I Didn't Know What I Didn't Know: A Case Study of Growth in Teacher Knowledge within the Intermediate Numeracy Project

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This paper reports a case study of one teacher, Jan, who was part of a whole school case study that was designed to explore the professional development journeys of the teachers in one Intermediate School (year 7 and 8) as they implemented the New Zealand Intermediate Numeracy Project (INP). Jan's voice is used to highlight individual transformations that she perceived occurred in her teacher knowledge. Her preparedness to acknowledge and challenge her mathematical content knowledge, her pedagogical approaches, her beliefs and her personal ability to implement change over the three year period of the study was a key to her increasing confidence to enact new approaches in her classroom.

In 2002 the New Zealand Ministry of Education offered selected schools a pilot professional development programme, the Intermediate Numeracy Project at year 7 and 8 (11 and 12 years old), to explore possible models for implementing Numeracy projects at this upper primary level following on the success of the Early Numeracy Project (ENP) at years 1-3 (Thomas & Ward, 2001, 2002) and the Advanced Numeracy Project (ANP) at years 4-6 (Higgins, 2001, 2002). The Intermediate Number Project (INP), focusing solely on year 7 and 8 became one of four projects that formed the Numeracy Development Project in New Zealand. The fourth Project is the Senior Numeracy Project (SNP) for teachers of year 9 and 10 students. Improving student performance in mathematics through improving the professional ability of teachers is the aim of the Numeracy Development Project. These projects have been reported at previous MERGA conferences (Hughes, 2002; Thomas, Tagg & Ward, 2002) and hence the detailed descriptions of the various aspects of the program will not be repeated in this paper.

Intermediate Schools which cater solely to year 7 and 8 students are a feature of the New Zealand school system. Teachers in stand alone Intermediate Schools are physically removed from both their primary colleagues in year 1-6 or full year 1-8 Primary Schools and their secondary colleagues in either year 7-13 or year 9-13 Secondary Schools. There are few specialists, mathematics teachers in Intermediate Schools. The uniqueness of the environment of teachers in Intermediate Schools makes them worthy of study.

Teacher Knowledge

Fennema and Franke (1992) highlighted "the interactive and dynamic nature of teacher knowledge" which they envisaged as comprising "the components of teacher knowledge of the content of mathematics, knowledge of pedagogy, knowledge of student's cognitions and teacher beliefs" (p.162). A relational link between mathematical content knowledge and pedagogical content knowledge is well documented in the research (Ball & McDiarmid, 1990; Bobis & Gould, 2000; Grossman, Wilson & Shulman, 1989; McNamara, 1991; Shulman, 1986). Fennema and Franke stressed the context-specific nature of teacher knowledge, noting that context provides the structure within which beliefs and knowledge interact "to create a unique set of knowledge that drives classroom behaviour" (p.162). Their model was drawn upon by Higgins (2002) to "highlight the

complexity or multiple layers of context" (p.8) within which teachers and facilitators work within the New Zealand Numeracy Project. Higgins used the phrase "teachers context of practice" (p.8), including features such as school structures, policies and student backgrounds, which she sees as shaped by the teacher pedagogical and mathematical knowledge as well as their knowledge of student learning and their beliefs. In this paper I explore these four aspects of teacher knowledge as they emerged in Jan's relating of her understanding of her developing knowledge within the INP Professional Development Project.

Method

The Intermediate School case study gathered data from three different sources, from the year 7 and 8 teachers who were implementing the INP programme in their classrooms, from the school principal and also from the in-school facilitator of the professional development programme. Information was collected over the three year period from 2002 to 2004 via teacher questionnaires, personal journey graphs, interviews and informal discussions with teachers and the in-school facilitator. Four qualitative, semi-structured interviews were undertaken with Jan, one at the start of the project, in June 2002, and three further interviews in December 2002, December 2003, and December 2004. Interviews were audio-taped and the resulting transcripts analysed for key themes related to Numeracy Professional Development (Bobis, 2004; Higgins, 2001, 2002, 2003; Irwin, 2003; Irwin & Niederer, 2002) and teacher beliefs (Handal & Herrington, 2003; Leder, Pehkonen & Torner, 2002). Personal journey graphs reflecting Jan's opinion of her ability to implement the approaches consistent with the Numeracy Project in her mathematics classroom were drawn by her at the end of 2003 and revisited and redrawn at the end of 2004.

