The Impact of Mathematics Education Reform in New Zealand: Taking Children's Views into Account

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This paper focuses on the New Zealand Numeracy Projects (NZNP), an initiative aimed at reforming mathematics teaching and learning. Evidence shows that students benefited from NZNP, regardless of ethnicity, socio-economic status, gender, or age, but that differential performance and progress were evident for particular subgroups - Asian and European students, high socio-economic status (SES) students, boys, and older students began higher and made greater progress than students in other groups. Evidence suggests that the gaps between some groups (eg, high & low SES) may be narrowing, possibly because of the benefits for low SES schools of being involved in other initiatives. Effect sizes provided a measure of how practically meaningful the benefits of NZNP were. The average effect size for Multiplication/Division, Proportion/Ratio and Addition/Subtraction was 0.40, 0.43, and 0.19, respectively, comparing favourably with those found in the UK (0.17 & 0.18). In a related study, children's perspectives on their mathematics learning were explored using individual interviews. Overall, children were more positive about the value of explaining their thinking to other people than about knowing the solution strategies used by their peers. Students at City School were particularly enthusiastic about the value of sharing their thinking with others than were those from other NZNP schools. Staff at City School indicated that for some time, they had been developing a collaborative approach to working with their students, encouraging them to discuss their thinking and reflect on their learning in all curriculum areas. The findings indicate that more emphasis needs to be given to the communication of thinking and reasoning in mathematics.

The New Zealand Numeracy Projects (NZNP), like other reforms in mathematics education worldwide (eg, Bobis et al, 2005; British Columbia Ministry of Education, 2003; Commonwealth of Australia, 2000; Department for Education and Employment, 1999; National Council of Teachers of Mathematics, 2000; New South Wales Department of Education and Training, 2001), came about as a result of concern about the quality of mathematics teaching. This concern was sparked by the results from the Third International Mathematics and Science Study (TIMSS) showing that New Zealand students' mathematics achievement was below international averages (Garden, 1996, 1997).

NZNP sits within the context of the Ministry of Education's Literacy and Numeracy Strategy, and reflects the key themes of that strategy: clarifying expectations (for student learning), improving professional capability, and involving the community (Ministry of Education, 2001a). The focus of the projects has been on improving student achievement in mathematics by improving the professional capability of teachers. Key aspects of NZNP include a research-based framework to describe progressions in mathematics learning, individual task-based interviews to assess children's mathematical thinking, and ongoing reflective professional development for teachers (for more information, see Ministry of Education, n.d.). The teaching model used in NZNP draws on the work of several key mathematics education researchers (Fraivillig, Murphy & Fuson, 1999; Pirie & Kieran, 1994).

NZNP began initially with children in the early years of primary school (Early Numeracy Project [ENP] years 0-3). A parallel initiative for students in the senior primary years (Advanced Numeracy Project [ANP] years 4-6) soon followed.

Consolidation and expansion of ENP and ANP was accompanied by exploratory work with students and their teachers in the intermediate years (Intermediate Numeracy Project [INP] years 7-8), and the first two years of secondary school (Secondary Numeracy Project [SNP] years 9-10). A Maori medium version of NZNP (Te Poutama Tau [TPT]) was developed for years 0-10 students in Maori immersion settings. By the end of 2005, approximately 17,000 teachers and 460,000 children will have participated in NZNP. It is predicted that by 2007, virtually all teachers at years 0-6, and the majority of those at years 7-8, will have had the opportunity to participate in NZNP.

The Impact of NZNP on Students' Mathematics Learning

Comprehensive evaluations have been done for each NZNP project (ENP: Thomas & Ward, 2002; Thomas, Tagg & Ward, 2003; Thomas & Tagg, 2004; ANP: Higgins, 2002, 2003, 2004; INP & SNP: Irwin, 2003; Irwin & Niederer, 2004; TPT: Christensen, 2003, 2004). These evaluations show NZNP to have been effective in raising mathematics achievement across the primary and early secondary years, in both Maori medium and in mainstream (English medium) settings. Teachers have reported developments in their professional knowledge as a result of their involvement in the projects, and noted changes in their classroom practices to accommodate their new knowledge and understanding (Higgins, 2002, 2003; Thomas & Ward, 2002). Increases in confidence and enthusiasm for mathematics teaching have also been reported.

