles of some students are suited to this type of teaching, I wanted to take the focus of our lessons off me, my notes and my structured discussions and start to challenge my students’ ideas about learning.

So these questions weren’t helping me feel confident about changing the focus of my lessons.

“Hands down! You can ask questions later,” I say and as today’s the day I’m passing the control of the lesson over to my girls, I let them pick their own groups.

“Yes!!” I hear them whisper. Down goes my confidence again.

But as I watched them in their pairs I was pleasantly surprised.

Almost everyone appeared to be on task:

“Five more minutes and then it’s time to discuss in your group of four.” I instructed confidently.

Wandering Around the Room

As I wandered around the room, I fought my natural urge to interrupt their discussions and steer their thoughts in a more productive direction but I did ask one group:

“How’s it going? Are you enjoying this activity more than our usual science classes?”

“Yeah, this is so much better,” was the overwhelming response.

“Wow! that’s exactly the response I was after,” I thought to myself not trying not to feel too crushed about what it meant about my “normal” lessons.

Maybe this is working. The girls are taking some control over their own learning and they are enjoying it. I’ll give them a little more time, then it’s back to the centre and away they’ll go with their presentations.

The first group got up and without any prompting they began their presentation.

Not bad, I thought to myself.

Then the next group and then the next. Before I knew it they had all done their presentations.

During the Presentations

As their classmates were presenting, the girls were attentive and to my surprise writing notes as they went.

So they don't need me writing endless notes on the board, I thought to myself.

Even more surprising was that every girl had a go at presenting. I was sure that a few of the quieter, less confident girls would try and get out of having a go.

It had all gone rather well, we had covered a lot of content and the girls seemed to really enjoy the different approach to the lesson.

Up Went a Hand

"Are we having a test on this stuff?"

"Yes, but not for a while. Don't worry about that now though please."

"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 realized 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 didn'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.

In Future...

I know I am not always going to have the time to give the girls control like I did in this situation.

The bottom line is we've all got deadlines to meet, curriculum to follow and balancing all the demands is not easy.

Sometimes there simply aren't enough days in the week to be able to do a hundred fabulous activities where the girls are able to challenge their ideas about their learning.

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 was a worthwhile thing to do.

Although the girls may not have seen the benefits immediately like 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.

A Focus on Learning: Developing Student Understanding

The sub-themes of this category suggest a similar approach to considerations of student learning as per the general trend in teaching (above). The frequency of sub-themes demonstrates how participants tended to focus on issues related to building on students' learning and working toward creating situations in which students took more control of their learning. The very nature of the sub-themes illustrates that participants' concerns for student learning moves way beyond the acquisition of propositional knowledge as they are clearly pushing students to be active, engaged, responsible learners, with the enhancement of students' metacognition (White 1989) as a noticeable goal.

In many ways, participants' cases illustrate what Osler and Flack (2008) described as the need to "establish an agenda for learning" (p. 8) with students. In so doing, ideas about learning need to be a part of the language of classroom practice, and talking about learning requires the establishment of a shared vocabulary amongst students and teachers in ways that allow common understandings – and associated intentions – to be realized in practice. For example, Osler and Flack introduced the language of linking, questioning, decision-making and reflection (amongst others) into their classroom discourse in ways that encouraged their students to adopt a more metacognitive stance in their learning. Although perhaps not quite so explicitly stated in the cases, teachers' intentions to develop a shared language about learning does seem apparent, particularly so in relation to the ways in which a serious focus on learning was realized by some of the participants. Consider for example the following case that raises such issues in relation to classroom science learning.

Being a Learner

I was looking forward to going on the STAL project.

"Wow! Five days of learning and being able to talk and learn from other teachers. No yard duty!" I thought.

I was hoping to improve my teaching to benefit the children that I am teaching.

The Learner

The large group was a mixed bunch of teachers from different schools including secondary science teachers. I sat at the table with my colleague from school and three other teachers. We felt comfortable with each other since we were all primary teachers.

The session began with the concepts of floating and sinking. I thought to myself that this sounds easy, especially since I teach a composite grades one and two.

As I listened to the comments flying around the room, my heart sank:

"Newton's Laws of Motion"

"forces of gravity"

"buoyancy"

density...

Those were big concepts that were being used.