The cycle of interviews allowed me to revisit themes from former interviews and enabled Jan to reflect on her previous comments, often reframing them in the light of another year's experience in the INP. Jan acknowledged her perceived personal growth in her mathematics teaching through a storytelling process initiated by the repeated interviews and the reflection on her personal journey graphs. Hence a narrative research framework, which bases itself on a process of growth through storytelling, was used (Clandinin & Connelly, 1994; Lyons & Kubler LaBoskey, 2002; Witherell & Noddings, 1991).

Changes in the key themes of mathematical and pedagogical content knowledge, knowledge of student learning in numeracy and changing attitudes and beliefs are interwoven in my presentation of Jan's story. The changes in these themes are explored in chronological order to highlight how Jan perceived her personal professional growth over the three years of the INP intervention.

The Context of the Project Intermediate School

The Project Intermediate School is situated in a densely populated lower socio-economic area in a New Zealand city. The school has approximately 300 students predominantly European (75%), but also includes a significant number of Maori students (15%), Pacific Islanders (8%) and other ethnic groups (2%). In 2002 there were 12 general classrooms, with 5 year 7 and 7 year 8 classes, and in 2003 and 2004 10 general classrooms with 5 year 7 and 5 year 8 classes. All the year 7 and year 8 general classroom teachers were involved in the INP professional development programme during the three year period of the research study. Nine, two-hour, after-school workshops for all the teachers

and four hours of individual in-class support was given by the external facilitators in the first year of the INP. The amount of in-school support diminished greatly in the second year, with only two after-school workshops and eight in-school modelling lessons in total, with four of each observed by a different group of five teachers. Only a few planning meetings occurred in the third year. For a full description of the professional development model used in the INP refer to Irwin (2003).

Jan's Story

At the start of the INP Jan was in her mid twenties and had been teaching for three years, all in the Project Intermediate School. In the first year of the INP she taught part time (every morning), having responsibility for teaching her year 8 class (12 and 13 year olds) mathematics each day. Jan was teaching full time at year 8 in 2003 and 2004.

Jan had studied mathematics at school until the end of year 11 and clearly articulated a negative attitude towards her school mathematics learning.

> I stopped maths at school as soon as I possibly could. I absolutely hated it. I arrived late to the exam (*School Certificate*) without a ruler or protractor and just scraped through. (Interview with Jan, June 2002)

Teacher training was perceived as less of a struggle for Jan than her school mathematics courses, because of the focus on pedagogy. She had completed an extra Essential Mathematics content course but she realized her lack of content knowledge was a problem when she found herself teaching in an Intermediate School.

> I did the Essential Maths course. That was a bit different, I didn't find maths at College so much of a struggle, because it wasn't so much looking at my mathematical knowledge, but ways to teach maths. However I found when I got to school and teaching form two (*year 8*) I certainly got a shock because I hadn't used it since fifth form. (Interview with Jan, June 2002)

The importance of knowing about progressions in mathematical learning was valued by Jan, but she identified a gap between her espoused beliefs and her ability to incorporate this developmental thinking into her practice at times, commenting:

> In order to lead in maths I think you have gotta have some idea where the approach is going and I don't always. (Interview with Jan, June 2002)

Wilson and Cooney (2002) identify the need to reconsider the "tendency to separate teacher's mathematical and pedagogical beliefs" (p.127) and the close intertwining of these two features becomes apparent in Jan's story.