Data on students' mathematics achievement, from individual assessments by their teachers using the diagnostic interview, consisted of judgements about the framework stages reached on various operational (strategy) and knowledge domains at the start and end of the project. Analysis involved comparing the percentages of students at particular framework stages initially and finally. Differential progress was explored by taking students who began the project at each framework stage, and examining differences in their progress as a function of grouping variables. These analyses showed that, not only did European and Asian students start the project at higher frameworks stages, but they made greater progress than Maori and Pasifika students who started at identical framework stages. A similar pattern was found for SES (reflected in school decile ranking[1]), with students at high SES schools starting higher and making greater progress than students at medium or low SES schools. Similarly for gender and age, boys and older children tended to start higher and make greater progress than girls and younger students. So, while all groups "improved", the project did little to change the relative differences between groups; if anything, initial differences were exacerbated. Finding differential benefits favouring certain subgroups indicated that a "one-size-fits-all" approach was not adequately addressing the learning needs of all students. Just over a year ago, facilitators were alerted to these findings and urged to think about how NZNP could be tailored to better meet the needs of particular subgroups, in effort to "narrow the gaps" (Young-Loveridge, 2004).

When patterns of progress in 2004 were examined closely in relation to particular starting points, a slightly different pattern emerged than that found in 2003. Of the students who began the project at stages 0-3, more at low SES schools progressed to

[1] A school's decile ranking indicates the extent to which the school draws its students from low socio-economic communities, and is calculated using Census information and school ethnicity data.

stage 4 or higher than comparable students from medium SES schools (44.2% compared to 39.9%). This "improvement" was almost as great as that found for comparable students at high SES schools (44.7%). In 2003, however, the proportion of students starting at stages 0-3, who progressed to stage 4 or higher was smallest for students at low SES schools, and highest for those at high SES schools (ie, 35.8%, 39.1%, 45.1%, for low, medium & high SES schools, respectively). I explored the possibility that the improvements for students at low SES schools in 2004 were the result of one of the special (Schooling Improvement) initiatives that had been put in place to provide extra support for schools in certain low-income areas (eg, the Manurewa Enhancement Initiative [MEI]). MEI was a schooling improvement initiative focusing on integration and alignment with NZNP, and had as one of its goals "added value" rather than just implementing NZNP in the normal way. I compared the progress of students at eight low SES MEI schools (n=942) with those at other low SES schools that did not participate in MEI (n=17,329). I found more MEI students who started the project at stages 0-3, or stage 4, then progressed to higher framework stages, than comparable students from other low SES schools. This finding indicated that extra support for low SES schools could help teachers there to deal with the additional challenges they face.

Effect sizes were calculated in order to get a measure of how practically meaningful the differences were (Young-Loveridge, in press, a). This was initially challenging because the stages on the number framework had been shown to constitute an ordinal (rather than an interval) scale; this came from evidence that the steps at lower framework stages are smaller (and hence easier to progress through) than those at upper framework stages. This made it difficult to analyse the data in terms of relative differences (eg, gain scores). However, the size of the 2004 cohort (more than 70,000 students) made it possible to calculate effect sizes separately for each starting point on the framework, and then to average these effect sizes to give an overall picture. I circumvented the lack of a "control group", by using adjacent year-groups, comparing slightly older students *before* the project with slightly younger students *after* the project (a relatively conservative "control" because of the half-year age difference favouring the older children by the end of the project).

The advantage of effect sizes is that they allow us to look at the impact of NZNP on students' learning in relation to those of other projects (According to Fan, 2001, effect sizes of .20, .50, .80, are considered small, medium & large, respectively). For example, the average effect size on Addition/Subtraction for NZNP was 0.19, a relatively modest value, but similar to that found for the UK National Numeracy Strategy (0.17 or 0.18; see Brown, Askew, Millet & Rhodes, 2003), an initiative described by Fullan and Earl (2002, p. 3) as "an impressive success." Average effect sizes for Multiplication/Division and Proportion/Ratio on NZNP were more than double (0.40 & 0.43, respectively, close to medium), and provide robust evidence that the project has had a substantial impact on students' mathematics learning in these operational domains.

