Two Decades of Mathematics Education Reform in New Zealand: What Impact on the Attitudes of Teacher Education Students?

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This paper explores the impact of almost two decades of mathematics education reform in New Zealand on the attitudes of pre-service teacher education students training to be primary teachers. More students were positive towards mathematics and fewer were negative compared to Biddulph (1999). In the present study, more students were positive about the prospect about teaching mathematics than about mathematics. Only 47% of the students were positive about both mathematics and the teaching of mathematics. However, students' reasons for their ratings revealed that a negative attitude towards mathematics sometimes resulted in enthusiasm about helping children to have better experiences than they themselves had had at school. Some students with positive attitudes towards mathematics worried about the responsibility of providing high quality teaching experiences in mathematics for children. The study showed that this issue is complex and attitudes towards teaching mathematics may be different from attitudes towards mathematics.

Mathematics education reform in New Zealand began with the introduction of a new mathematics curriculum document in the early nineties (Ministry of Education, 1992; Young-Loveridge & Peters, 2005). Continuity and progression in mathematics learning were emphasised and learning goals specified via stated achievement objectives. There was a strong focus on diagnostic and formative assessment as part of the teaching and learning process. Also stressed was "the need for mathematics to be taught and learned within the context of problems which are meaningful to students and which lead to understanding of the way mathematics is applied in the world beyond school" (Ministry of Education, 1992, p. 5). To support the emphasis on problem solving, a *mathematical processes* strand was included alongside those of number, measurement, geometry, algebra, and statistics. Mathematical processes skills included problem solving, reasoning, and communicating mathematical ideas. Mathematics education was seen as contributing to the development of a broad range of skills, including numeracy skills, problem-solving and decision-making skills, communication skills, social and co-operative skills, and information skills.

The new millennium saw the introduction of the government's Literacy and Numeracy Strategy (Ministry of Education, 2001), aimed at raising expectations for progress and achievement, building the professional capability of teachers, and strengthening links with families and communities. A definition of what it means to be numerate was "to have the ability and inclination to use mathematics effectively in our lives - at home, at work and in the community" – reflecting a strong link between mathematics and numeracy (Ministry of Education, 2001). The Numeracy Development Projects (NDP), has been a major initiative in mathematics education, beginning in 2001 and involving professional development with teachers at the primary (Years 1-6), intermediate (Years 7-8), and early secondary (Years 9-10) levels teaching in the medium of English, as well as those providing instruction in te reo Maori (Bobis, Clarke, Clarke, Thomas, Wright, Young-Loveridge et al., 2005; Christensen, 2003; Trinick, 2009; Young-Loveridge, 2008).

Just over two years ago, a revised curriculum was published (Ministry of Education, 2007). It took as its starting point, a vision of students as "lifelong learners who are

L. Sparrow, B. Kissane, & C. Hurst (Eds.), *Shaping the future of mathematics education: Proceedings of the 33rd annual conference of the Mathematics Education Research Group of Australasia.* Fremantle: MERGA.

confident and creative, connected, and actively involved" (p. 4). Included are statements about the principles on which curriculum decision-making is to be based, values to be encouraged, modelled and explored, and key competencies considered to be critical in sustaining learning and effective participation in society. Recently the *Mathematics Standards for Years 1-8* were published for implementation in schools this year (Ministry of Education, 2009). There are likely to be far-reaching effects from these most recent developments, but it is too soon to tell.

Researchers have had a longstanding interest in the affective domain in mathematics, including beliefs, values, attitudes, and emotions (Leder & Grootenboer, 2005; Grootenboer, Lomas, & Ingram, 2008). According to Burns (1998), negative attitudes towards mathematics in the US have limited the numbers of people who can "think, reason, and solve problems" and this so-called "phobia" can have adverse consequences on people's life choices and career options. A decade later, Boaler (2008) picked up a similar theme in her recent book, arguing that the future of the American economy rests on the quality of the mathematics teaching students receive in schools.

In 1999, Biddulph reported that a significant proportion (more than half) of primary teacher education students in New Zealand had deeply negative feelings and attitudes towards mathematics and lacked understanding of relatively simple mathematics. The relationship between mathematics anxiety and mathematics understanding in pre-service teachers was investigated more recently by Canadian researchers Rayner, Pitsolantis, and Osana (2009), who found a negative correlation between mathematics anxiety scores and measures of conceptual ($r = -0.49$) and procedural (-0.48) knowledge of fractions.

