DAVID WINTER AND CHRIS ASTALL

22. PRESERVICE HIGH SCHOOL SCIENCE TEACHER IDENTITY

Using Drawing Enhanced Learning Monographs

INTRODUCTION

The construct of teacher identity is complex and difficult to define. In addition to professional elements such as subject knowledge, teaching skills and understanding of pedagogical practices, it encompasses personal ideas about what teachers are and what they are expected to be. Sachs (2005) has described teacher identity quite succinctly as a framework for teachers to construct their own ideas of "how to be", "how to act" and "how to understand" their work and their place in society. In her review of teacher identity in science education, Avraamidou (2014, p. 164) summarised the nature and characteristics of teacher identity and identity development as *'(a) teacher identity is socially constructed and constituted; (b) teacher identity is dynamic and fluid and constantly being formed and reformed; and (c) teacher identity is complex and multifaceted, consisting of various sub-identities that are interrelated.'*

The process of teacher identity construction, for preservice teachers, is part of their learning and development and during their training identity is perhaps more readily influenced than at any other stage in their career. At this time there will be occasion for preservice teachers to explore and construct their identity through examining their prior experiences; practicing in safe contexts and supporting their understanding of a participatory role in varied learning communities (Luehmann, 2007).

The personal experiences that teachers themselves have of education are a powerful influence on their teacher identity, as is race, gender and personal history (Avraamidou, 2014). There is growing research evidence that also identifies the connection between an individual's emotions and the development of professional identity (Arvaamidou, 2014). We were aware that the most recent classroom experience for many of our graduate preservice teachers was the didactic lecture-style approach prevalent in their undergraduate university science courses. Several of the preservice teachers were career changers and we were also cognisant of the fact that these individuals may retain a professional identity encompassing particular conceptions associated with their past employment that competed with and framed their new and evolving teacher identity (Williams, 2010).

Our science methods course, as a component of a university-based teacher preparation programme, has been carefully designed to provide structured and safe opportunities for preservice teachers to engage in multiple experiences. We were interested in examining the changes and development of science teacher identity in our graduates as they progressed through the methods course. The principal features of drawings as an investigative tool to probe understanding have been considered earlier in this book. In this chapter we describe how drawings were used to explore developing science teacher identity in preservice teachers, specifically their existing and developing beliefs about science teaching and learning during this relatively short but pivotal time when they are learning their craft and making the transition from student to novice professional.

METHODOLOGY

Context and Participants

The participants in this study were preservice secondary school science teachers enrolled in a one year Graduate Diploma in Teaching and Learning programme. They had a minimum of a Bachelor of Science degree as part of the admission requirements for teaching. These prospective teachers were required to complete a one-semester science methods course designed to address the Science Learning Area of the New Zealand Curriculum for students in Year 9 (about age 13) to Year 13 (about age 18). The science methods course explores pedagogical content knowledge, teaching strategies, planning approaches, assessment practices and health and safety with an emphasis on practical work and student engagement. As part of the programme, this first semester course was divided into two 5-week teaching blocks, punctuated by a seven week teaching-practicum. This provided an opportunity to explore preservice teachers' developing beliefs of science teaching and learning as the course progressed. Of the 31 students enrolled, 13 agreed to participate in the study.

Limitations

The pre-service teachers self-selected to participate. It is acknowledged that self-selection can lead to bias in the resulting data as those who choose to take part may not well represent the entire target population (Olsen, 2008), In this study, prior to selection participants were informed that the research was to explore their ideas of teaching and learning science through drawings and interviews. We

P. Katz (Ed.), Drawing for Science Education, 247–261.

attempted to minimise the respondents choice based on their propensity to engage, however the main factor that may have influenced engagement was the presumed time taken to participate. We acknowledge this possible limitation.

Data Collection

In this project we set out to explore how preservice teachers' identity and beliefs of science teaching and learning developed as they experienced new science teaching contexts, specifically a science methods course and associated programme practicum. We were interested in exploring the knowledge and beliefs constructed by the preservice teachers prior to and during engagement with the course, particularly as the focus on student-centred learning emphasises the role of the teacher as a guide or facilitator of activities and investigations, where student inquiry is promoted and teachers create a learning environment to support individual learning needs (Gluckman, 2011; Ministry of Education, 2007).

Drawings have been identified as providing rich sources of information (Weber & Mitchell, 1996; Hancock & Gallard, 2004; Katz et al., 2011; Katz et al., 2012; Ucar, 2012). The Draw a Scientist Teacher Test Checklist (DASTT-C), developed by Thomas, Pedersen, and Finson (2001), has been used to explore preservice teacher beliefs regarding teaching and learning science. The DASTT-C includes both a drawing and narrative component. The test initially requires the preservice teachers to *'Draw a picture of yourself as a science teacher at work'*, then it asks two questions *'What is the teacher doing?'* and '*What are the students doing?'* that provide a narrative to allow for additional description to help interpret and make sense of the drawing. This is especially important when metaphors, symbols or abstract imagery is presented for interpretation (Thomas et al., 2001).

Katz et al. (2011) adapted the 'Draw a Scientist Test' (DAST – Chambers, 1983) by asking subjects to draw a response to the prompt *'Draw yourself teaching science'* and *'Draw your students learning science.'* They were later able to analyse the drawings and code or score for particular attributes that were identified. Asking for these two images allowed for different perspectives on an individual's belief of teaching science as emphasis is placed specifically on the effect of the teacher's actions on learning and the role of the learner. Comparison of the resulting two images provided evidence of similar themes regarding beliefs of science teaching and learning (Katz et al., 2012).

In this study we also asked preservice teachers to complete two drawings at each sampling point. The sampling points were; T1, at the start of the course; T2, prior to teaching practicum; T3, following teaching practicum; and T4, at the conclusion of the course. There was no time limit to complete the drawings. In order to be able to identify their teaching beliefs the DASTT-C checklist was applied to each drawing (Thomas et al., 2001).

Drawing provides an alternative, supplementary data source that may reveal inadvertent glimpses of cognizance (Weber & Mitchell, 1996), however care must be taken to 'read' or interpret the drawings, particularly as the representations of teacher beliefs are individualised. Each image may contain a very personal story that would explain details about those aspects included in the drawing (Thomas & Pedersen, 2003). Since drawings are often deciphered through 'subjective prejudices and interpretations' they become most useful when combined with other forms of data collection (El-Deghaidy, 2006; Bennett, 2012). Often this supplementary data is gathered as written (Thomas et al., 2001; Markic & Ellis, 2008; Barak, 2014) and verbal explanations for drawings as well as interviews (Barak, 2014; Hancock & Gallard, 2004; Katz et al., 2011; Katz et al., 2012; Thomas et al., 2001) and student reflections (Rule & Harrell, 2006). In this study, we applied video narration as a method of supportive analysis. Once the drawings had been completed, the preservice teachers were then asked to complete a narrative video. This consisted of the preservice teachers talking to a fixed video camera about their picture, describing and explaining what they had drawn. This was repeated for both drawings.

