The Numeracy Journey: How Long Does it Take to get on Board?

Linda Cheeseman
University of Auckland
l.cheeseman@auckland.ac.nz

A common reaction for many experienced teachers when faced with classroom mathematical reforms is "Why change? What is wrong with the way we teach mathematics?" This paper describes the complex journey three teachers took in attempting to acknowledge, and consolidate the inherent changes required in the mathematical reforms. The journey commenced with their schools' participation in the New Zealand Numeracy Development Projects, a vehicle for mathematical reform, which provided teachers with the impetus to make changes to their personal and pedagogical mathematical content knowledge and practice.

This paper focuses on the amount of ongoing support teachers require in order to consolidate, internalise and implement effectively the mathematical reforms promoted by New Zealand Numeracy Development Projects (NDP) professional development program. In doing so it presents the stories of three primary school teachers as they attempted to accommodate the new mathematical approaches presented in the NDP and implement them in their classroom practice.

The support provided to teachers through the formal NDP professional development program is situated in the schools. The NDP program aimed to increase both professional and community capability by providing a long-term, school-based focus on mathematics for teachers, students and parents (Young-Loveridge, 2004). NDP was designed to up-skill teachers in their ability to teach numeracy by introducing two key elements The Number Framework and the strategy-teaching model. The Number Framework provided a breakdown of the developmental stages that describe students' thinking while the strategy-teaching model supplied teachers with an approach to develop students' thinking (Hughes, 2002). To achieve this NDP incorporated a series of facilitator-led workshops and in-class support sessions over the course of one year, as experienced by the teachers in this study. These support sessions were intended to assist teachers to increase their mathematical knowledge and make changes to their pedagogy in order to promote and develop their students' use of mathematical mental strategies.

Background

The NDP strategy-teaching model required most teachers to change their ways of thinking about children's learning of mathematics. This entailed a shift away from teaching rules, procedures and algorithms to guiding students to use multiple strategies to solve a problem (Young-Loveridge, 2004). Initially many teachers had difficulty understanding the more complex strategies and the shift to a more constructivist pedagogy (Hughes, 2002). Stigler and Heibert (1997) observed the difficulties American teachers encountered while attempting to make changes to their deep-seated beliefs when faced with mathematic reforms similar to those advocated by NDP. Fullan (2001) talked about an "implementation dip". This was a decline in teacher confidence when encountering innovative professional development, such as NDP, which required new skills and new understandings to be learned. This "implementation dip" occurs at a time "when innovations call upon people to question and in some respects to change their behavior and

beliefs" (p. 40). Rata (2002) claimed that this loss of confidence and the resulting anxiety was caused by the tension or dissonance between familiar beliefs and knowledge and the new ideas being introduced.

The literature suggests that teachers are at different stages of readiness and commitment to cope with the process of accommodating new learning and practice, and to reflect on the changes required (Fullan & Hargreaves, 1996; Hill, Hawk & Taylor, 2002; Poskitt, 2001). The literature reported that many primary teachers lacked confidence and enthusiasm in mathematics (Wilson & Ball, 1996). It is likely that these teachers were the ones who had the most difficulty understanding the range of strategies and the strategy teaching model promoted by NDP. It is also likely that they required more practice and support to understand and consolidate the new learning (Young-Loveridge, 2004).

The collaborative nature of the NDP professional development does enhance the chances of teachers overcoming the initial anxieties or dissonance caused by the presentation of new mathematical knowledge and pedagogy changes. The NDP workshop sessions were deliberately designed to support teachers in coming to terms with strategies so that teachers could develop at their own rate. Teachers were able to help each other to problem solve and discuss their use of strategies just as the students are expected to do, thereby developing professional and community capability (Young-Loveridge, 2004).

Fullan and Hargreaves (1996) found that teachers who were willing to take risks and were commited to improving their personal knowledge increased their sense of 'efficacy' resulting in gains in student achievement. Researchers agree that there is a close correlation between teacher and student achievement, which is reciprocal in nature (Barth, 2001; Fullan & Hargreaves, 1996; Hill et al., 2002). The NDP program enabled teachers to practice their new mathematical knowledge and strategy-teaching approaches in the classroom with their own students thereby witnessing their students' reponse to the innovative pedagogy. Higgins (2004) suggested that teachers were more inclined to sustain the changes they had made (in mathematical knowledge and pedagogy) as a result of observing their students' success in numeracy and their own success in teaching it. Professional development programs like NDP will be sustained if the teachers acknowledge the educational advantages of the new learning and the school professional learning community supports the new learning (Parsons, 2001).