I was used to talking about floating and sinking and not the interaction of different forces.

I looked at my colleague and her face was as blank as mine. All at once I felt like a child again and so insecure. I didn't want to put my hand up to ask questions because I didn't want to appear to be stupid.

My mind began to whirl with different thoughts:

“I hadn't done science classes in over twenty years.”

“Maybe I shouldn't be here.”

I was really dredging through the memory bank to recall things that I had learned in science. I was really panicking at what I had gotten myself into.

My Reflection

At the end of the day as I sat in my room, I thought about my experience. I remembered the thoughts and feelings that had flooded me:

Inadequacy...

Inferiority...

Incompetency...

Not being intelligent...

I thought about how I had nearly blocked out the opportunity to learn.

I reflected on the learners in my classroom and how my slow learners must feel when they don't understand as quickly as the others do. They don't want to put themselves out where others might think they are dumb or feel that they are inadequate. They want to feel confident and competent in their learning.

How could I improve my teaching to assist their learning?

After completing the first 2 days, I returned to school thinking about this question and wanting to enable all the children in my class to learn more effectively.

We were doing the water cycle.

I wanted something that would involve everyone and help my slower learners and extend my capable learners. As I read through the different practices, I came across Role Playing.

I reflected on that and thought to myself:

“That might be a good one to use. It's different and involves using creativity to engage and stimulate learning.”

I had never thought about using drama in teaching science concepts.

The Activity

How could I effectively do this?

I cut up wool into lengths of about 30 cm and got a large torch. Each child would need a length of wool to use in our role play.

On Wednesday afternoon we revised what we had learnt previously. I explained to the children that we were going to role play the water cycle.

They were enthusiastic about doing this. The ground rules were laid out. The children giggled as they grouped themselves together to form a body of water.

“We have to get closer because we are drops of water,” called out a child.

Once they were grouped very closely together, I used the torch to simulate the sun shining on the water. They slowly separated as the water began to evaporate and moved onto the top of their tables as the water began to rise into the atmosphere.

Slowly they joined hands by using the length of wool to show the water molecules joining together to form large clouds. The large clouds became heavy with rain. The torch flashed on and off to simulate lightning. They roared a large boom as thunder sounded after the lightning.

There were lots of smiles as they prepared to fall as rain. Each child jumped off the table as the rain fell. Then they slowly joined together in small groups as they formed puddles.

“That was great.”

“Can we do that again?”

“Mrs. Hart, that was the best!”

My Evaluation

My awareness of my own reaction as a learner to the science activity opened my eyes in new ways to my teaching.

It has improved my planning and helped me to be a better teacher and think creatively for all my students to learn effectively.

This activity not only helped those students who are slower but also extended my more academic students in being creative in their thinking. I remember watching two of the children who have learning difficulties. Their eyes lit up and they were full of enthusiasm.

After we sat back on the floor one of these children was able to explain the water cycle to the class and write a text of their journey as a water droplet as a narrative.

That wouldn't have happened if I'd have taught the water cycle the normal way. Being a learner sure reminded me of what it means to be a teacher.

A Focus on Teaching and Learning: Pedagogical Development

Inherent in the sub-themes of this category is that of teachers “noticing” (Mason 2002) differently the pedagogical interactions occurring in their science classrooms and the subsequent impact of such changed noticing, not only on their teaching but also on their understanding of student learning. Some of the things that these teachers began to ‘notice differently’ as documented through their cases, included how they plan and organise their teaching for learning, the way that individual students react to particular teaching approaches and learning tasks, and their typical (or taken-for-granted) ways of reacting and responding to the various issues and challenges that they encounter every day in their science classes.

When these issues are conceptualized through the lens of pedagogy (the relationship of teaching and learning as an inextricably linked notion) conceptions of professional learning (Berry et al. 2007a, 2007b) arise that have much to say about the ongoing development of

teachers and their professional knowledge of practice. A starting point for considering this important category of learning through case construction is encapsulated in the question: “So, what was it that led to these teachers’ changing awareness of their pedagogy?”