Children's Perspectives on their Mathematics Learning

Finding substantial effect sizes for data based on teachers' judgements about the strategies children use to solve mathematics problems is encouraging. However, measures of student learning provide information on just one aspect of the projects' impact on students. Questions remain about just how NZNP impacts on the children's views about their mathematics learning (Guskey, 2002). In order to explore this issue, I initiated a research project that involved talking to children themselves about how they saw their mathematics learning. I reasoned that if NZNP was making a major difference to what happens in classrooms, there should be evidence of this in the ways that children talk about their mathematics learning in classrooms. Earlier evaluations had explored the perspectives of teachers, principals, and facilitators towards NZNP, but little had been done to find out about students' views of the project and its impact on their mathematics learning.

A sizeable body of literature has demonstrated the usefulness of finding out how students see themselves as learners (eg, Carr, 2000; Duffield, Allan, Turner & Morris, 2000; Fielding, Fuller & Loose, 1999; Freeman, McPhail & Berndt, 2002; McCallum, Hargreaves & Gipps, 2000; Phelan, Davidson & Cao, 1992; Pollard, Thiessen & Filer, 1997; Young-Loveridge & Taylor, in press). We (myself, Merilyn Taylor and Ngarewa Hawera) explored students' perceptions and dispositions towards learning mathematics by interviewing (individually) approximately 180 children in years 5 and 6 (9- to 11-year-olds) at six schools, four that had been involved in NZNP, and two that had not (Young-Loveridge, Taylor & Hawera, in press). We explored a range of issues with students, including their views about the nature of mathematics, mental computation processes, communication of solution strategies with others, and teachers' and family/whanau roles in supporting mathematics learning. The focus here is on how students feel about the importance of communicating their mathematical thinking to others and listening to the strategies of their peers.

We told the children that we were interested in finding out more about "how kids learn maths and how their teachers can help them," and "what kids themselves think about learning maths." Prior to the questions that are the focus here, we had asked the children to comment on the importance of working out problems mentally, of getting answers correct, and whether they thought there was only one or several different ways of working out an answer. We then asked them these questions and the reasons for their responses:

> Do you think it is important for you to know how other people get their answers? Is it important for you to be able to explain to other people how you worked out your answer?

Findings

We found considerable variation from school to school in children's responses to the questions (see Table 1). Of the six schools, City had the highest levels of agreement from students about the importance of knowing others' strategies (77.8%), and also about the importance of explaining one's strategies to others (74.1%). The majority of students at Edge School, on the other hand, felt strongly that it was <u>not</u> important to know how other people work out their answers (71.4%). Overall, there were higher levels of agreement about the importance of explaining one's thinking to other people, than to knowing about other people's strategies and thinking.

When the "yes" responses of students at the four NZNP schools were aggregated and compared with those of students who did not participate in NZNP (non-NP), an interesting pattern emerged. The responses of students at non-NP schools were similar to those of NZNP students on the question about the importance of explaining one's strategies to others, with about half of the students thinking it was important. However, a statistically significant difference between groups was found for responses to the question about the importance of knowing how other people work out the answers to their problems [$\chi 2$ (2) = 9.47, $p < 0.01$]. Almost half of the NZNP students thought that knowing how other students' solved problems was important, whereas only a quarter of the non-NP group thought so. The analysis of "No" responses showed a corresponding pattern; almost twice as many non-NP as NZNP students thought that knowing others' solution strategies was not important.

Table 1
Percentages of students who responded to the questions about knowing and sharing solution strategies with peers (numbers are shown in brackets; schools that had participated in NZNP are asterisked)

		Importance of Knowing Others' Strategies				**Importance of Explaining One's Own Strategies to Others**			
School	**SES**	**Yes**	**No**	**Unsure**	**Total**	**Yes**	**No**	**Unsure**	**Total**
Arch*	low	27.8 (10)	52.8 (19)	19.4 (7)	36	48.6 (18)	27.0 (10)	24.3 (9)	37
Bank*	low	39.1 (9)	43.5 (10)	17.4 (4)	23	56.5 (13)	39.1 (9)	4.3 (1)	23
City*	mid	77.8 (21)	11.1 (3)	11.1 (3)	27	74.1 (20)	7.4 (2)	18.5 (5)	27
Dale*	low	46.7 (14)	46.7 (14)	6.7 (2)	30	60.0 (18)	23.3 (7)	16.7 (5)	30
Edge	low	17.9 (5)	71.4 (20)	10.7 (3)	28	48.3 (14)	17.2 (5)	34.5 (10)	29
Farm	low	31.3 (10)	56.3 (18)	12.5 (4)	32	50.0 (16)	46.9 (15)	3.1 (1)	32
NZNP		*46.6 (54)*	*39.7 (46)*	*13.8 (16)*	*116*	*59.0 (69)*	*22.2 (26)*	*18.8 (22)*	*117*
Non-NP		*25.0 (15)*	*63.3 (38)*	*11.7 (7)*	*60*	*49.2 (30)*	*32.8 (20)*	*18.0 (11)*	*61*

