Observing the process of mathematics teacher change: part 2

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In the first part of this editorial (Reid and Zack 2010), we introduced ourselves and the focus of these two special issues. The four articles in the first special issue provided the basis for our discussion of the diversity of perspectives evident in work on mathematics teacher change, mathematics teacher education and mathematics teachers working with university mathematics teacher educators and researchers more generally.

We also touched on the importance of emotional engagement to the process of change and the vulnerability that occurs as part of change, concerns that are evident also in this issue. For example, Chapman posits that emotional engagement is the starting point for teacher change. In the case, Chapman reports, of Brea, the emotional tension associated with her search for meaning at one point leaves her unable to sleep at night.

Vulnerability is often related to trust between teachers and the teacher educators who work with them. The establishment of trust is a special focus of the article by Potari, Sakonidis, Chatzigoula and Manaridis in this issue. They note that at the beginning of the collaboration, there was suspicion, which caused the researchers to become more careful in observing and listening. Once a climate of trust was created, the group could move forward with a shared agenda.

The article by Males, Otten and Herbel-Eisenmann is interesting to consider in terms of vulnerability and trust, because there it is not explicitly considered, but runs as a thread through much of the discussion. Early on disequilibrium and empathy are mentioned in connection with Lord's critical collegueship framework, but these elements are not explicitly discussed in the later analysis. Certainly, one senses that the teacher-researchers felt vulnerable in some of the situations described and this must have had implications for their processes of change, but this, and the trust that was needed to help them continue to change in the face of feelings of vulnerability, is not considered.

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Issues of emotional engagement and vulnerability are not unique to *mathematics* teacher change, and we would like to turn here to some explicitly mathematical issues raised in the eight articles in these two special issues (JMTE 13.5 and 13.6).

The first issue is the parallel between the process of learning mathematics based on inquiry that is often advocated in mathematics teacher education and the process of teacher change thorough inquiry that is described in the articles in these two special issues. As Boylan, Hunter and Males, Otten and Herbel-Eisenmann note, professional development of teachers sometimes suffers from a mismatch between the top-down, prescriptive methods used by teacher educators and the student directed, open methods they advocate. The articles here offer a wide range of examples where the message and the medium are aligned, involving teachers in the processes of inquiry, sometimes with no explicit goal (as in Chapman's article), that lead to significant changes in thinking, beliefs and teaching. As in the case of the mathematics students in Clive's classroom (reported by Boylan) who gained "first-hand information" by discovering it for themselves, the teachers whose change is described in these two special issues discovered for themselves things about teaching mathematics that, because they were not learned "second hand" from others, had significant effects on their practice.

A specific area of inquiry for some teachers was the nature of mathematics. In Potari et al., the educators/researchers explicitly questioned teachers' assumptions about the nature of mathematics, for example that it is "like a foreign language" and this provoked clarification and consideration of such assumptions. In Chapman's article, Brea shifted from a linear view of view of mathematics to seeing it as "a living discipline", but this created a new challenge as now she wanted her students to share this view.

Shifts in understandings of the nature of mathematics are sometimes related to shifts in understandings of the nature of mathematics teaching. For example, Brea initially saw her role as a mathematics teacher as simplifying mathematics. After her understanding of the nature of mathematics changed, her teaching changed. She presented mathematics as open, living, "rich and complicated" and asked her students to question and to cope with uncertain answers.

Similarly, for Danica (in Liljedahl's article, JMTE 13.5), efforts to define "numeracy" in terms of the characteristics of students she felt were especially numerate led to a shift of focus away from computational fluency and onto the process of communication, leading to the insight that better articulation leads to better thinking.

Another way in which a teacher's understanding of the nature of mathematics can influence teaching is related to time. If mathematics is seen as requiring long and focussed engagement with problems, as opposed to quick and accurate calculation of answers, this suggests that teaching must allow students the time they need to engage in mathematical activity. Moana (in Hunter's article, JMTE 13.5) made a connection between the time needed for mathematical thinking and the time given elders in a family meeting to reflect before speaking. Time is also identified as important by teachers in the articles by Potari et al., Muñoz-Catalán, Carrillo, and Climent (JMTE 13.5), and Males, Otten and Herbel-Eisenmann.