Via the school based support component of the STaL program, participants commonly reported that their involvement in STaL was important in stimulating their thinking about teaching and learning as it created both time away from the classroom for them to reflect on their views of science, teaching and learning and their needs as science teachers, as well as an opportunity to experience alternative teaching and learning approaches that combined to focus more attention on pedagogy itself; especially so through the workshops and in discussion with colleagues. The various types of experiences in STaL then became a stimulus for noticing; sensitising teachers to look differently into their work, to seeing what they previously could not see in themselves and their classrooms, and to serve as an impetus for change.

The following case offers some insights into such a situation.

On Reflection...How Did I Miss This?

I have come to the realization that what seems like a successful lesson to me is not always a success for all of my students.

Every week I teach Environmental Studies to five different, gender based classes. It is a great day where students are given the opportunity to learn about their world through hands on, practical activities.

Most of my lessons follow a similar format: introduction; practical activity; and, discussion at the end.

I’ve always believed the discussions were productive; sometimes they even went into recess. As far as I could see students were learning and everyone was engaged.

It wasn’t until a guest speaker came in and taught a 6 week unit on water that I had a chance to observe and reflect on each class. This is when I came to the realization that many of my lessons were only engaging for a particular group of children.

How Could I Have Missed This?

It all began in term two. I was contacted by the Water Watch Organization who offered to teach a 6 week unit on water. On the first day when the teacher arrived I noticed that her lesson format was exactly the same as mine: introduction; practical activity; followed by a discussion at the end. I had decided that this would be a great opportunity to observe each class and take notes on their understanding. After the first 2 weeks I noticed that each week I had similar notes:

Suzanne, Jenny, Monica and Pat participated well, showed good understanding through questioning and discussion.

Marg, Gab and Kelly were a little off task, but completed the activity and showed some understanding through questioning.

Scott and Sean – hesitant to take part in activity, showed little understanding and did not participate in class discussion.

After a third week of similar notes I became concerned:

“Had this been the same in my classes?”

“Why hadn’t I noticed?”

This made me reflect on some of my Environmental lessons and I realized:

“All of the fantastic discussions and interesting questions come from the same core group of students; the ones who sit at the front and fling their hand into the air every time there is question.”

It became very clear to me that:

“The same students who were shrinking down and avoiding eye contact at all costs, with this guest speaker, were the ones that I could not remember hearing from in my own lessons!”

After the guest speaker had ended her 6 week unit I decided to write a reflection at the end of each of my own lessons, to see if in fact that they were behaving the same way in my class.

It was no big surprise that the notes I took were almost identical to the ones taken earlier:

“How could I have missed this?”

How Do I Engage Students who Think They Are “Not Good at This Stuff”?

Now I was approaching my Environmental Lessons with a new determination to engage these students. But first I had to figure out how to engage them.

When I asked one student why she did not participate in discussions, she replied:

“I am not that good at this stuff.”

Thinking about this answer I asked myself:

“How can I develop a unit that will cater for the different interests and strengths of all of these students?”

That’s when I remembered a flier I had received earlier in the year. It was from Australian Recycling Cardboard (A.R.C), advertising a competition which asked students to write, film and create a 30 seconds commercial explaining how buying recycled products helped the environment.

To introduce this unit I decided to use an activity that would force all students to participate in a discussion.

Students were given the criteria of the commercial and then took part in a Think, Pair, Share to explain how buying recycled products impacts on the environment.

During the ‘Paired’ part of the activity students were engaged and appeared to have some good discussions. Moving around the room I could hear statements like:

“...but they’re made from trees.”

“...why would they cut down trees if they can just recycle?”

It was great. It was everything I wanted to hear and I could observe their understanding as I took my notes moving around from group to group.

Students then broke into groups of two to three and had the next 4 weeks to research, write and prepare for their 30 s commercial. It was during this time that those students, who

had tended to step back, had no choice but to work with their group. Many of the students worked to their strengths. Sean loved drawing so he was the “story boarder”, Scott’s great with computers so he would film it. These students who were often reluctant to ask questions were clarifying ideas and displaying their own understanding or misunderstanding of the issue, by asking questions such as:

“Where are the trees they’re cutting down?”

“How do trees help our air?”

When each group was prepared they filmed and edited their commercial during their weekly computer lesson. (Some students are still filming their commercial, but are continuing to show a high degree of engagement.)

Looking Back

Every Professional Development session I go to stresses the importance of reflection and often I have thought:

“That’s great, but when do we get the time?”