Analysis

Each of the drawings was analysed using the DASTT-C (see Thomas et al., 2001 for further details), which provided an indication of the preservice teacher beliefs about science teaching. In summary, the checklist identified three general categories that each drawing was scored against: 'Teacher' that focused on the teacher's activity, position relative to the students and posture; 'Students' that focused on the actions of the students and their position in the classroom and 'Environment' that identified aspects of the classroom associated with the physical environment. The scoring rubric identified the presence of an element as representation of a teacher-centred approach to teaching. The final scores can range from 0–13, where a high score indicates a teacher-centred representation of teaching and learning and a low score depicts a student-centred approach. Thomas et al. (2001) assigned DASTT-C final scores to three models of teaching proposed by Simmons et al. (1999), which were the exploratory model (0–4), conceptual model (5–9) and explicit model (10–13).

The video narrations for each of the drawings were transcribed. Each transcription was then checked against the video and notes made when the preservice teacher made specific non-verbal cues such as facial expressions or hand gestures to emphasise a point. The transcriptions were then used to reanalyse the DASTT-C score for each of the drawings. The narrative component of the analysis frequently removed ambiguity in the interpretation of the drawing elements and also provided reasons or meaning for the images portrayed.

In addition to using the DASTT-C checklist, each of the drawings was analysed using a 'grounded theory' framework (Glaser & Strauss, 1967). Here, theory is derived and emerges from data systematically gathered and analysed using an inductive approach (Cohen,

Manion, & Morrison, 2007). The drawings were explored and themes regarding preservice teacher beliefs about science teaching and learning were identified and derived using a constant comparative method (Cohen et al., 2007).

RESULTS

Preservice Teacher's Beliefs of Science Teaching and Learning

Use of drawing prompts. Initial analysis of the drawings indicated that preservice teachers' drawings of themselves teaching science and drawings of students learning science had very similar contexts. Activities, subject-content and class layout reflected in those drawings showing preservice students teaching science were mirrored in the drawings of their students learning. We did identify, however, two distinct representations of science teaching and learning from the drawings.

In the first, the preservice teachers clearly identified a difference between their beliefs regarding themselves *teaching* science and how they saw their role in students *learning* science. These drawings indicated a schema of *teaching* science that involved imparting information, demonstrating practical work and providing instruction or clarification. They described it as delivering content. They often placed themselves at the 'centre' of the teaching process, as seen by their location at the front of the class, and they identified with clearly defined roles for the teacher that linked to behaviour management or control. The students, if drawn, were often shown seated as passive observers. Drawings were usually from an observer's perspective looking into the class at the teacher, who was often situated near the front of the room. These images typically had a high DASTT-C score indicating a teacher-centred approach to *teaching* science.

However, when drawing their students *learning* science, the drawings often depicted students working in groups, collaborating on tasks, completing independent work or engaged in inquiry, activities or experiments (Figures 1 and 2).

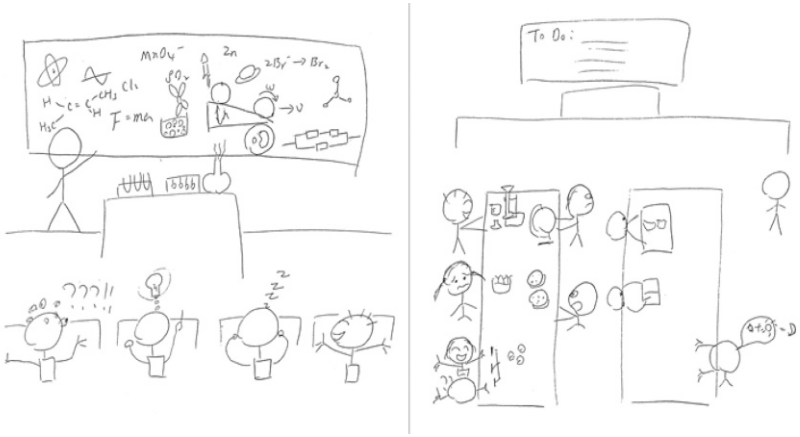

Figure 1. A preservice teacher response to 'Draw yourself teaching science' (DASTT-C score = 13) and 'Draw your students learning science' (DASTT-C score = 6) at the start of the course

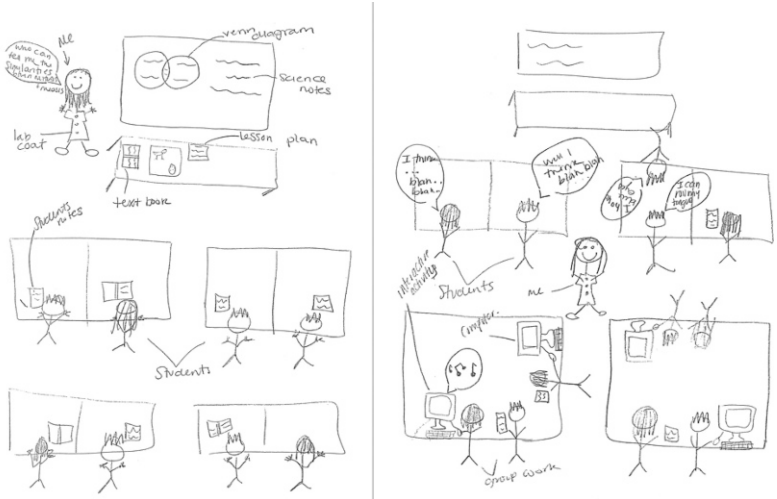

Figure 2. A preservice teacher response to 'Draw yourself teaching science' (DASTT-C score = 12) and 'Draw your students learning science' (DASTT-C score = 4) prior to their teaching practicum

This appeared to be in contrast to the drawings showing them teaching. Drawings of students *learning* science showed the teacher positioned to the side or centrally and identified as a 'facilitator'. The DASTT-C scores were much lower and typically identified as a more student-centred inquiry based model of teaching. For this group of preservice teachers, where there appeared to be two different schema operating, it suggests that they perceive 'science teaching' and 'learning about science' as distinct pedagogical approaches. 'Science teaching' appears to be more of an active pursuit where the teacher maintains a dominant central role in imparting information and managing the learning environment, whereas 'learning about science' suggests the students are more actively engaged in understanding and the teacher assumes the role of facilitator. Preservice teachers who held these beliefs tended to retain them throughout the duration of the course and consistently showed very clear differences in their *'teaching'* and *'learning'* drawings (Figure 3).