Research Design

This study reports on three teacher case studies (stories) derived from a wider study involving face-to-face interviews with eight primary school teachers. The study investigated the teachers' experiences after they had participated in the NDP professional development program. A qualitative interpretive approach was selected as the methodology of this study and the data was collected from in-depth interviews with the three teachers to allow for maximum focus on the voices of the participants (Davidson & Tolich, 2003). The study was about achieving an empathetic understanding of the perceptions of the participants. With this in mind the interview questions were open-ended and sufficiently broad to be used as conversation starting points (Denzin & Lincoln, 2003).

The data collection focused firstly on what the teachers knew about and did with the NDP incorporating the Number Framework and the Teaching Model. Then secondly, what impact the professional development had on them in terms of developing mathematical knowledge and classroom practice. The teachers were reflective in their comments and

provided insights regarding perceived strengths and weaknesses of the professional development that either helped or hindered them to make the required changes to their mathematical content and pedagogical knowledge.

The three teachers in the case studies are referred to by pseudonyms. At the time of the interviews Janet and Claire were teaching in the junior school (5-6 year olds) while Amanda was teaching at the year five/six level (9-10 year olds). Janet and Claire both participated in the ENP professional development while Amanda participated in a whole-school approach incorporating ENP and ANP. Claire also participated in the ANP program the following year in preparation for moving to teach in the senior school.

Although the small sample of teachers involved in this qualitative research study made generalisation problematic, the in-depth responses from the interviews provided valuable information about the understandings these teachers have acquired during their participation in NDP.

Results

All three teachers were enthusiastic about participating in NDP and all felt included in their school's decision to be part of the long-term professional development program. Despite feeling happy with the way they traditionally taught mathematics they were interested to find out what new ideas the program had to offer. As a result of their participation all three teachers claimed to have increased their personal mathematical content knowledge, their understanding of mathematical strategies and their understanding of the strategies their students' used:

> Janet: Massive changes actually! ENP made massive changes to the way I saw kids maths [too]. The fact, that some children with a really good mathematics background can have a lot of knowledge but not have the strategies.

They found the use of a range of strategies to problem solve was new to their thinking and it changed their view of teaching and understanding mathematics:

> *Claire:* ENP actually made me think about number in a very different way by providing me with the strategies and different teaching approaches.

> *Amanda:* ANP has increased my personal [content] knowledge — it has to especially when you're working at the year five - six level [9-10 year old students] … it has quickened my own mental strategies. It's just a totally different way of looking at number and patterns and visualising how can I do this quickly in my head?

All three teachers talked about the challenge they encountered in understanding new mathematical knowledge and strategies. They described this new learning as demanding and commented that it did not happen immediately:

> *Claire:* I've never been crazy about mathematics because I've never been that successful at it myself [mathematical knowledge], and the initial learning [of ENP] was hard work.

> *Amanda:* Trying to get your head around what all these different things — levels, strategies and knowledge all mean. Yes, we [the whole school] found it [NDP] really complicated and complex at times.

> *Janet:* Yes there was a lot to take in! I loved teaching maths. I've always enjoyed it but math's knowledge has never been a strength! The [new] key ideas about the difference between knowledge and strategy and taking children passed countable numbers to part-whole strategies in addition and subtraction took a long time to grasp.

Amanda and Claire discussed the greater demand required of NDP as the age of the

students increased in terms of teacher content knowledge. They found the strategies far more complex at the ANP level of the program challenging to their personal mathematical knowledge:

> *Claire:* I must admit that some of those things that they were doing in the ANP workshop were a wee bit challenging and I had to be brave enough to say, "How did you get that? I understand what you are doing but I got lost in there somewhere."
>
> *Amanda:* I now understand fractions but I'm not really clear on decimals and percentages. I could do with going through a maths course myself.

In addition to taking time to understand the range of strategies to be taught the teachers found implementing the pedagogical changes required to effectively teach the strategies was challenging, in particular the development of quality interactions with their students. Listening to their students' explain their thinking was seen as a major pedagogical shift and took time to develop:

> *Claire:* It's harder to maintain their attention when you are trying to involve everybody and interact with everybody and get them interacting. Groups of four to six do give each student the opportunity to interact and I actually listen carefully to how they respond.
>
> *Janet:* The children weren't used to analysing how they thought [explaining strategies] - you almost had to put words in their mouth at first. So that was quite hard to get them to admit sometimes that they had thought processes! It did take a while … to get them used to that.
>
> *Amanda:* You've got to be able to understand how the students have gone about it [a strategy] and help them to explain to others … [Initially I found] I really wasn't giving the children enough time to actually mentally work it out before replying. I find it particularly hard with these children because their listening skills sometimes aren't great and they're not used to having to listen to others.