Children's responses to the interview questions reflected the extent to which they thought communication was important for their mathematics learning. In the interviews, we endeavoured to find out *why* students held particular views. In the following section, students' responses to the question about *knowing* about other people's solution strategies and presented (first those who thought it was important, then those who thought otherwise). A corresponding section on the importance of *explaining* one's own solution strategies to others follows.

Knowing Others' Strategies is important

Several students referred to the usefulness of having *alternative* ways of solving problems as the reason that knowing others' strategies was important:

> They might have another way (A11, boy, high)
>
> I could try and do it their way (A24, girl, middle)
>
> Because other people may have different ways and you can learn off them and you maybe get better and better (C18, boy, low)

Some students referred explicitly to the value for their own *learning*:

> So you can learn from them (F12, girl, high)
>
> Because they're helping you understand (F8, girl, high)
>
> Yes because then I can learn from it and other people can too (B8, boy, middle)

It was interesting to note that some of these responses (F12 & F8) came from students attending Farm School, a non-NP school.

Helping other students learn was given as the reason by some students:

> Because you want to see people succeed with stuff because they do have a bit of trouble, but I just sometimes help them a bit (F2, girl, high)

A group of students seemed preoccupied with the *correctness* of their answers, even though NZNP had tried to shift the focus away from correct answers onto examining the variety of strategies:

> To get the answer right (B5, girl, middle)

> Because if they get what the answer is, if they get it right… it can be in your head too (F32, boy, low)

Some students seemed more concerned about classroom *etiquette* and showing respect for their classmates:

> Because when you listen to other people, those other people might listen to you and learn your answer (A29, girl, middle)

Relationships were an important consideration for some children. One student thought that knowing how other people solve problems was only important among close friends:

> Only if they're really close to you and they're really good friends (A37, boy middle)

Knowing Others' Strategies is <u>not</u> important

Students who disagreed with the idea that knowing others' strategies is important had a range of different reasons for their view. The most frequent reason given referred to *dishonesty*:

> Because you're using their brains not yours (A31, girl, low)

> Because you don't do that, because that's cheating (A8, boy, middle)

> No, because then you'll be just like cheating off them and you don't really learn for yourself, you're learning off other people and when you go to do it by yourself you don't actually know (A13, girl, high)

Privacy was referred to by some of the students who thought that knowing about other students' strategies was not important:

> Because it's their own business how they do it… it's not important for me because I know my own way to work things out (C15, boy, low)

> Because it's their way they do it, you don't have to, 'cause it's really none of your business (C26, girl, low)

> Because you don't want to know about it, it's only important to them (F31, boy, high)

Some students thought that *individuality* was important:

> Because everyone's different and everyone has their own way (F5, girl, middle)

> Because you should know yourself (F22, girl, middle)

> Because I like doing it by myself (A2, boy, middle)

The idea of *reciprocity* came through in the responses of some children. They expected to alternate between being the "helper" and the person being helped.

> Because if they get the answer right then they can tell you and help you and then if they don't know a question, if they don't know the answer then we can help them (A16, boy, high).

Explaining One's Strategies to Others is important

Students tended to be in greater agreement about the importance of explaining their strategies to other students than they had been about knowing others' strategies. Many of these students referred to helping others with their *learning*:

> So they can learn how to do it next time they go to do it (B15, girl, high)

> Because they can learn and they can go up another level (B6, girl, middle)

> Because others may not understand it and you might (A31, girl, low)

Sometimes the helping involved withholding some information because of *concern* that too much information might prevent other children from working something out for themselves.