Figure 3. A preservice teacher response to 'Draw yourself teaching science' (DASTT-C score = 8) and 'Draw your students learning science' (DASTT-C score = 4) at the conclusion of the course

In the second representation, preservice students identified a more complex belief of the process of teaching and learning. For this group of preservice teachers, their drawings identified multiple episodes of teaching and learning (Figure 4 and 5). Episodic teaching may involve teachers using a range of strategies that identify with student-centred and teacher-centred approaches.

These could be identified as teacher-centred (high DASTT-C score) where "teach episodes" are drawn characterised by the teacher explaining or demonstrating new content and linking this to the student's existing knowledge. Preservice teachers identified these teach episodes as connected to theory, practical demonstrations or teacher directed talk around a challenge or problem. The student-centred (low DASTT-C score) drawings often showed the students engaged in a "work episode". This is where students are able to work independently on written tasks, practical work and student inquiries often resulting in the practise of a new skill. These multiple teaching strategies became more difficult to code using the DASTT-C checklist as they often represented characteristics of both student-centred and teacher-centred approaches.

We encountered the portrayal of these multiple episodes in several drawings on each occasion that the DASTT-C instrument was administered.

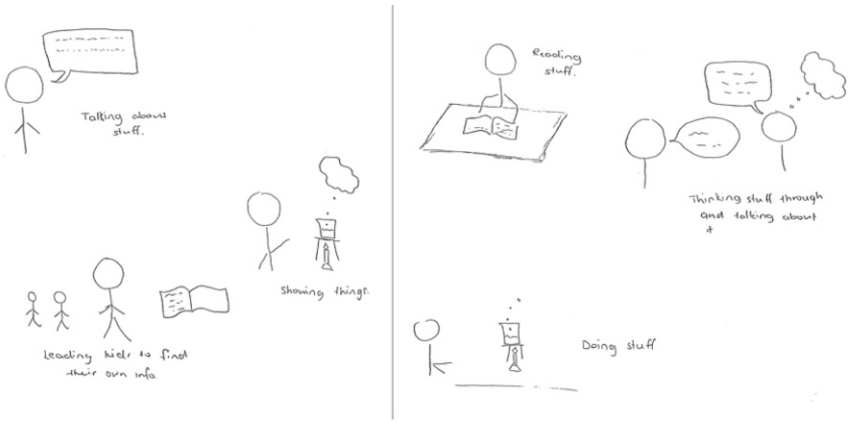

Figure 4. A preservice teacher response to 'Draw yourself teaching science' (DAST-C score = 4) and 'Draw your students learning science' (DAST-C score = 2) showing episodic teaching. This example is prior to the start of the course

For a number of students this representation of teaching became very explicit in their drawings as the course progressed (Figure 5).

Figure 5. A preservice teacher response to 'Draw yourself teaching science' (DAST-C score = 4) and 'Draw your students learning science' (DAST-C score = 4) showing episodic teaching. This example is at the conclusion of the course

Changes in preservice teacher beliefs of science teaching and learning. Prior to the course, preservice teachers had high DASTT-C scores, suggesting teaching was initially perceived as more about giving information, lecturing and providing directions and demonstrating (an 'explicit' teaching model). In these images, students were typically seated in rows, watching and responding to the teacher. Drawings of students learning science, however, had much lower DASTT-C scores with students shown engaging in activities or with one another (an 'exploratory' teaching model). The changes over the duration of the course for the DASTT-C scores for both drawings are shown in Figure 6 and Figure 7. The drawings at T3 occurred following the practicum experience.

Drawings of preservice teachers *teaching* science showed a progressive shift from a teacher-centred, explicit model (DASTT-C score 10–13) to a student-centred, exploratory model (DASTT-C score 0–4), or a mixture of the two (identified as the 'conceptual teaching model') over the duration of the course (Figure 6).

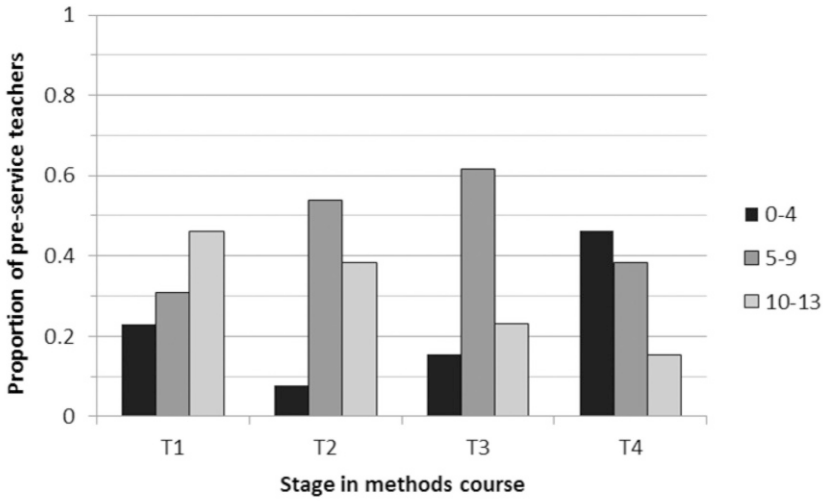

Figure 6. 'Draw yourself teaching science' DASTT-C score for secondary science preservice teachers (n=13) at four different stages throughout their course. DASTT-C scores indicate exploratory model (0–4), conceptual model (5–9) and explicit model (10–13)

Drawings of students *learning* science showed more of a student-centred approach, however following the practicum there seemed to be more of a shift towards a conceptual teaching model (Figure 7).

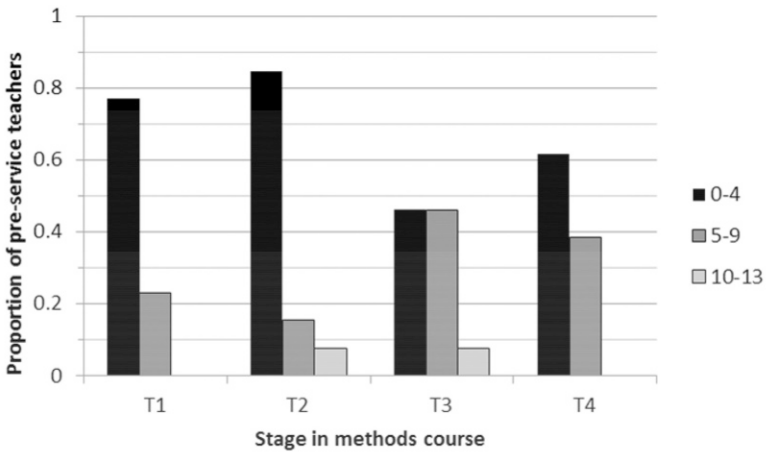

Figure 7. 'Draw your students learning science' DASTT-C score for secondary science preservice teachers (n=13) at four different stages throughout their course. DASTT-C scores indicate exploratory model (0–4), conceptual model (5–9) and explicit model (10–13)

The 'Hidden' Stories

The drawings made by the preservice teachers focused largely on the cognitive, psychomotor and social domains of learning and were supported by their accompanying video narrative. Explicit drawing elements that exhibited these characteristics included images of teachers transmitting information to attentive but passive students, students engaged in teacher-facilitated cooperative problem solving with their peers, teacher demonstrations, students performing practical work and the integration of computer-based technologies into inquiry learning tasks.