With so much effort put into reforming mathematics education over the past couple of decades, an obvious question arises about the impact of this effort on students' attitudes and feelings about mathematics. With at least a generation of children having gone through the compulsory school system and entered tertiary education, the fruits of mathematics education reform should by now be evident in both mathematics achievement and attitudes towards mathematics. This study set out to investigate the extent to which this is the case.

Method

Participants

The participants in this study were 125 students nearing the end of their three-year Bachelor of Teaching degree for primary teaching. Only students who had consented to data on their attitudes and solution strategies for mathematics tasks were included in this study. The participants constituted 73 percent of the potential sample of 170 students who were invited to participate (Note: 27 students did not hand in a consent form, 15 consented only to their attitude responses being included, and 3 consented only to the inclusion of their responses on mathematics tasks). Only students who gave consent for both parts have been included in the analysis presented here.

Procedure

As part of a course on assessment, students were given a written mathematics test consisting of a range of question types, including written explanations about solution strategies, drawing diagrams to show solution processes, and multiple-choice items. The test was accompanied by three attitude questions using a five-point Likert scale. These included: attitude towards mathematics/numeracy, attitude towards teaching

mathematics/numeracy, and preparedness to teach mathematics/numeracy (see Appendix). After marking their response on the Likert scale, students were asked to give reasons for each rating. Responses at either end of the scale were aggregated to create a cluster of positive and negative responses for each of the questions, with the neutral category used for those who chose the mid-point on the scale. Students were also given a consent form to sign, if they were happy for their responses being used as part of a research project. Students were assured that the test did not count towards their grades.

Results

Attitude Ratings

Table 1 presents the numbers and percentages of students whose responses fell in each of the categories on the three attitude questions. It is interesting to note in Table 1 that more students were positive about teaching mathematics than were positive about mathematics themselves. Analysis was done of students' responses as a function of both attitude towards mathematics and attitude towards teaching mathematics (see Table 2). While the largest category of students (56 out of 120) were positive towards their own mathematics as well as teaching mathematics, a number of students gave responses which differed on these questions. Of the students who were neutral (n=20) or negative (n=20) about the prospect of teaching mathematics, they were relatively equally distributed across the three categories of liking mathematics personally. Of the students who were positive about the prospect of teaching mathematics (n=80), more than two thirds (70%) were positive about their own personal mathematics. However, one quarter of them were neutral about their own mathematics, and 5 percent claimed to dislike mathematics themselves.

Table 1: Numbers and percentages of students whose responses fell in each of the categories on the three attitude questions. (Note: Percentages are rounded to whole numbers)

Question	N	%
Attitude towards Maths		
Positive	69	57
Neutral	33	27
Negative	20	16
Total students	*122*	*100*
Attitude towards Teaching Maths		
Positive	80	67
Neutral	20	17
Negative	20	17
Total students	*120*	*100*
Preparedness to Teach Maths		
Positive	58	48
Neutral	48	40
Negative	14	12
Total students	*120*	*100*

Not all of the students who liked mathematics felt positive about the prospect of teaching mathematics. Approximately 18 percent of students who were positive about their

own mathematics were either neutral or negative about teaching mathematics. Of the 32 students who were neutral towards mathematics themselves (n=32), 63 percent were positive about teaching mathematics. Twenty students were negative towards mathematics themselves, but 20 percent of these were positive about teaching mathematics, with the remainder equally divided between neutral and negative responses about the prospect of teaching mathematics.

Table 2: Numbers and percentages of students' responses as a function of attitude towards mathematics and attitude towards teaching mathematics

	Attitude towards Teaching Maths			
Attitude towards Maths	Positive	Neutral	Negative	Total
Positive	56 70%	5 25%	7 35%	68 57%
Neutral	20 25%	7 35%	5 25%	32 27%
Negative	4 5%	8 40%	8 40%	20 17%
Total students	*80 100%*	*20 100%*	*20 100%*	*120 100%*

Reasons for Attitude Ratings

The responses of students who showed a mixed pattern of ratings and those who were not positive towards either mathematics or teaching mathematics were subjected to a content analysis to identify common themes.