> Just how you solved it up, only a little bit, not too much, because people get out too much information [Asked: "What's the problem with giving too much information?"]. They'll know heaps about it so they won't figure it out for themselves (D1, boy, middle)

> Sometimes if they're really stuck, but I won't actually give them my answer… I'll give them clues on how to work it out and that (A13, girl, high)

Sometimes the reason for helping others with their learning was that the teacher was very busy and it facilitated *classroom organisation* if the more proficient mathematicians explained their ways of solving problems to less proficient classmates.

> Because if they wanted to learn something and they asked the teacher and the teacher's busy then they can go to a person that will know the answer and they can explain to them how you can add up to that (B11, girl, high)

The value of *alternative* strategies was mentioned by some students:

> Because there's lots of different ways, and maybe I have a different way to them (B17, boy, middle)

The responses of some children hinted at the need to **"***prove***"** that they had solved the problem themselves *before* finding out how other children had come up with a solution.

> So they know that you don't copy off other people (B1, boy, middle).

> Because sometimes people ask you how you did it, so you've got to know how you did it, so before you take their answer, you say the answer, you think about how you did it (C20, boy, high).

Building and maintaining *relationships* was important for many children and this came through in their responses to the question.

> So you can help your mates out (A17, boy, middle).

Explaining One's Strategies to Others is <u>not</u> important

Relatively few students thought that explaining their thinking to others was <u>not</u> important. The reasons they gave for their responses were similar. *Dishonesty* was the most frequent reason given:

> It's just cheating (A19, girl, low)

> Because that's just like cheating (F28, boy high)

Individuality was given as a reason for not explaining one's strategies to others:

> You should always worry about your work before you go to other people about their work. You never know when they could get a wrong answer and you could as well (B1, boy, middle)

> Because they could have their own way to work it out (C15, boy, low)

> Because different people have different ways of doing their answers (F4, girl, middle)

Privacy was also referred to as the reason for not explaining one's own strategies to others:

> Because it's my work and not theirs (F5, girl, middle)

> Because if we tell them how you worked out the answer, then they'll go round telling everybody else, then everybody else would get the same answers (A38, girl, low)

Some children thought that explaining one's strategies to other students might *hinder learning* rather than help it:

> If you told them the answer they won't be able to learn (A18, girl, middle)

What made City School Different?

City students were particularly articulate about their reasons for taking the view that knowing about others' strategies was important (Young-Loveridge, in press, b). Their explanations often referred to multiple advantages and elaborated on the value for classroom learning processes:

> Because it might help you in working out your ways, because you might be working out a really difficult way but you're not knowing it, and then somebody else shares something with the class, and then it would be really good because you would then find out that you might be able to use that way (C1, girl, middle)

> Because it can help you grow and develop because if you are always just doing your way and never seeing anybody else's way of doing it. Sometimes when you are stuck, other people's ways can help you, 'cause one time … my way didn't work for it, and then I just sat there and thought about some other people's way and one person's way helped me solve that problem (C2, boy, high)

> It could help your learning by getting better, if they can show you how they got to work it out. Sometimes you can get very confused about what other people say, but it's good to hear their learning because sometimes it's most likely to help your learning as well (C19, girl, low)

Most City students thought that explaining their thinking was important, and gave detailed explanations of their reasons for holding this view:

> Because it's good that I know how I worked out the answer first of all, and it's good 'cause I like sharing my ideas with other people and my point of view of how I can work it out, and so if I say my way and another person tells their way and their way's a bit easier, I can just try it their way, and then you get lots of different ways by telling your one, then other people go "I've got a simpler way of doing that", so it helps you to learn (C2, boy, high)

> It's helping my learning as well so it's good to share what your side of the story is (C19, girl, low)

City School serves a middle SES community, whereas the other five schools are all low SES. The established relationship between SES and oral language skills (see Gilmore, 1998; Ministry of Education, 2001b) could explain why City students were more articulate in talking about their mathematics learning. However, there were other things happening at City School that may also have influenced students' views.

The Perspectives of City Teachers

Further information from City teachers provided a wider perspective on the ideas shared by students. According to City staff, it is the culture and climate of the school that is its distinctive feature, and "teachers feel supported in the school". They commented on the pride staff feel about their relationships with students. "We are keen to communicate with students openly and honestly" [and] "students know the school listens to them – they trust us". An ethos of self-responsibility is encouraged in both staff and students, with the management team modelling this to all members of the school community. They remarked on the importance of having strong leadership, and about the school being a "non-judgemental environment" where staff can reflect on their practices honestly with a view to addressing any issues as part of an ongoing process of improvement. Trust was thought to be important also. Staff commented on the importance of responding to children's learning needs rather than simply delivering the curriculum. A positive approach was taken to managing behaviour, with an emphasis on virtues, values, and overall social development, together with fostering self-regulation of behaviour in students, an approach described as a "solution-oriented focus".