Having used these reflections I now see what a useful practice this is in all of my teaching. Whether it is a quick note or a full page rant I am determined to make this a regular part of my teaching practice.

At the start of this Case I said that “I have come to the realisation that what seems like a successful lesson to me is not always a success for all of my students.” Knowing this I have decided that to judge a successful lesson I need to take the time to reflect on my teaching.

Noticing: Becoming Sensitive to Pedagogy

It is not difficult to imagine how, over their years of experience, many teachers develop fixed or habitual patterns of working that become their classroom routines. This is not a bad thing in itself as these habits and routines are important in helping teachers to structure and organise the learning environment so that both teacher and students know what is expected of them. However, these habits and routines can also become problematic because, if they become engrained in practice, it can be very difficult to see beyond them and to notice what is really going on in the classroom.

Over time, teachers and learners can perhaps unquestioningly enact and perpetuate the roles they create for themselves. As a consequence, their teaching routines can become so deeply internalised that they feel like the ‘natural order of teaching’. As the case above illustrates, when a teacher has an opportunity to look differently into her own classroom, she may begin to see her practice and her students’ learning anew. In so doing, the links between teaching and learning; the relationship that is at the heart of pedagogy then begins to emerge as a focus worth noticing.

As noted previously, it is interesting that volume 3 of the cases book seems to have led to a greater awareness of, and writing about pedagogy by teachers, in ways that are not apparent in the previous two volumes. Perhaps as facilitators of the program, we too

became more skilled at supporting teachers in pushing the boundaries of their writing so that the issues they were prepared to invest time and energy in writing about became qualitatively different over time.

In some way, the differences in terms of teachers' professional learning between volumes 1, 2 and 3, as documented through the cases, seems to be that teachers came to recognise that the classroom routines they had established impacted their students' learning in ways that caused them to look again at what they were doing and why. By stepping back, opportunities for noticing increased for some of these teachers and so they become freer to observe with enhanced sensitivity, the interactions that were occurring in their classrooms. Stepping back from the teacher role (even for a short time – as per the case above) offers possibilities to see and hear what may usually go unnoticed. In so doing, change becomes an invitation rather than a directive.

For some teachers it was an event other than their own teaching that prompted them to see themselves and their learners differently. The idea for the case in the previous section (*Being a learner*) was stimulated from an experience in the STAL program, whereby the teacher's noticing of her own response as a learner to a particular situation, led her to renewed understandings of the feelings of the students in her classroom as they experience her teaching. By noticing herself as a learner, deeper understanding of the relationship between feelings of adequacy and the ability of individuals to learn came to the fore, prompting questions about how teachers might inadvertently "block out [students'] opportunity to learn".

In the case above (*On reflection...How did I miss this?*), the chance to observe the class from a different perspective (moving out of the teaching role) led to a new appreciation of the importance of conceptualizing practice through a pedagogical lens. As Suzanne sat back to watch the children interacting with the visiting teacher, she was suddenly struck by the realisation that many of her own lessons followed a similar format – only engaging a particular group of children. Although Suzanne asked herself with genuine puzzlement, "How did I miss this?" in the reality of a busy teaching life, it is not surprising. Importantly, Suzanne used this experience of noticing as a stimulus for change in her practice; writing a reflection at the end of each lesson in order to monitor the progress of different students and then building on her observations and reflections in order to examine what these meant for her own understanding of pedagogy.

An interesting link then emerges between noticing and the discipline of Science. Being open and sensitive to noticing aspects of one's environment is a value associated with the conduct of science that many science teachers would hope their students might learn. Being thorough and systematic, open minded in looking for alternative explanations, being ready to see new evidence and ideas, to suspend judgment and to engage in self critique are attributes, not just of professional teaching, but also of working scientifically.

There is of course considerable challenge associated with both opening oneself up to the act of noticing differently, and in sharing what happens in so doing. Such acts require considerable courage – and it is clear evidence of the professional commitment of these teachers who were prepared to notice their classrooms differently, to act on what they saw and then document their insights to share with others through their cases. By so doing, they not only created possibilities for change in their own classrooms, but through publication and dissemination of their work, there is the likelihood that their cases might encourage others to consider their own practice in new ways. This is then an important aspect of the STaL project whereby the professional knowledge of practice is captured, articulated and portrayed in ways that might have real meaning for others. It is an opportunity to bridge the theory-practice divide.