The teachers agreed that the NDP resource booklets provided some direction on how to teach the strategies by outlining lessons that linked to the appropriate stages on the Number Framework and that clearly followed the strategy-teaching model. However, they claimed these also took time to use confidently:

> *Claire:* The booklets are most helpful to access information … they make suggestions and you have all your support material … I familiarised myself with the support material over the holidays. I made that a personal goal and I'm glad I did but it's time-consuming.
>
> *Janet:* The booklets are totally practical because you can do your whole planning from them … Teaching from the book is still taking me a bit of time and I still need to have it on my knee. I don't know it well enough yet but I don't think that will take too long to come.

The teachers observed that dependency on following the lesson guides provided in the teacher resource books detracted from fully listening to and noticing the students' use of strategies. Overall, the three teachers were at different stages of confidence implementing the pedagogical changes. Amanda and Claire commented on the time and organisation required to competently implement the strategy-teaching model:

> *Amanda:* You get really bamboozled with trying to take in - now what is it I'm actually teaching here? What equipment do I actually need and what stage am I at? And, oh yes, I need to record where the kids are … there's an awful lot to think about … It all takes time! It's getting better but it is quite a panicky stage really. It is important to jot down well, this girl didn't actually get that today and I'll need to take her back whereas the other children did get it. … My pedagogy has [also] changed because of the visualisation [imaging] part of the teaching model. I never did that or realised the importance of it!
>
> *Claire:* It took time to organise my maths program. Each session I send my [non-teaching] groups off to do either a [strategy] practice or knowledge activity. Or they will have a group box

full of strategies, strategy-building games and activities. I've had to organise a range of teacher resources for effective planning so that I can focus on my teaching group.

All three teachers felt the demand of the NDP program in terms of acquisition of personal mathematical knowledge and making pedagogical changes to teach the strategies was challenging and difficult to consolidate within the formal professional development timeframe. They valued the long term, school-based design of the program but appreciated the need for further support for the transition to embedding the new mathematical knowledge and strategies in their practice either at a personal or school community level:

Amanda: We have had a different [additional] facilitator this year [second year of project]… and we've had four staff meetings throughout this year with her and it's really helped to clarify things … also the ACE [Auckland College of Education] course 'Helping Children Succeed in Mathematics' looked more into the theory behind NDP and for me, highlighted the necessity to use the teaching model.

Claire: I feel much more confident and happy with the program this year. Well, I have to say the materials, the booklets, the second time around [participated in ANP course this year after completing ENP last year] have been very useful.

Janet, on the other hand, felt that the support of the formal NDP program was insufficient to give her an overall knowledge of NDP.

Janet: If the school had more money and the teachers were willing to do it — it would have been good to do more courses [workshops] … maybe twice a week … one session pertaining to the syndicate level of the program and the other session dealing specifically to your own class level.

To overcome this she expressed interest in participating in the school's follow up ANP professional development for the teachers of the senior school:

Janet: I thought I might attend those [ANP workshops] just to see where it is going [NDP]. They [the facilitator] will backtrack a little bit to show the linking to ENP and I will be able to reiterate or revise some of it.

However, the senior management informed her that the school could not afford to financially support this idea and her syndicate's involvement in the New Zealand Literacy Project as professional development the following year directly competed with NDP for her attention to ongoing mathematical pedagogical change. By comparison the other two teachers were in school communities committed to a numeracy professional development focus for a minimum of two years. Claire, however, acknowledged the tension caused by other curriculum initiatives competing for teachers' focus at the completion of the NDP program as her school management team also considered pursuing the literacy project:

Claire: Our school was going to go through the literacy project and it was like whoa! Hold on a minute - let's get this maths program down first, you know? Because there are a lot of changes going on in NZ education right now because we recognise the need to be better, but it's no good if we are going to bring something like this [NDP] in and then don't follow it through.

The advantage of belonging to a school community that endorsed a longer-term school commitment to numeracy by acquiring additional facilitator support assisted Claire and Amanda to consolidate and internalise the new mathematical learning generated by the professional development. By the completion of their second year of focusing on numeracy they responded with these personal reflections:

Claire: It's [NDP] changed my attitude - I love maths now. I really like it - the kids say, "Oh can we have some more time?" And they don't want to get off the mat. It [NDP] is very effective. The children absolutely love it. The first thing every morning they say, "Can we have maths now?"