Positive towards mathematics but not positive towards teaching mathematics

Students in this category tended to have been reasonably successful at mathematics when they were at school, but felt overwhelmed by the responsibility of teaching mathematics to children. For example:

> [I like maths] because I was quite good at it at school. I'm just nervous that I'm worried about not moving the kids along far enough. Additionally I am worried about how to extend the lower end (S80).
>
> [I like maths because] I enjoy being challenged. [I'm apprehensive about teaching maths because I] feel I need more knowledge about maths (S152).
>
> [I love maths], however [I] feel completely unprepared to teach numeracy with any great confidence. [I'm apprehensive about teaching maths because] very little covered in [the program] so far. A new concept which is tricky to grasp all strategies and concepts without instruction (S27).
>
> [I love maths.] I can't explain it. I love thinking, working through problems. [I'm apprehensive about teaching maths because] I feel I have not had enough training in this area (S50).

Not positive towards mathematics but positive towards teaching mathematics

Students in this category tended to identify with the needs of their students and wanted to prevent the negative attitude towards mathematics that they had developed. For example:

> [I hate maths because] I hate being put on the spot and expected to perform well without any kind of warning. [I'm positive about teaching maths because] I want to help my future class enjoy maths and not be scared of it like I have been. Maths can be enjoyable and should not be about scary test situations. Children should not have that pressure (S55).
>
> [I dislike maths because of] bad high school experiences and all around not a mathematically sound person. Know I can do [teaching maths] because have done. If I can learn the maths I can teach it (S102).
>
> [Dislike maths] because it is hard. [I'm positive about teaching maths] because students need to learn it (S168).

[Dislike maths because of] experiences at school. [I'm positive about teaching maths because] I want to make maths a more enjoyable experience for students today compared to what I had (S89).

I was not good at maths at school, but as I am learning how to teach maths I am beginning to understand it and enjoy it. I feel I will learn to "love" it as I continue. The way maths are taught in schools today compared to when I did it at school is far better – more enjoyable. [I feel very positive about teaching maths because] I can see how this way is setting the students up for success in maths (S15).

Some strategies are confusing and I find numbers daunting [but I feel very positive about teaching maths because] I love seeing the way the children learn and use their own understandings and learning (S143)

Not positive towards mathematics or teaching mathematics

Students in this category gave a range of reasons for their negative ratings. Some students commented that their apprehensiveness was limited to teaching the upper primary years only. Others appeared to empathise with their students in not wanting to be taught by a teacher without a strong understanding of mathematics.

[I don't maths. It] was always my weakest subject at school, and [I] was punished for it. [I am apprehensive about teaching maths because I] don't want students to feel how I felt about maths (S149).

[I don't like maths] On the whole I feel I could cope with basic maths but feel completely confused with terminology regarding where children are re stages and how to assess that. [I am very apprehensive about teaching maths because] I do not understand what Part/whole, Advanced Proportional Part-whole etc means and do not feel the maths taught in [program] covered this for me (S33).

[I hate maths because I have] no confidence. Didn't like maths at school. Teacher was very strict and mean. [I'm apprehensive about teaching maths] because I haven't got enough experience yet to teach it confidently (S12).

[I dislike maths because] I have always found maths difficult as I have begun to gain strategies that I wished I had been taught years ago. I still however need to draw most things and can not do it in my head. [I'm very apprehensive about teaching maths] This is due to my own understandings more for the older aged students. I am happy to teach years up to 5 confidently (S20).

[I dislike maths because I'm] extremely confused surrounding mathematics. [I] lack understanding in strategies and numbers themselves. [I'm] keen to learn more but must always do mathematics lessons myself first in order to explain more clearly to others. [I'm apprehensive about teaching maths and] wary of how my understanding may affect others; ie, basic knowledge. [I'm] unclear of various wording in different strategy types (S169].

Performance on Selected Tasks

Because the time to complete the mathematics tasks and attitude ratings was limited, not all students had time to finish all parts. Hence, only students who attempted a particular task are included in the analysis for each task. It is difficult to know whether missing data was the result of insufficient time or inability to complete the task, and it is possible that the results may be distorted in the positive direction as a consequence. A summary of responses to selected fractional number tasks is included below.

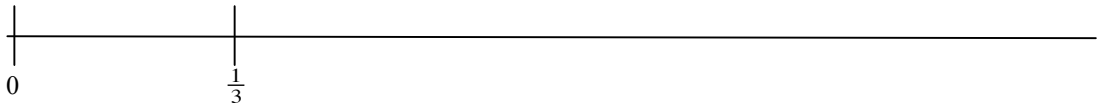
Q3. Almost two thirds (62%) of the 108 students who attempted Question 3 were successful on the task shown below. Acceptable answers included ½ or 9/18. A common misconception was to simply add the numerators and denominators.

Complete the following equation:

$\frac{7}{18} + \frac{1}{9} = \frac{\square}{\square}$

Q4. Ninety percent (113 out of 125) of the students were successful on the task below.