However, some of those influences that shape teacher identity are more abstract and these are difficult or impossible to identify and interpret through the images projected on paper. Even though the drawings allowed the preservice teachers to project attitudes and emotions, the interpretation or the explicit nature of those affective aspects were not revealed until we had examined the video narratives. It became clear that using the narration as a reflective tool allowed the preservice teacher to revisit the drawings and provide greater clarity regarding connections between their images and their experiences, something that as a viewer becomes very subjective and liable to misinterpretation. Indeed, the drawings provided a focus for thoughtful reflection with a number of preservice teachers pointing to elements within the drawings providing greater detail and even adding additional explanatory content to their drawings as they talked.

In terms of developing teacher identity, we defined three key themes to categorise these hidden elements presented within the drawings: the influence of experiences; affective expectations; and the developing comprehension of the complexity of teaching. All of these themes have the potential to drive particular behaviours, influence decision-making and shape outcomes.

(a) The influence of experiences. Personal and professional experiences act as a lens through which preservice teachers interpret their course content and begin to construct their developing teacher identity. Memories of their own educational experiences may be very strong and enduring, even though the most recent formal learning environment for most of our graduate trainees was the tertiary institution where they completed their undergraduate science qualification.

This influence of prior experiences was described by many of the preservice teachers in their drawings prior to the science methods course and some of these experiences endured throughout the programme. In her narration, Grace described how she drew her classroom as being set up

> the way my school laboratory was. I have always had a classroom where you do the work in the middle, like textbooks or drawings or any work on a desk. And then you go to the outsides and do practical work on the edges obviously to keep chemicals away from your work and books and everything.

Similarly, William explained

> I drew it like this because it's pretty much how all my high school classes were like. The teacher's at the front explaining stuff and the students were sitting and listening and doing activities.

For Kim the image of the physical environment of her high school persisted and she portrayed herself teaching and the students learning in this setting in her first drawings (Figure 8).

…I've drawn this because of, I think I've always been a student… portraying like someone teaching to me. So I've done it, I've drawn it exactly like my old school laboratory was like. So I've kind of drawn it from a student perspective, of me teaching in my old high school laboratory. I'm a chemistry major, so I've kind of taught it, like I'm teaching chemistry…

Kim then talked in detail about how she remembered her school classroom making connections to the layout of the whiteboard, skeleton display, position of benches and place for completing practical work. In her drawing of the students learning she was very clear about the classroom being set up with activities the way my school laboratory was…"

The memories of her own school environment persisted through the course and even following her practicum experience. She made clear reference to the the layout being influenced by her high school experiences, however the changes apparent in the drawings are around the activities of the teacher and students. For Kim, her high school experiences of science teaching spaces was reinforced by her practicum experience. As she stated;

…my drawing is very similar to the one I drew last time admittedly. I think that's because of the lab I was in on placement [practicum]. It was very similar to my old school lab and probably most labs.

Again for these drawings, even though the teaching space is predominantly the same, her use of that space and the interactions in her role as a teacher and those of her learners have developed considerably following the first set of drawings completed prior to the course. In her last set of drawings Kim identifies with her shift in thinking about her role as a teacher drawing on her previous experiences, not only as a high school student herself but also as a student within the programme;

[I've drawn] … footprints, handprints kind of just from the crime scene that we just did. And note the stars and the moon, how it's astronomy based, like there are lots of places where you can teach Science, it doesn't always have to be in a classroom. In the classroom I have drawn though, I've still got the same things. I've got Chemistry, but then I've also got Physics, so in the class we've been doing we've been looking at Physics circuits and everything like that. And I'm not very confident in it, but I think I…I need…I know I need to start incorporating other sciences into my classroom obviously because even though I'm just Chemistry [specialist subject] … so there's some Biology in here as well.

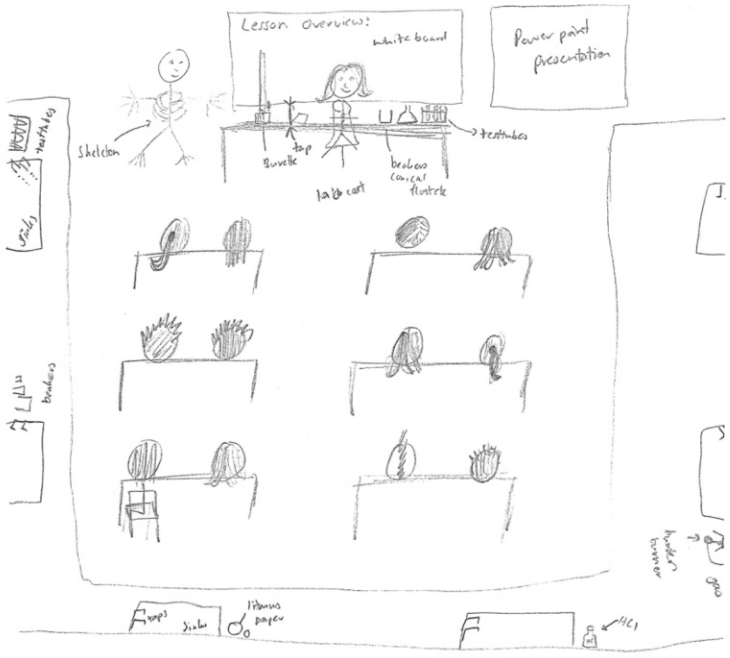

Figure 8. Kim portrays her experiences of teaching science in her drawing 'Draw yourself teaching science' at the start of the science methods course

Jasmine had a previous career in environmental conservation and significant personal experience working outdoors participating in field trips. This background and the type of learning that such activities support, explained why she portrayed herself in an outdoor setting for her first two drawings.

… my background is working in Fiordland and South Westland for quite a period of time. And so hence the trees. I did do a lot of sort of explaining and teaching when I was out there, if there were volunteers or if there were new people coming on board.