The high priority placed on children's learning needs could be seen in the use of "learning logs" (a book in which comments about a student's learning were recorded) as a means of getting children to think about their learning. The children were helped to write about their "learning intentions" in the learning log, and later to select pieces of work to be pasted into it, showing how well they had met their learning intentions. Staff described the way that the children were encouraged to "talk about their learning and relate it back to their learning intentions".

A deliberate decision had been made at City School to try to reduce the power imbalance in the relationships between teachers and students. City teachers had moved away from holding an authoritarian role over their students, towards building more collaborative relationships in which goals were negotiated with students. The emergence of the learning logs at City seems to have played an important role in this shift towards more democratic relationships with students. According to City staff:

> What the learning logs have sparked for us really is the importance of the teacher-student relationship, and the power that teachers have traditionally held over students, and the ways we've been breaking that down, working on that, anyway. [We] think that's probably why you've had the sort of feedback from our students that you did.

It appeared that City School's involvement in NZNP (in 2003 & 2004) had come at an opportune time. Teachers had already established a climate within the school in which students were expected to converse with their teachers and other students about their learning, and this was happening across the whole curriculum. The idea of discussing one's thinking and reasoning in mathematics was already familiar to City teachers (unlike many other NZNP schools). These kinds of conversations with students were already part of accepted practice in the school across all areas of the school curriculum. City staff spoke about the way that the philosophy behind NZNP fitted very well with what was already happening at City School in curriculum areas apart from mathematics.

> ANP and ENP have had a huge influence, and our staff love it, they just love it… It fits in with the way we work with kids.

Discussion

Analysis of the data has shown that students who participated in NZNP did significantly better in mathematics than would have been expected simply as a result of getting older. Although the average effect size for Addition/Subtraction was "small" (0.19), it was similar to that found in the UK for the National Numeracy Strategy (0.17 or 0.18; see Brown et al, 2003). Effect sizes for Multiplication/Division and Proportion/Ratio were substantially larger (0.40 & 0.43), indicating that NZNP has had a substantial impact on mathematics learning for those operational domains. Analysis of the patterns of progress showed that overall, it was students who started with higher levels of mathematical proficiency (eg, Asian & European students, high SES students, boys, and older students) who also tended to make the greatest progress. This kind of pattern is referred to as the "Matthew Effect" because "the rich get richer and the poor get poorer" (relatively speaking) (see Stanovich, 1986).

However, in 2004, there was evidence to suggest that shifts may be beginning to occur in patterns of progress for some groups of students (eg, students at low SES schools that were involved in another initiative: MEI). This is consistent with interventions by literacy education researchers who have helped teachers "fine-tune" their teaching in order to meet the learning needs of their students more effectively (eg, Phillips et al, 2002; Timperley, Phillips & Wiseman, 2003). As Phillips and colleagues have pointed out, the pattern of low progress is neither inevitable nor unbridgeable" (2002, p. 6).

Although mathematics education reforms have called for mathematics to be a more public activity, with learners communicating openly about their solution strategies (Hiebert et al, 1997; Lampert & Cobb, 2003; Yackel & Cobb, 1996), our interviews with children show that this may be easier said than done. Only about half of the students in our 'perspectives' study thought that explaining their strategies to others was important, and students at NZNP schools were similar to those at non-NP schools in this view. Students at NZNP schools were more likely to see the value in knowing how others solved problems than those from non-NP schools, perhaps because they had experienced the sharing of solution strategies as part of the project. However, a substantial number of NZNP students still believed strongly that mathematical thinking should be private. It is not clear what role SES might have played in the findings of the 'perspectives' study, given that five of the six schools were low SES. The difficulties that low SES students experience with classroom discussion led one researcher to conclude that "discussion-intensive mathematics classrooms might be more aligned with middle-class cultures" (Lubienski, 2001, p. 377). Another possibility is that differences in oral language skills evident at school entry (Gilmore, 1998, Ministry of Education, 2001b) persist through the primary years, making the communication of thinking and reasoning more difficult. Strong communication skills may be an aspect of "cultural capital" taken for granted by medium and high SES students (eg, City School) that fewer low SES students possess (Bourdieu, 1997).