Cases: Looking into the Professional Knowledge of Practice

The STaL project was conceptualized with the aim of creating possibilities for enhancing science teachers' professional learning. The exemplar cases offered (above) are illustrative of how such aims were realized in practice.

As the StaL project has been developed and refined over three years, the nature of the case writing by participants has similarly developed. As facilitators it seems reasonable to suggest that we have learnt more ourselves about how to help participants focus more attention on problematic aspects of practice in meaningful ways rather than simply creating descriptive accounts of a teaching procedure or episode. In considering the cases written over the past three years and the ideas associated with the thematic analysis (Table 1), it certainly appears as though case writing helps to focus teachers' attention on issues in science teaching and learning that are important to the individual teacher, rather than issues imposed or mandated by others. Hence, as Barnett and Tyson (1999) have suggested, there is a certain sense of professional autonomy that emerges through case writing that is important and can be a useful aide for teachers in coming to better value their knowledge of practice. Engaging in structured reflective practice through writing cases helps to place teaching and learning at the centre of teachers' attention and gives them opportunities to consider more carefully not only what they do in pedagogic situations, but also how and why. Pedagogy therefore becomes central to the work of teachers.

As the exemplar cases above illustrate, the nature of teacher talk changes through case writing as it offers new ways of raising critical issues about teaching and learning. For example, issues such as the way students approach learning a particular concept, the effect of different teaching procedures and strategies on student learning, and ways in which teaching might be critically reviewed and reconsidered, take on a qualitatively different form from the regular kinds of teacher talk based on sharing "activities that work" (Appleton 2002).

As one way of considering what it might mean to be a teacher researcher, cases are a window into that type of role. Through careful attention to detail, authors of cases begin to notice classroom incidents differently and therefore begin to elicit interesting and useful information (or evidence) that becomes an impetus for change. The type of data that teachers draw on is that which is meaningful to them about issues, ideas, dilemmas and concerns that require their attention. It has been well noted that educational change requires teacher change (Fullan 1993) and as these cases make clear, teacher change is at the heart of professional learning through case writing.

The development and use of cases is empowering for many teachers. Cases open up possibilities for dialogue within the profession with views about practice – as articulated through cases – being presented in a manner that is inviting and open to professional scrutiny in ways that imposed or mandated change does not always allow. The process of sharing, especially when initiated by case writing and reading (Lundeberg 1999; Mitchell and Mitchell 1997; Shulman 1992), leads to increased self-confidence forged through the valuable learning that occurs through the risk-taking at the heart of the experience that stimulated the case (Lieberman 1995; Osler and Flack 2002; Palmer 1998).

As the exemplar cases offered in this paper illustrate, cases are readable, practical and thought provoking. They are evidence of the professional learning approach these teachers have taken towards the development of their professional knowledge or practice. They help to offer new ways of seeing into teaching and to address the sense of isolation that is inherent in classroom teaching and so often limits the ability of teachers to articulate, share and further develop their knowledge of practice.

Conclusion

As the CECV (2005) report that led to the development of the STaL project suggests, in order to address some of the common concerns about science teaching and learning in schools it is important that teachers focus attention on their practice in their classrooms with their students. It has been continually noted in the literature over the years how teachers lack the time and opportunity to reflect on their practice in ways that might go beyond preparing the next activity or refreshing the mind on the content to be taught. Being encouraged to develop a teacher researcher stance as conceptualized through the STaL project has given time and space for participants to develop their professional autonomy and, in so doing, to reflect on their practice in ways that are not always possible in the normal busy life of teaching.

One goal of STaL was to create for participants, possibilities to develop richer understandings of science teaching and learning that might lead to real change in participants as they came to better value their professional knowledge of practice. The results of the STaL program certainly suggest that cases offer one concrete way of attempting to enhance the quality of science teaching and learning in classrooms. Initially, that enhancement might be limited to these participant case authors, but hopefully the profession more generally will be impacted, as other teacher readers have the opportunity to learn through the vicarious experiences available through the sharing of the professional knowledge of practice articulated in these cases.

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