> Obviously they weren't at sort of Year 9 or Year 13 level, so there was a little bit more of a maturity and where we were most of the time was very isolated, so people were a bit more sort of self reliant about what they could do and looking after themselves. I had myself as teaching Science, laying out all the equipment in an area which would be considered the study site, and explaining to people the techniques involved in getting their data, their information. When I thought, when I was teaching Science that it would be as you can sort of see my hand pointing, that I would be in sort of a role of just giving out information. I'd be in kind of quite an authoritative role.

In her role as an outdoor educator, Jasmine refers to her drawing of students learning science and discusses what is not shown in the drawing:

> …they're using their own equipment and they're carrying out their own experiments in groups…but then we would get back together after a certain period of time and from what I remember, and I remember this when I was drawing this, is that then we would go back to wherever we were staying. Because this is obviously more like a field trip. And then all the kids would collate their information and there would be quite sort of latish nights of getting information you know, ready for the next day or finishing what they needed to do.

Kate received her secondary education at a co-educational state high school in a small rural and remote town in South Australia. Teacher–student professional relationships were strong and several years after attaining a tertiary qualification and commencing her teacher training, Kate still recognised the enduring influence that her former school teachers had on her understanding of the world.

> …A lot of my views of teaching come directly from how I was taught… I was influenced by my teachers, so I would have the same sort of influence on the students I teach. Because the teachers I had at school were probably the most influential…I found that the teachers I had in High School had a big impact on how I viewed the world and what opinions I had. So, my picture is pretty much directly how I remember my school being.

Following her practicum experience, Kate's reflections on her drawings of herself teaching science clearly shows the influence of experience on her developing teacher identity:

> So on teaching practice, we've just got back from teaching practice, I've noticed that my first picture was very traditional, it was like you write on the board and the students write down your notes and kind of you teach and they learn. And then my second one [picture] was kind of the other extreme, where it was a lot more students teaching each other and interacting. And when I was on placement I kind of realised you need a balance of both. So, this kind of, is supposed to indicate that. So I'm still the teacher and I'm still the one passing on information but they, the students talk to each other and understand it to some degree, but at certain points in time they do actually just have to sit and listen.

John's narration of his initial drawing teaching science depends on memories of smells, colours and emotions. His drawing shows a typical high school laboratory layout, very similar to that described by Kim earlier. John models his drawing from his early high school and he describes the drawing as "almost replicating my school years as a science student." What is apparent from the narration is the clarity and depth of description and explanation that could not be interpreted from the drawing;\:

> … and then there's a Bunsen burner and these benches sort of go across but they, they're the side benches where they can do experiments… then there's windows here… and that's the door, where the only entrance and exit into the classroom. I remember the classrooms, the roof was really high. It was a really old fashioned sort of classroom. Brown colours, and very dark and dingy. With old curtains. I'm remembering back to my Science class, but the way I kind of see it is, back in the day, the teachers would just stand there and just blah blah blah… no enthusiasm. So I want to capture the attention of the students.

In his narration, John reiterates a number of times about the importance of engaging the students, keeping them attentive and focused. Making reference to prior experiences of science teachers who did not engage him, he makes a number of comments about the need for the teacher to be enthusiastic. This concern regarding the desire to keep the students engaged and happy was also reflected in his drawing of the students learning science and as he describes in the narration:

> …they're clearly quite attentive in what they're doing. They've got big smiles on their faces, they like what they're doing. So again I'm doing my very best here to make them have as much fun as they can…the main point of this is they're, they like what they're doing. They're happy about it. They're loving it. And I'm overseeing them.

It becomes clear in the narration from the drawings that John is starting to make connections between experiences of his own schooling, student engagement and behaviour and how this may be shaping his own teacher identity.

(b) Affective expectations. While attention is often focused on the cognitive domain in science education, it is known that affective constructs play an important role in the teaching-learning process. Birbeck and Andre (2009) have pointed out the difficulties of precisely defining the affective domain, although it has been described simply as an individual's beliefs, perceptions, attitudes, values and emotions (McCloud, 1992).

Examination of the drawings and interpretations using the DASTT-C provided one data source with respect to the teaching model. In some cases elements of the affective domain could be seen in the drawings, through the facial characteristics, body posture, annotations or speech bubbles, however the affective attributes were not always clearly identifiable and in some cases the drawings alone provided little information for interpretation (Figure 9). The narrations, however, provided an opportunity for the preservice teachers to explain their images and many made reference to the importance of the affective attributes in their teaching and student learning.

In narrating their drawings, preservice teachers discussed the importance of attitude, motivation and enthusiasm – both as a teacher and for the learner. There seemed to be a strong correlation between the affective attributes and the interaction between the teacher -student and student-student and the construction of a supportive learning environment. Preservice teachers identified the importance of using the affective attributes to engage and motivate students in science, often through fostering awe, wonder and challenge, and this was seen partly to facilitate learning and enthusiasm for science as a learning area as well as a means of managing the learning environment and controlling behaviour. There did not seem to be any pattern or correlation between the timing of the drawings and the presence of affective attributes within them.

Kate's image shows herself at a desk in front of the class (Figure 9). On the desk an assortment of science equipment suggests a practical demonstration. What really stands out is the smile Kate has drawn on her face. The difficulty arises when we try to interpret the smile. When asked to narrate the image, Kate starts to explain a developing philosophy for teaching based on affective attributes. She says:

> …part of it's how enthusiastic you are, as you can see I've got a big smile on my face. If you care about what you teach about I think the students will care about what they're learning. If you care about it [what students are learning] and you can show them that it's an important learning aspect I think they'll appreciate it as well.

Kate explained she had drawn herself in the image of her Biology teacher from high school who she remembered had creative flair and enthusiasm for science that made the subject exciting. The role of affective attributes on Kate's developing philosophy is becoming apparent as she reflects on how the interactions between the students and teacher can lead to a developing relationship that will support her teaching. She says "I think one of my teachers once said, it's thirty percent content, seventy percent of how you pass the information on." In later drawings Kate refers to the need for the teacher to motivate students as she describes her role in "…getting involved, getting excited and being happy to answer questions and knowing the answers."

Figure 9. Kate's drawing to the prompt "Draw yourself teaching science' at the start of the science methods course

Similarly, John identifies this aspect in a number of his drawings. In his first drawing of students learning science, John has drawn smiles on the students' faces. He explains this in the narration as his role is ensuring the students are having fun and are engaged. John, in his drawing just prior to practicum, continues with the idea that his role as a teacher is to "encourage the kids and get them all excited and really enjoy coming to class and learning Science. And I'll try and be as enthusiastic as possible and make it fun." He sees his learners as being fully engaged and having "high energy, they're [full] of high energy, you can see with their mouths open and their eyes are wide."