Finding that many students were reluctant to communicate mathematically with their peers, despite encouragement to do so, highlights the difficulties involved in bringing about changes in children's ideas about learning mathematics (Lampert & Cobb, 2003). Much of the literature on professional development stresses that change is difficult without support and guidance (eg, Borko, 2004; Borko, Wolfe, Simone & Uchiyama, 2003; Guskey, 1986, 2002; Tirosh & Graeber, 2003). Each teacher who participated in NZNP was one of approximately 60-90 teachers being supported by a particular facilitator. Teachers came together in clusters for workshops with their facilitator several times over a ten-month period for about 16 hours in total. A small number of in-class visits by the facilitator enabled him/her to model effective practice with the students in a teacher's classroom. Once a school had participated in NZNP, the opportunities to get further support from facilitators were limited, as their focus shifted to a new group of teachers.

The responses of most children in the interviews indicated that they continued to regard mathematics from an individualistic perspective as being a private activity that was of little or no concern to others in their class. This fits with the "acquisitionist" metaphor identified by Sfard (1998, 2003), which sees learning as the process of acquiring mathematical knowledge (Lampert & Cobb, 2003). Sfard distinguishes the acquisitionist approach from the "participationist" approach, which views learning as a process of coming to participate in a community of mathematical practice. Communication is an important aspect of participation in the activities of a mathematical community like a classroom (Lampert & Cobb, 2003). However, learning to communicate effectively depends on the presence of supportive participants who can scaffold and extend the learners' language as they grapple with more challenging ideas.

Although there is much rhetoric about the value of communication in mathematics (eg, Ministry of Education, 1992; NCTM, 2000), the findings reported here indicate that students are far from comfortable about communicating with peers about their thinking, let alone appreciating the benefits of communication for their own learning. Even though there may be debate about the role of communication in mathematics learning, "communication skills cannot be taken for granted… [and] if conversation is to be effective and conducive to learning, the art of communicating has to be taught" (Sfard et al, 1998, p. 51).

Sharing power with students and encouraging them to become active participants in determining their learning goals seemed to have been important for students at City School. These findings are consistent with Dadd's (2001) assertion that "serious involvement of pupils in their pedagogical experiences seems essential to quality provision" (p. 53). In another analysis, we have looked at how children perceived the role of their teachers, and identified four possible roles that teachers are seen to adopt: mentor, classroom manager, transmitter (of information), and arbiter (Taylor, Hawera & Young-Loveridge, submitted). We found that only those students who saw their teacher in the role of mentor seemed to take an active role in their own learning. Children who perceived their teacher in one of the other three roles tended to adopt a passive stance towards their teacher and their mathematics learning. More City students saw their teacher in the role of mentor than did students in the five other schools. We believe that students should be encouraged by their teachers to collaborate in setting goals for their learning in mathematics.

What is clear from this account is that bringing about change in how schools teach mathematics is a hugely complex and challenging issue. Consideration needs to be given, not just to what happens in the classroom during a mathematics session, but also to the wider perspective of the school as a whole, including the overall climate and practices of the school (Barth, 2002; Hiebert et al, 1997). Research on school capacity has highlighted the importance of instructional leadership, the provision of learning opportunities for teachers, and membership of a professional community, as key factors in the success of reform efforts (Borko et al, 2003). City teachers talked about the importance of all three of these factors in contributing to the special climate and culture of their school. It is possible that the success of the MEI initiative for certain low SES schools can be attributed to these factors.

Conclusions

What can be concluded about the findings presented here? Although the NZNP initiative has been successful in terms of enhancing mathematics learning, its impact on other outcomes, such as attitudes and dispositions towards learning mathematics, seems to have been more modest. More work is needed to understand why NZNP has been more effective in certain schools (eg, City and those in the MEI initiative). City School provides a powerful example of just what can be achieved in a school when the conditions are favourable and teachers are committed to changing their practices to improve students' learning. The verbatim quotes from individual children provide valuable insights into the children's unique perspectives on their mathematics learning, and underline the importance of taking children's views into account (Civil & Planas, 2004; Cook-Sather, 2002; Young-Loveridge & Taylor, in press).

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