The two special issues offer at least two examples of what happens when teachers assign cognitively challenging mathematical tasks and provide ample time to explore them: Clive (reported by Boylan, JMTE 13.5) and Brea (reported by Chapman). In these cases, the students are discovering for themselves and at times the teachers learn from the students. Brea says that her students are continually seeing things in ways she could never have imagined and end up exploring material "way beyond the 'curriculum' for that grade." When Clive speaks of the students discovering the circle theorem for themselves, he notes

that he learns from the students, and he observes that given sufficient time proof becomes a normal part of the lesson.

The importance of time in teaching that focusses on complex processes like problem solving and proving has been noted elsewhere. As Bieda (2010) notes, the “effect of time restrictions wreak havoc on the process of proving, potentially more so than on other kinds of mathematical activity” (p. 378), and she suggests that when students do not have adequate time to discuss a topic with the teacher and their peers “they may only develop a surface-level understanding of the content” (p. 378). Reid and Zack (2009) report the time spent on a single problem in classrooms where proving occurred could be four or more hours in some cases. While there are many factors in addition to time allotment that come into play when students and teachers work to make meaning of mathematics (for example, Clive and Brea stand out because of their passion for teaching mathematics), allowing adequate time (even though that might seem over generous) seems to enhance the possibility that significant learning might occur.

Time is also identified by several authors as an important element in teacher change. Boylan, for example, speaks of the need for “fluidity and spaciousness” in teacher professional development. Teacher B (in Potari et al.) observes the importance of time to the process of teacher change, noting that the researchers spent considerable time listening to teachers’ answers to their questions, and she relates this to her decision to reduce her own talking time in the classroom. An interesting contrast to this is Liljedahl’s article (JMTE 13.5) that reported cases where teacher change is a process more akin to an “Aha!” insight than a protracted experience of mathematical problem solving or proving.

A final aspect of mathematics that is important in several of the articles in these two special issues is that of mathematical expertise in teaching mathematics. Readers of JMTE will be aware that the role and nature of the mathematical expertise teachers have is the topic of a considerable body of research (e.g., Ball and Bass 2000; Baumert et al. 2010; Ma 1999). Teacher A, in Potari et al.’s article, shifted from believing that the teacher’s mathematical expertise was a key element in effective teaching to seeing it as limiting if it results in the teacher leading too much. In this case, expertise is seen as having a negative consequence. However, Dave, in Walshaw’s article, offers another possibility. Dave is aware of multiple meanings for the equals sign and pays explicit attention to these conceptual differences in his teaching. His expertise allows him to present his students with a variety of approaches to conceptualising linear equations and allows him to reflect on his teaching in a deeper way. He is aware of multiple meanings of the equals sign and consciously tries to shift his students from the meaning they are familiar with (a process that “makes” the answer) to a more static, balance signification. How exactly to manage this shift is a point on which he continues to reflect.

It is striking that even though there is a considerable diversity of theoretical perspectives, cultural and educational contexts, and methodologies for research and for teacher education represented by the eight articles in these two special issues, nonetheless some common themes emerge. We have noted the importance of emotional engagement to the process of change, the vulnerability that occurs as part of change and the parallel between the process of learning mathematics based on inquiry that is often advocated in mathematics teacher education and the process of teacher change thorough inquiry that is described in the articles in these two special issues. We have also reflected on issues that seem specific to *mathematics* teacher change, including the nature of mathematics, providing time for the complexity of mathematics process and the complex process of teacher change, and the complicated role of mathematical expertise in teaching mathematics. The diversity of approaches represented by the articles in these two special issues might be seen

as leading to confusion, but the common themes among them indicate a common focus from multiple perspectives, which can only shed more light on the enigmatic process of teacher change.

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