In her reflections following practicum, another preservice teacher Karen, explained her belief that encouraging student interest and motivation was necessary in order to engage students in learning. Her drawing did not indicate the frustrations she had experienced on practicum nor her desire and aspirational goals for teaching science (Figure 10) and appeared symbolic. In her narration she explains her challenging practicum experience and her reflection identifies her growing desire to be able to use student interest in science as a means of keeping students purposefully engaged in learning.

> So what I've drawn here …. it's not just me, but it is what I represent as the topic or the concept or whatever it is that I'm trying to teach. The students are gathered around because they have genuine interest in the subject. I'm not saying that's what I did

in my placement, because I utterly, totally failed to do that. To be honest I don't know how I can create that kind of interest in students. How it can be done, or whether it really can be done. But that would be ideal in my mind and I would love to be able to teach that way.

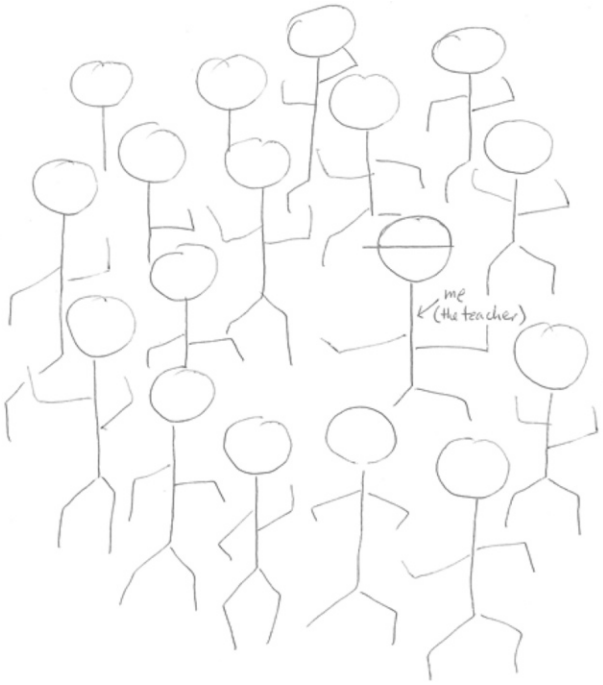

Figure 10. Karen's drawing to the prompt 'Draw yourself teaching science' following her practicum

In her reflection on the drawing of her students learning, Karen makes further reference to her role as a teacher in encouraging students with learning. In particular, Karen is starting to think about her own attitudes and feelings in terms of her actions as a teacher.

> It doesn't have to be with a PowerPoint presentation or the whiteboard, it doesn't need any tools, but just that…focus of everybody wanting to know more, interested and asking questions and being involved and being engaged in the topic. And you, yourself, being the one who is probably the most interested, the most enthusiastic on the topic of all, and the whole group working together to investigate and to discuss and to come up with the next step of the learning. Um, yes, I'd love to be able to teach that way. That would be my ideal.

At the conclusion of the science methods course, Karen reflects again back to her practicum and the need to excite, motivate and engage students in learning. She makes the connection between providing a "safe" learning environment in which students, and Karen, are prepared to take risks. She makes the connection between those affective attributes and her developing teacher identity when she states;

> At least giving them or providing an environment in which they feel they would find out. They are engaged and they are excited about learning. And also they feel safe to try different things, even if they fail or make a mess or do something wrong that it doesn't matter. And so I think that's the kind of learning that I want my students to do. I don't know sitting here, having done my first placement I feel that that's almost an impossibility in real life. But one can only try. And I think that when I teach what I'm hoping to do is, I'm not expecting myself to be able to teach in this way all the time, but if I can start teaching in this way maybe for one project with one class, and then I'll do another, and one more, and if I can build it up that way, so that my lessons are more student oriented, it's inquiry based, and it is engaging and challenging and is investigative, rather than transfer of knowledge as such, then I guess I'd be happy.

(c) The complexity of teaching. Darling-Hammond and Bransford (2005) identify that successful teaching is a complex act requiring an understanding of how students learn, knowledge of the subject-matter taught, and the ability to organize and represent it to students in a way likely to best promote their learning within the specific context in which it takes place. Novice or experienced, to develop and improve classroom practice teachers need to develop the capacity for ongoing inquiry and reflective practice (Timperley, Wilson, Barrar, & Fung, 2007; Feiman-Nemser, 2001; Timperley, 2012).

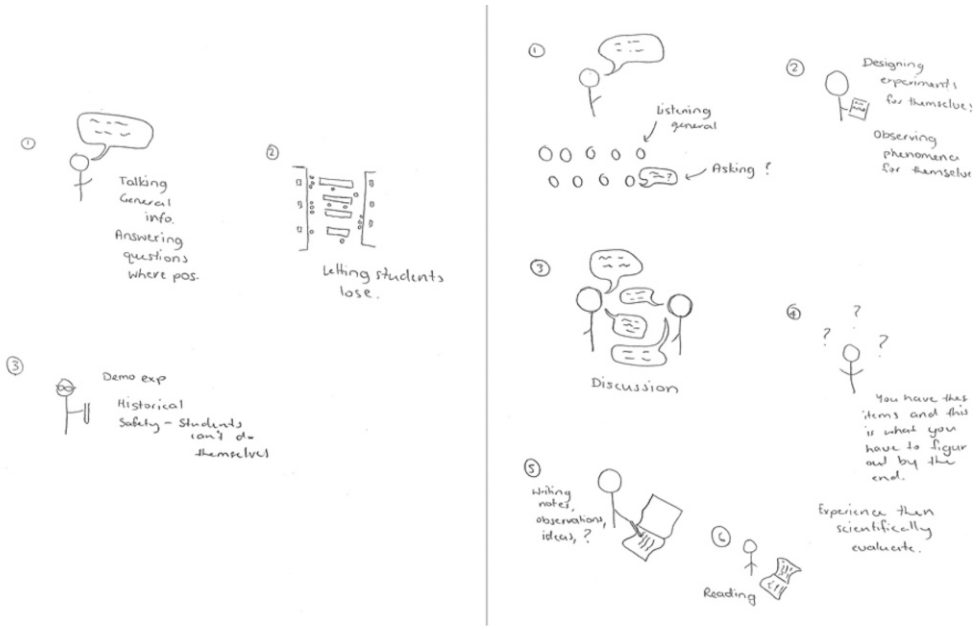

Figure 11. Sarah's drawings to the prompt 'Draw yourself teaching science' and 'Draw your students learning science' following her practicum

Following her practicum, Sarah, in both drawings, identifies some of the multiple roles of the teacher (Figure 11); facilitating interactions with students; demonstrating experiments for various reasons (safety, lack of resources, impracticality for whole class work); managing students as they engage with their own learning. Sarah explains her developing beliefs about science teaching as she states

> I think sometimes teaching students Science is not about telling them stuff and showing them stuff, it's about letting them loose to just experience it, and then decide for themselves what they actually needed to take out of it.