Amanda: The good thing is the project is evolving and getting better [all the time]. I am a firm

believer in it [NDP] now. I'd never go back to just teaching algorithms without teaching children [a range of] mental strategies … it's really doing them a disservice. I just see it as so good, encouraging the children to think. I am sold on it, despite getting your head around it all. I wish that I'd had it when I was at school. We owe it to children to expose everything [a range of strategies] to them.

Janet was enthusiastic about the NDP professional development and the way her students' responded to the changes she had made in pedagogy. However, her self-reports indicate that given her new professional development focus on literacy her knowledge gained in numeracy may not be sufficient for it to be adequately embedded in her classroom practice.

Janet: The numeracy project is the best professional development I've done in years, but there was a heck of a lot to learn … so it sort of went in but what stuck was the bit [knowledge and strategies] that you use in your class level.

Discussion and Concluding Comments

The demanding nature of the new learning involved in NDP, discussed by the teachers, was due to the amount of new knowledge they were expected to accommodate and the degree of high-level thinking involved in understanding the range of strategies and strategy-teaching approaches within the timeframe of the formal professional development. Research studies have found increased mathematical content knowledge for most teachers is deemed essential for improving the quality of mathematics instruction in schools (Britt, Irwin & Ritchie, 2001; Education Review Office, 2000; Hill & Ball, 2004). The NDP program introduced teachers to new increasingly sophisticated part-whole strategies which in turn, for most teachers, challenged and increased their own mathematical knowledge (Irwin, 2003; Thomas & Ward, 2002). The introduction to a range of strategies to solve mathematical problems mentally was an innovative approach for the teachers in this study and they found the thought processes involved initially challenging to follow. They claimed their increased understanding was demanding and did not happen immediately, and for two of the teachers proved more challenging at the ANP levels compared to the ENP levels. The literature acknowledges that many primary school teachers are not confident mathematicians (Young-Loveridge, 2004) and this was the case for two of the teachers who stated their mathematics knowledge was not strong.

The nature of the NDP program required a major shift in pedagogy from teaching approaches that focused on a transmission approach to a teacher facilitation approach focusing on student thinking and reasoning (Stein & Strutchens, 2001). The teachers in this study claimed that the required changes to pedagogy were complex (in particular the implementation of the strategy-teaching model and student-teacher interaction) and that the shift in pedagogy took time to develop. The NDP intended pedagogical shifts parallels the literature on innovative professional development in that it requires the teachers to change their pedagogy from the way they themselves were taught in schools (Hargreaves, 2000). The complexity of pedagogical knowledge involved in this expectation makes the professional development requirement extensive if teachers and learners are to gain maximum benefit.

Ideally, schools were expected to commit to the NDP program thus focusing on numeracy for at least two years in line with Fullan and Hargreaves (1996) recommendation for a two-year minimum professional development commitment as necessary to make and embed significant changes. To be successful the NDP program, like other long-term

professional development programs, required ongoing commitment by the principal and school management team in order to support teachers in their new practice (Henri, 1999; Parsons, 2001; Sergiovanni, 1996). The literature suggests that the more closely aligned the aims of the school are with the aims of the project (NDP), the greater the chances are for teachers to consolidate and sustain their new practice (Higgins, 2004). This, indeed, was the case for two of the teachers in this study who were able to consolidate their practice because of the continued facilitator support beyond the formal NDP program; an outcome of the longer-term commitment by their schools to the project. Conversely, the third teacher felt less confident with the changes to her personal mathematical knowledge and pedagogy because her understanding of the project was not fully developed at the completion of the formal professional development program. Her school community was less committed to the continuation of the numeracy initiatives instigated by NDP and appeared to provide inadequate support for her to consolidate her practice.

Overall, the teachers regarded the professional development program as very worthwhile. The professional development made a difference to the delivery of the teaching / learning program for these three teachers ensuring that both outcomes and opportunities for students improved (Hill et al., 2002) — an outcome intended by the NDP program. However, the findings imply that, given the demanding nature of the new learning involved in NDP, teachers are more likely to require ongoing support beyond the timeframe of the formal professional development in order to fully consolidate, internalise and implement the NDP reforms. The professional development literature reports new knowledge and pedagogical experiences are filtered through the teachers' belief system and then interpreted in the teachers' own way (Fennema & Franke, 1992; Keast, 2001). If the professional development is not adequate to change teachers' beliefs in regard to mathematical knowledge and pedagogy, then teachers will revert to their existing beliefs about best practice. A possible outcome for Janet if she is not adequately supported over time to consolidate and internalise her new beliefs about mathematics and the ways to teach it.