In discussing her attitudes towards mathematics teaching at the start of the INP Jan showed evidence of a right-wrong dualistic orientation (Wilson & Cooney, 2002) towards her teaching of mathematics and made comments that reflected the security this approach had given her. Her explanations about why she liked teaching mathematics included the following:

> I like the black and white nature of it to a degree; it is more black and white than other areas. I find that it (*her maths class time*) is almost a controlled session. (Interview with Jan, June 2002)

She continued noting that her students "almost always worked quietly" in her mathematics time suggesting to me she taught mathematics in a non-discourse focused environment. When I asked Jan at the start of the project if there was anything she disliked about teaching mathematics her responses included the following:

> The top end stuff, I just feel like I am not entirely sure. You can do as much preparation as you like; you can do it the night before and think you have gone through it and some kid who's well and truly above your level, um, makes some suggestion and you are floored already cause it's different to the solution I worked out and I haven't got a clue whether that makes any sense or not. (Interview with Jan, June 2002)

As I unpacked these comments in discussion with Jan she acknowledged that her ability to help students make sense of their mathematical world was limited by the way in which she herself came to know the mathematics she was teaching. Jan learnt the material she was teaching in a procedural way and struggled at times to interpret others' understandings.

Before embarking on the INP Jan had not had any mathematics-specific professional development since she had started teaching. An historic lack of mathematics-based, in-service courses targeted specifically for Intermediate level (year 7 and 8) teachers was identified by all of the participant teachers.

By the end of her first year involvement in the INP Jan had started to question her "one-way to do it" approach. Jan's daughter, Samantha, was involved in the numeracy project at her primary school and the realization that her own child was developing a range of strategies had triggered some uncertainty in Jan about her dualistic approach to mathematical learning. She shared a family story saying:

> I had a classic example driving in the car a couple of days ago with Samantha and we said "days to Christmas" and she said "10", and I said "how many hours" and she thought for about 20 seconds and she said 240. And mum and I thought what! But she had done the part whole thing, which in itself wasn't so surprising but what I realize was that I hadn't, I had seen that as an algorithm. I didn't actually see that (*mental strategy*) as a valid way of doing maths. I saw that as a way, I mean I quite often do that, but I saw that as a way of cheating rather than, so I certainly wouldn't have been promoting it sort of thing. (Interview with Jan, December 2002)

In discussions with Jan I revisited her concern about not being able to deal with alternative student produced approaches to problems. She talked of this as a "failing in me", but remarked reflectively how this view had been challenged through her involvement in the INP.

> I would have said in the past that there is one way to do it and that you should all have that basic knowledge and then if you have got splinter ways of doing it then that is fine but they need to have the basic knowledge first. And I guess what I am saying now is that maybe you don't. (Interview with Jan, December 2002)

Surprisingly Jan then proceeded to reveal a "ridiculous thing" that she usually solved problems "in a splinter way" herself, but that she had seen this as "cheating" based on her own rule-based experience of learning mathematics. The key message I drew from Jan's self-reflection related to the almost emancipatory effect the valuing of a range of strategies for solving problems had on releasing Jan to believe in her self-developed approaches to solving mathematical problems.

The first year of the project was very much a "starting point" for Jan and at this point she was questioning the benefits that engaging fully with the demands of the INP would have for her and her students. In exploring with her what she thought her future professional development needs would be for the coming year she remarked:

> I have enough maths to get by for my own personal needs in life and after that trying to scratch myself to work out how you do it. You know, I'm sort of like the kids that go: "poof" (*shrugs*). So I think the most help to me would be if we could teach to our strengths where somebody else – I am a great believer in if you are passionate about something or you really enjoy it then you do better by

the kids. So maybe up-skilling myself would actually do that for me. (Interview with Jan, December 2002)

By talking through her feelings Jan identified the possibility that improving her content knowledge would lead to better outcomes for her students. Despite the articulation of this possibility, looking back on the second year of the INP Jan acknowledged that at the start of the year she was "still pretty negative" about it and admitted to initially teaching her own units rather than the numeracy units developed by the mathematics syndicate groups. Later in the year she did teach a numeracy fraction unit but suggested that she didn't know what she needed the children to know, commenting:

> I don't know that I necessarily knew what I needed them to understand previously. Yeah. There were, you know, there's a range of different things you could do, but I didn't actually understand what the base understanding needed to be. (Interview with Jan, December 2003)

After two years in the Project Jan was starting to appreciate the importance of understanding the students' cognition and the broad progressions in numeracy learning, which had been stressed throughout the INP. For me, this highlighted the importance of individual teacher self-realization about what comprises valuable teacher knowledge. New ways of thinking, although talked about and apparently accepted by teachers need to be integrated into teachers' personal belief systems before they have any chance of being enacted in their classroom (Haynes, 1996; Koehler & Grouws, 1992).

Personal Journey Graph

Ability to implement the approaches consistent with the Numeracy Project in my mathematics class
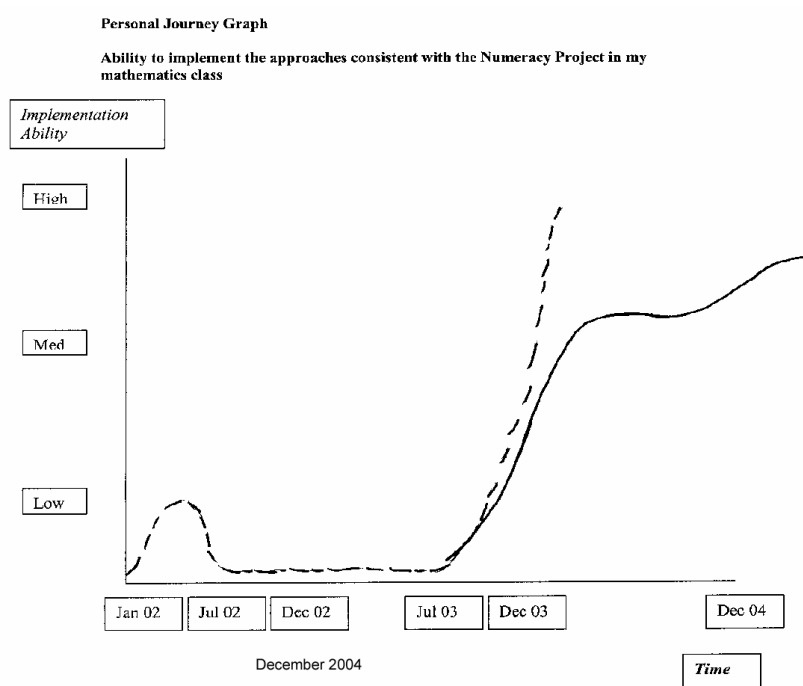
Figure 1. Personal journey graphs: December 2003, revisited December 2004.

Reflecting on her ability to implement the approaches consistent with the INP at the end of the second year, December 2003, Jan drew the Personal Journey Graph shown by the dotted line in Figure 1. Jan had felt some initial confidence, but this waned as the reality of the issues surrounding content knowledge, strategy sharing, time, resource

production, the amount of reading material, changing class management and catering to a range of individual students were realized. Jan got "quite sort of grumpy about it" and only when she thought "that it might actually become curriculum" did she decide to give it another go. Once she decided to "do it her own way" after trying three times to "follow the suggested plan" she felt more in control.

> People have their own way of doing things and I don't feel like I have got any ownership over it. So what I've found helpful about Nina's (*the facilitator*) stuff was seeing how she used the things that I would then take and translate and use in my own way anyway. (Interview with Jan, December 2003)

She identified planning more on a daily basis in response to the students' needs rather than setting out a whole unit and using the diagnostic assessment in bits during the year rather than the full interview, as ways she made the programme her own. It wasn't until the latter half of 2003 that she felt she developed a greater ability to implement INP approaches in her mathematics classroom. At the end of 2003 when discussing her perception of her content knowledge development she said:

> I feel much more secure in teaching the units myself because it's not magic about how the, yeah, I came across the answers. (Interview with Jan, December 2003)

Jan commented, that she thought she would have been "more rebellious about it" but now felt "that makes sense, that's quite achievable". She identified a rapid rise in her confidence over the later half of 2003 as shown in her December 2003 graph. Interestingly she decreased this slope when given the opportunity to make changes to her graph at the end of the following year as shown by the solid line in Figure 1, appreciating she had been over-ambitious about her ability at the end of 2003.