As Sarah talks she points to her drawings;

> To experience and then kind of scientifically evaluate maybe. It doesn't convey it, what I suppose I was trying to put in there, is… that there are no limitations, it doesn't really come across in the picture, but that's what I was intending.

Another student, Kate, recognised this complexity and tried to portray it in her drawings just prior to beginning her first practicum. She explains how her drawings have changed:

> You can see my drawing's changed compared to my first one. I don't have the blackboard or anything like that. [There is] more emphasis on inquiry teaching and learning… I've set out a task where they actually have to investigate, and they're working in groups, and actually bouncing ideas off one another and it teaches the students to, like it comes to them naturally as opposed to just rote learning content.

In her drawings following practicum, Kate reflects on the experiences and it is clear she is making adjustments to her beliefs about science teaching and learning.

> … when I was on placement I realised you need a balance of both. I'm still the teacher and I'm still the one passing on information but they, the students talk to each other and understand it to some degree, but at certain points in time they do actually just have to sit and listen. So it's kind of finding that balance where they are still processing information, and whether you're doing more, them teaching each other, and teaching themselves as opposed to just dictating.

In her reference to the drawing of students learning science, Kate's narration provides more indication of the role of practicum experience in developing understanding of the complexity of teaching. She is trying to understand how and when to implement different teaching models:

> …but there's a lot more teacher involvement compared to my last picture, because I'm pretty sure in my last one I kind of give them concepts and they go ahead and take initiative and do things on their own [student-centred exploratory model]. But with Science, because you're introducing so many new concepts, sometimes you need to be a bit more, I don't know, try to explain things a bit more. And not leave it for them to come to their own conclusions.

In her final set of drawings she explains the importance of developing teaching opportunities that allow students to gain a "better understanding of certain concepts…getting them to be more conscious of what Science is and how it's a part of our lives, and therefore how important it is." Kate then goes on to explain her beliefs about science teaching as she narrates her final drawing of students learning science:

> As you can see they're [students] actually teaching each other and it's less content based and more about them becoming objective learners and being critical about the information they receive and the information they gain. I want my students [to] be leaving their classroom with the view that whatever information is provided to them there can be more, what you're told isn't the be all and end all. They should be willing to explore that. I want my students to be more in-charge of their own learning…to be in control, control their own learning, to be able to impact how they want to learn and I think I want students to be more driven and be more responsible for themselves. It's not so much about the content [but] the Nature of Science and then understanding that they need to be better citizens in life. I think Science is a vital part of our education and they need to know more to better understand themselves, to better understand society, to be able to understand how life is. And why it is like it is instead of just accepting it for what it is.

At the end of the course, preservice teachers talked about the complexities of teacher-student interactions in terms of their teaching. They often identified a range of pedagogical strategies, such as hands-on activities, group investigative work, one-on-one tutorials, demonstrations, field trips, online tutorials and didactic teaching. Preservice teachers identified with the role of digital technology to support their teaching and student learning, through providing content knowledge, alternative modalities (videos, interactives) and opportunities to collaborate (shared learning spaces, online tutorial, collaborative documents). Comments from preservice teachers also mentioned the importance of a shifting role of the teacher towards being a facilitator of learning, encouraging students to be more responsible, independent learners. Figure 12 exemplifies this developing understanding of the complex nature of teaching and learning.

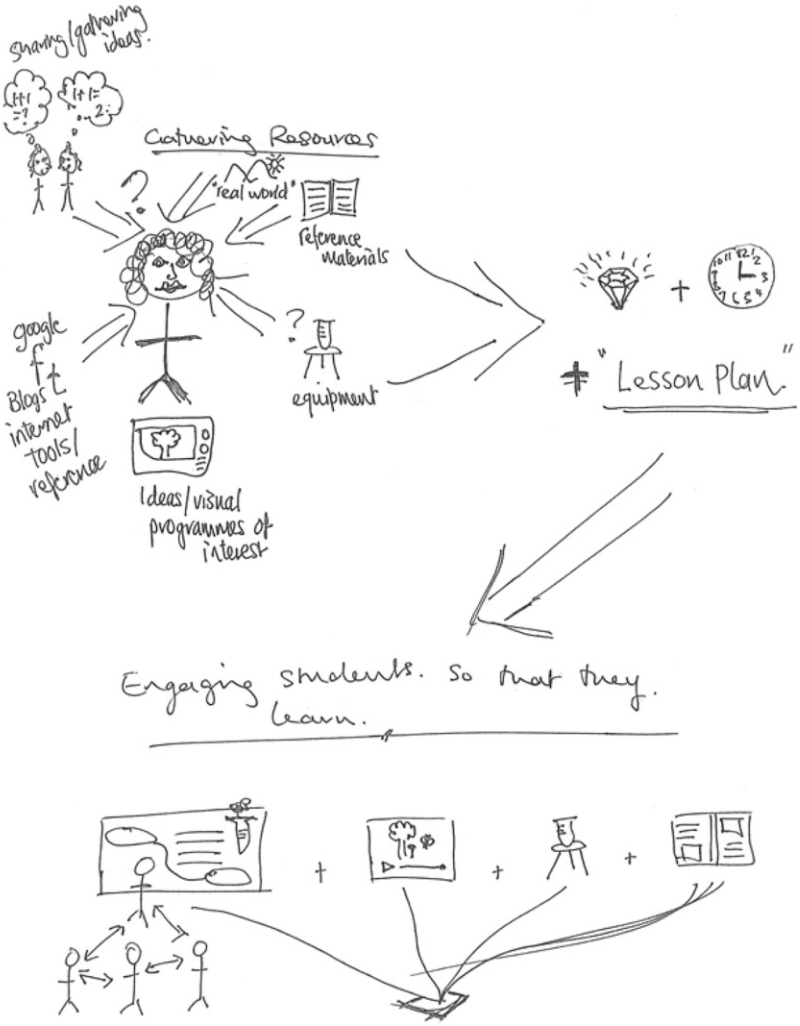

Figure 12. Jasmine's drawings to the prompt 'Draw yourself teaching science' following the science methods course

DISCUSSION

Our science methods course (indeed every course in our graduate diploma programme) was intended to equip the preservice teachers with the skills and knowledge to realise the aspirations of the New Zealand national curriculum. This outcomes-based statement of official policy, last revised in 2007, requires schools in New Zealand to promote and model articulated *principles, values* and *key competencies*[1] as they prepare students to live and work in a knowledge-based society (Ministry of Education, 2007). The *science learning area* of the curriculum encourages a social constructivist approach to learning and emphasises student-directed inquiry and understanding about the nature of science (Ministry of Education, 2007). These, and other characteristics of the curriculum, shift the responsibility and accountability for learning away from the teacher and onto the student and so fit well with a student-centred pedagogical model.