This number line shows where the **number** $\frac{1}{3}$ is.
Put a cross (x) where you think the **number 1** would be on the number line.



Q8. Just over half (58%) of the 108 students who responded to the ordering fractions task below were able to place them correctly in sequence. The improper fractions presented a particular challenge to some students, who confused the magnitude of eighths and tenths.

Place these fractions in order from **smallest** to **largest**.

$\frac{1}{2}$ $\frac{1}{4}$ $\frac{7}{8}$ $\frac{12}{10}$ $\frac{3}{5}$ $\frac{10}{8}$ $\frac{1}{10}$ $\frac{3}{4}$

Q14. One third (33%) of the 99 students who responded to the following question were correct. Many students appeared to confuse their knowledge of whole number processes such as "multiplication makes bigger" and "division makes smaller" with that for decimals.

Which is the largest number?

A. 29 + 0.8 B. 29 x 0.8 C. 29 ÷ 0.8 D. 29 – 0.8

Q17. Three-quarters (74%) of the 90 students who responded to a question below about the equivalence of multiplication by 0.5 to division by 2 were correct.

0.5 x 840 is the same as:

A. 840 ÷ 2 B. 5 x 840 C. 5 x 8400 D. 840 ÷ 5 E. 0.50 x 84

Q19. Just over half (57%) of the 86 students who responded to a question about equivalent ratios were correct.

If 6 packets of chips cost the same amount as 4 ice creams, how many packets of chips would cost the same as 10 ice creams?

A. 8 B. 12 C. 14 D. 15 E. 16

Discussion

The results from this study indicate that students were more positive towards mathematics in the recent past than they were when Biddulph (1999) conducted his study. More than half (57%) of the students were positive about mathematics, and only 16 percent were negative, compared with 22% to 28% positive and 54% to 64% negative in Biddulph's study. When asked about their attitude towards the prospect of teaching mathematics, slightly more students (67%) were positive and only 17% were negative. It is difficult to know just how much the improvement in attitudes towards mathematics is related to mathematics education reforms.

Although there appears to have been an improvement in pre-service teachers' attitudes towards mathematics over the past decade, the content of some students' comments is of considerable concern. Unlike some institutions, students are not required to meet a standard of mathematics knowledge and understanding before being allowed to graduate. Students are encouraged to choose from several option papers, rather than being guided into papers that might strengthen areas in which they are not as strong.

The numbers of students who were unable to successfully complete particular fractional number tasks presented to them was disappointing. Some students claimed that they were severely disadvantaged by not being given prior warning about the written assessment tasks. However, if students had been warned, some not have attended the class. Moreover, advanced warning of the test may have caused more distress to certain students with a tendency to worry about their performance in the period leading up to the test, even though it did not contribute to final grades.

An important question that needs to be asked is about the extent to which the consent process required for ethical approval of the study distorted the pattern of findings. It is clear that the responses of those students who did not consent to being included in the research (~30 out of 45) did tend to be more negative or neutral than those who of students who gave consent. It is unfortunate that some of those students for whom support may be most needed did not cooperate with efforts to gain a better understanding of their situation. It is also possible that students' performance on the mathematics tasks was effectively inflated by including only those responses where a task had been attempted. Consequently, care needs to taken in interpreting these findings.

The findings show the complex nature of pre-service students' attitudes towards mathematics and the prospect of teaching mathematics, and the importance of making a distinction between these.

Acknowledgements

Thanks are extended to the New Zealand Ministry of Education and the University of Waikato School of Education Research Committee for funding parts of this research.

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Appendix

Questions used to assess students' attitudes towards mathematics/numeracy

Attitude towards Mathematics/Numeracy

Circle the number corresponding to how much you enjoy maths. Explain why you feel this way in the space below.

1	2	3	4	5
love maths	like maths	neutral OK	dislike maths	hate maths

Attitude towards Teaching Mathematics/Numeracy

Circle the number corresponding to how much you are looking forward to teaching maths/numeracy in the future. Explain why you feel this way in the space below.

1	2	3	4	5
very positive re teaching maths	positive re teaching maths	neutral OK	apprehensive re teaching maths	very apprehensive re teaching maths

Preparedness to Teach Mathematics/Numeracy

How well prepared do you think you are to teach mathematics/numeracy next year? Comments?

1	2	3	4	5
very well prepared to teach maths	well prepared to teach maths	neutral OK	unprepared to teach maths	very unprepared to teach maths