During the third year of the INP the Project Intermediate School had a "whole school" focus on formative assessment in the classroom. This involved sharing student learning outcomes and developing student-based "success criteria" for the learning outcomes across a range of curriculum areas. Jan felt this emphasis developed easily out of her work in the INP where she was used to identifying learning outcomes for each activity with her student and stated, "we just modelled it off the maths". She explained her perceived value in making the students more aware of their own learning:

> Making the kids aware of what the learning intention is, what we're covering and success criteria so that it's not just me who's aware of what I'm wanting them to do but they are too and they can verbalize. (Interview with Jan, December 2004)

Jan felt her planning, now, was much more responsive to her students and rather than just "reading the books (*Numeracy booklets*) word for word" and using the activities "regardless of whether that's where my lesson had gone" she expressed more confidence in setting her follow up activities based on the students' progress during the lesson. Instead of trying to plan whole units in advance she found it "more relevant and easier" planning on a day by day basis.

> I'm tending not to set the follow up activity before teaching the lesson because depending on what happens in the lesson is what I'm going to need and sometimes its been a case of follow up activity has been the lesson but independently. (Interview with Jan, December 2004)

By the end of 2004 Jan, had shown, in my "readings" of her interviews, a shift of focus from herself, her lack of content knowledge, her dualistic beliefs, her procedural approaches to a focus on her students' learning. She now valued their strategies, their understanding of what was to be learnt and planned to cater to their differential progress.

When talking about this shift she expressed surprise at her own growth, commenting that "I wouldn't have said that I'd moved that far on so there".

Conclusion

Jan's lack of mathematical confidence, her beliefs about how mathematics is learnt, her "one-way", procedural approach to her teaching and her initial inability to cope with alternative approaches to problems, all contributed to her difficulty in engaging with the teaching approaches promoted in the INP. Despite being accepting of the material presented as part of the Professional Development Programme, Jan struggled over the first eighteen months of the INP intervention to incorporate the approaches into her classroom mathematics teaching. Once faced with the reality that "it wasn't going to go away" Jan challenged herself to find ways to adapt the programme to make it manageable for her. She spoke of breaking her diagnostic assessment up into smaller sections, planning in shorter time frames and responding to the students' progress more flexibly and on a daily basis. These adaptations gave Jan more ownership of the INP material.

Jan's need to understand what she was teaching and her willingness to acknowledge her lack of content knowledge and challenge herself to improve was crucial to her changing attitude. Her content knowledge developed through her attendance at the workshops, her interviewing of her students, her observation of the in-class modelling by the facilitator, her exploration of the Numeracy Booklets and her discussion with her colleagues. This helped her to believe in her ability to solve problems in a range of ways and to value and make sense of a variety of strategies when they were shared by her students and her daughter. Jan identified a shift in her thinking from a focus on her understanding of the mathematical content and the activities in the Numeracy Booklets to listening to her students and responding to their learning. She highlighted the importance of both her and her students' understanding the learning intentions for the lessons and how these were to be achieved and monitored when discussing her third year in the project.

Wilson and Cooney (2002) confirm that "teachers' beliefs can change when they are provided opportunities to challenge those beliefs" (p.134). Beliefs need to be acknowledged and confronted during the change process "otherwise teachers will maintain their hidden agendas in the privacy of their own classrooms and the implementation process will result in a self-deceiving public exercise of educational reform and a waste of energy and resources" (Handal & Herrington, 2003, p.66). Over the three year period of the INP Jan was able to identify and challenge her growing mathematical understanding and her changing beliefs about how she thought mathematics is learnt and taught. This helped her gain confidence and motivation to enact new approaches in her classroom.

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