On entry into the science methods course, despite their diverse epistemological journeys, most of the participants saw themselves applying a teacher-centred and content orientated approach to science instruction that emphasised teacher authority and students acquiring teacher-transmitted knowledge. This contrasted markedly with participants conception of students learning science where they identified the focus as being on active learner engagement. This was often portrayed as students engaging and constructing knowledge through various practical tasks, often with other students, with the teacher providing support by acting as a facilitator and expert guide. The participants initially seemed unaware of the incongruence of these disparate views of science teaching and learning. As the science methods course progressed, we identified a gradual shift from a predominantly teacher-centred model to one that emphasised the importance of the learner. We suggest that this change occurred as the preservice teachers examined their beliefs about the respective roles of teacher and learner, developed their pedagogical content knowledge and understanding of the different modes of classroom interaction, and examined the tenets of a teacher-centred and student-centred pedagogy from both a theoretical and practical perspective.

Similar shifts in preservice teacher beliefs regarding teaching and learning science have been reported in other studies using the DASTT-C instrument (El-Deghaidy, 2006; Minogue, 2010; Thomas & Pederson, 2003; Ucar, 2012). In this study, the practicum (or field experience) provided opportunity for preservice teachers to explore their developing beliefs in context, their drawings and narrations clearly showing the influence of the classroom and their mentor teachers. As Hancock and Gallard (2004) identified, practicum provided opportunity to 'reinforce and challenge the beliefs held by preservice science teachers.' In studies that have explored preservice teacher beliefs about teaching and learning science, the influence of the practicum has been identified by few researchers (El-Dehghaidy, 2006; Hancock & Gallard, 2004; Katz et al., 2011; Mensah, 2011; Minogue, 2010; Thomas & Pederson, 2003; Ucar, 2012).

In our study, the use of drawings afforded our participants an efficient and unrestricted means to reveal their developing beliefs about science teaching and learning. We felt that aspects of these beliefs and the relationships between these aspects could be investigated more readily using drawings than by alternative probes. This aligns well with the views expressed by other researchers including White and Gunstone (1992) who assert that drawings provide participants with an opportunity for self-expression and a means for them to reveal qualities of understanding that are hidden from other procedures.

Our participants enjoyed completing the drawings and none expressed concern about a real or perceived lack of artistic ability or about the visual realism of their depictions.

Narration of the drawings revealed symbolism and meaning that were often abstract, individualised and personal to the participant. Once we were aware of these "hidden" aspects in our participants' drawings we were alerted to the potential for the drawings to be misinterpreted. There is always some subjectivity and ambiguity associated with the interpretation of images (Bennett, 2012; El-Deghaidy, 2006; Minogue, 2010). Minogue (2010) has already indicated that aspects of DASTT-C are difficult to apply or score. In our study, this subjectivity was reduced by both authors independently analysing the drawings and then meeting to reconcile differences. It would, however, be a simple matter to ignore or underrate elements of significant importance and make a less complex and less-than-adequate interpretation of what a drawing portrays. We suggest it is essential that drawings be accompanied by a comprehensive supporting data source, particularly when exploring complex phenomena, such as the multiple dimensions of science teacher identity and how these are constructed. We have no hesitation in recommending video narration for this purpose. We found recorded video to be a richer supporting data source than the more traditional written narrative that accompanies DASTT-C. The video recordings captured not only the linguistic content but additionally non-verbal cues such as hand gestures that participants used to emphasise important points and sometimes convey affective information. The video narration removed much of the ambiguity inherent in our interpretation of the images and provided insight into aspects of the participants beliefs that would have otherwise not been revealed to us.

The invitation to complete the video narration immediately after each set of drawings were completed provided the participants with the opportunity to make changes or add annotation, to think deeply about what they had portrayed on paper and to critically reflect on their evolving beliefs. Clearly the DASTT-C instrument allows preservice teachers to start constructing an image of themselves as a science teacher and to consider those influential aspects that shape their developing philosophies and beliefs. The ability to evaluate self and practice is an important and well-documented element of professional identity and one that we wished to cultivate in our preservice teachers. The video narration provided opportunity for our preservice teachers to reflect and consider their individual stories around the construction of their images. This characteristic of the data collection for our investigation complimented other strategies we use in our science methods course to develop inquiry into the teaching and learning relationship (Ministry of Education, 2007).

The relationship between beliefs about teaching and learning and practice was of special interest to us as the science methods course was punctuated by the seven-week practicum. The preservice teachers identified very clear connections to their beliefs of science

teaching and learning and their experiences on practicum. For some, the experiences reinforced developing beliefs and our preservice teachers gained in confidence and were able to articulate a developing philosophy for teaching and learning. However, for others there were clear tensions between their notions of teaching and learning science as developed in the science methods course and the practice that they were exposed to whilst at schools. For some they were restricted in their opportunity to express their teaching and learning beliefs as this was not the established practice in their practicum school, even so the drawings and video narration provided an opportunity for critical reflection and reconsideration of their emerging beliefs.

We believe our study has implications for future iterations of our science methods course. At the next course occurrence we will at regular intervals during the course have our preservice teachers complete a drawing of themselves teaching science and a drawing of their students learning science. On each occasion that drawings are made the preservice teachers will explain their drawings to their peers, who will be invited to act as critical friends. By exploring individual preservice teacher narratives and by exposing discrepancies between the teaching and learning drawings we hope our preservice teachers will develop greater cognisance of their evolving beliefs about instruction and learning.

The complexity of science teaching and learning derived from a multitude of prior experiences can lead to tensions between the preservice teacher and their teacher educators and teacher mentors (Hancock & Gallard, 2004). As teacher educators, we are challenged by the emerging beliefs that the preservice teachers express, through drawing and narration as they move through their university science methods course, and the actual practice that they engage with on practicum. Are those preservice teacher beliefs enacted upon during practicum? Strauss (2001) identified that teachers held an espoused and an in-action model of teaching and learning. The espoused model being that identified by the teacher in interviews and the in-action model the one observed from practice. In the near future we aim to use drawings and narration to explore the beliefs of science teaching and learning and compare this to the enacted teaching and learning model of our preservice teachers.

NOTE

[1] Eight principles underpin school curriculum decision making. Values are those beliefs developed and expressed throughout the school community. Key competencies are five identified capabilities that are developed through the school curriculum. See http://nzcurriculum.tki.org.nz/

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