The literature cautions that effective professional development to produce teacher change should provide sufficient time and follow-up support to assist teachers to implement new practice (Corcoran, 1995). The three teachers who took this numeracy journey clearly felt that the provision of ongoing support beyond the first year of formal professional development was necessary to put into practice the extensive changes in knowledge and pedagogy that were required to fully implement the mathematical reforms embedded in the NDP.

References

Barth, R. (2001). *Learning by heart.* San Francisco: Jossey Bass.

Britt, M., Irwin, K., & Ritchie, G. (2001). Professional conversations and professional growth. *Journal of Mathematics Teacher Education, 4*(1), 29-53.

Corcoran, T. (1995). *Helping teachers teach well: Transforming professional development.* New Jersey: Univerity of New Jersey

Davidson, C., & Tolich, M. (2003). *Social science research in New Zealand: Many paths to understanding* (2nd ed.). Auckland: Pearson Education New Zealand.

Denzin, N., & Lincoln, Y. (2003). *The landscape of qualitative research: Theories and issues* (2nd ed.).

Thousand Oaks, California: Sage.

Education Review Office. (2000). *In time for the future: A comparative study of mathematics and science education.* Wellington.

Fennema, E., & Franke, M. (1992). Teachers' knowledge and its impact. In D. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 147-164). New York: Macmillan.

Fullan, M. (2001). *Leading in a culture of change*. San Francisco: Jossey-Bass.

Fullan, M., & Hargreaves, A. (1996). *What's worth fighting for? Working together for your school.* New York: Teachers College Press.

Hargreaves, A. (2000). Four ages of professionalism and professional learning. *Teachers and Teaching: History and Practice, 6*(20), 151-182.

Henri, J. (1999). The information literate school community: Not just a pretty face. In J. Henri, & K. Bonanno (Eds.), *The information literate school community: Best practice.* (pp. 1-10). Wagga Wagga, NSW. Centre for Information Studies, Charles Sturt University.

Higgins, J. (2004). *An evaluation of the advanced numeracy project 2003.* Wellington: Ministry of Education.

Hill, H., & Ball, D. (2004). Learning mathematics for teaching: Results from California's mathematical professional development institutes. *Journal for Research in Mathematics Education, 35*(5), 350-351.

Hill, J., Hawk, K., & Taylor, K. (2002). Professional development: What makes it work? *Set 2,* 12-15.

Hughes, P. (2002). A model for teaching numeracy strategies. In B. Barton, K. Irwin, M. Pfannkuch, & M. Thomas. (Eds.), Proceedings of the 25th annual conference of the Mathematics Education Research Group of Australasia: *Mathematics Education in the South Pacific* (pp. 350-357). Auckland, NZ: Mathematics Education Research Group of Australia.

Irwin, K. (2003). *An evaluation of the numeracy project for years 7-10, 2002.* Wellington: Ministry of Education

Keast, S. (2001). Identifying testable teacher beliefs through teacher-led professional development. In J. Bobis, B. Perry & M. Mitchelmore (Eds.), *Numeracy and Beyond: Proceedings of the 24th Annual Conference of the Mathematics Education Research Group of Australasia Incorporated* (pp. 314-321). Sydney: Mathematics Education Research Group of Australasia Incorporated.

Parsons, R. (2001, December). *Professional development: Improving teacher capability.* Paper presented at the Numeracy Hui, Auckland College of Education.

Poskitt, J. (2001). Schools doing it for themselves: Successful professional development. *Set 1,* 1-7.

Rata, E. (2002). *Democratic Principles in teaching and learning.* Auckland College of Education Monograph Series.

Sergiovanni, T. (1996). *Leadership for the schoolhouse: How is it different? Why is it important?* San Francisco: Jossey-Bass.

Stein, M., & Strutchens, M. (2001). Mathematical argumentation: Putting umph into classroom discussions. *Mathematics Teaching in the Middle School 7*(2), 110-113

Stigler, J., & Heibert, J. (1997). Understanding and improving classroom mathematics instruction: An overview of the TIMSS video study. *Phi Delta Kappan, 79*,1, 14-21.

Thomas, G., & Ward, J. (2002). *An evaluation of the early numeracy project 2001.* Wellington: Ministry of Education.

Wilson, S., & Ball, D. (1996). Helping teachers meet the standards: New challenges for teacher educators. *The Elementary School Journal, 97*(2), 121-138.

Young-Loveridge, J. (2004). *Patterns of Performance and progress on the numeracy projects 2001-2003.* Wellington, New Zealand; Ministry of Education.