Students' Perspectives on the Nature of Mathematics

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This paper reports on one small component of a much larger study that explored the perspectives of students towards mathematics learning. Students were asked, "What do you think maths is all about?" Some students responded in terms of mathematical content. Others commented on learning in general or on problem solving in particular. Some students talked about the usefulness of mathematics for everyday life. An overwhelming number of students answered the question by talking about the importance of mathematics for the future, particularly for getting a job. An analysis of students' responses by whether or not they had participated in the Numeracy Development Project showed few differences between the groups.

The nature of mathematics has been the focus of much writing over the last few decades (for example, Begg, 1994, 2005; Dossey, 1992; Fuson, Kalchman, & Bransford, 2005; Ocean, 2005; Presmeg, 2002; Winter, 2001). Dossey (1992) argues that different conceptions of mathematics influence the ways in which society views mathematics. This can influence the teaching of mathematics and communicate subtle messages to children about the nature of mathematics that "affect the way they grow to view mathematics and its role in their world" (p. 42). Similarly, Presmeg (2002) has argued that beliefs about the nature of mathematics either enable or constrain "the bridging process between everyday practices and school mathematics" (p. 295).

Different dichotomies have been used to highlight the contrasting ways in which mathematics is viewed. For example, Dossey (1992) has distinguished between external conceptions of mathematics, held by those who believe that mathematics is a fixed body of knowledge that is presented to students, and internal conceptions that view mathematics as personally constructed, internal knowledge. Begg (1994, 2005) has contrasted mathematical content (knowledge and procedures) with mathematical processes (reasoning, problem solving, communicating, and making connections). Winter (2001) has written about a tension between a mechanistic view of mathematics (as in the development of skills and knowledge) and mathematics as a means towards fostering citizenship and responsibility within society (as in the development of personal, spiritual, moral, social, and cultural dimensions).

A distinction has been made between mathematical activity carried out for its own sake and mathematical activity that is useful for something else (Huckstep, 2000). In order to distinguish between the aims and purposes of mathematics education, Huckstep asks: "What are we trying to do *in* mathematics education?" and "What are we trying to do it *for*?" (p. 8). This particular dichotomy is closely related to the debate about what is mathematics and what is numeracy (Hogan, 2002; Stoessiger, 2002). Definitions of numeracy emphasise the practical or everyday uses of mathematics in contexts such as homes, workplaces, and communities (Stoessiger, 2002). Writers who argue that mathematics is valuable for its own sake often note the beauty and aesthetics of mathematics and the sheer enjoyment of doing it (for example, Holton, 1993; Winter, 2001).

The current mathematics curriculum document for schools in New Zealand also considers the nature of mathematics:

> Mathematics makes use of specific language and skills to model, analyse, and interpret the world ... [It] involves creativity and imagination in the discovery of patterns of shape and number, the perceiving of relationships, the making of models, the interpretation of data, and the communication of emerging ideas and concepts. (Ministry of Education, 1992, p. 7).

The "new" curriculum that will soon replace this 1992 document has a greater emphasis on thinking and defines mathematics as:

> the exploration and use of patterns and relationships in quantities, space, and time ... [a way] of thinking and solving problems ... [that] equips students with effective means for investigating, interpreting, explaining, and making sense of the world in which they live.
>
> Mathematics ... [enables] students [to] develop the ability to think creatively, critically, strategically, and logically. They learn to structure and to organise, to carry out procedures flexibly and accurately, to process and communicate information, and to be positive about intellectual challenge (Ministry of Education, Draft as at June, 2006).

Book 1 from the Numeracy Development Project (NDP) states:

> The Number Framework has been established to help teachers, parents, and students to understand the requirements of the Number strand from *Mathematics from the New Zealand Curriculum.* (Ministry of Education, 2005a, p. 1)

According to NDP Book 3 (inside front cover),

> in the first four years of schooling, the main emphasis should be on the number strand; [but] in the middle and upper primary years of schooling, the emphasis is spread across the strands of the curriculum. (Ministry of Education, 2005b)

This means that mathematical processes, including problem solving, developing logic and reasoning, and communicating mathematical ideas, should be an important part of classroom mathematics programmes from about year 5 onwards.

In recent years, writers have drawn attention to the importance of talking with and listening to students in order to appreciate their unique perspectives (for example, Fielding, Fuller, & Loose, 1999; Rudduck & Flutter, 2000; Young-Loveridge, 2005; Young-Loveridge & Taylor, 2005; Young-Loveridge, Taylor, & Hāwera, 2005). Although children spend a lot of time doing mathematics, we know little about how they view the mathematics they do. A few studies have explored this issue, but most were with students at about the year 5–6 level (Grootenboer, 2003; Howard & Perry, 2005; Masingila, 2002). Howard and Perry held conversational interviews with Aboriginal children living in a remote rural community in New South Wales to explore their beliefs about learning mathematics. Most examples of the children's responses seemed to reflect an external conception of mathematics, with the children positioning themselves as passive recipients of the teacher's wisdom and superior knowledge. According to Howard and Perry, these children did not seem to be aware of their own mathematical competencies, strategies, and problem-solving abilities in mathematics. Instead, they emphasised the importance of watching and listening to the teacher. Grootenboer investigated the views and feelings of New Zealand children on the nature and purpose of mathematics and how they saw themselves as learners of mathematics. The children's responses indicated a rather narrow conception of mathematics, limited mostly to number concepts and arithmetic.

Research on the perspectives of year 5 and 6 students who participated in the NDP has shown that they were fairly similar to those who had not yet participated in the initiative in their ideas about the value of communicating mathematically with others (Young-Loveridge, Taylor, & Hāwera, 2005). There was a somewhat greater difference between the two groups in recognising the value of knowing how others solve mathematical problems, with NDP students valuing this more highly than those who had not yet participated in the initiative. Subsequently, the study was broadened to include students in years 2–4 and years 7–8, as well as those in years 5–6. The present paper reports on the students' views of what mathematics is.

Method

Participants

The participants in this study were 459 students from years 2–8 (six- to 13-year-olds) attending six primary schools and six intermediate schools in two major urban centres. Half of the schools (three primary and three intermediate) had already been involved in the NDP, and half had not yet been involved. The year 2–4 group were from one of the NDP schools whose year 5–6 students had been interviewed the previous year. The selected schools included substantial numbers of Māori and Pasifika students. This was done so that a better understanding of Māori and Pasifika perspectives could be taken into account in efforts to raise mathematics achievement and narrow the achievement gap.

Table 1
Composition of the Sample as a Function of Ethnicity and Year Group

Ethnicity	Years 2–4	Years 5–6	Years 7–8
European	43.2%	29.0%	23.8%
Māori	35.1%	55.2%	35.1%
Pasifika	8.1%	8.2%	38.1%
Asian	13.5%	6.0%	2.9%
Number of students	37	183	239

Procedure

Schools were asked to nominate students from across a range of mathematics levels. The students were interviewed individually in a quiet place away from the classroom. Students were told initially that the interviewer was 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". The interviews were audio-taped and later transcribed. A content analysis of the tape transcripts was completed to identify common themes and ideas. Coding categories were then constructed for use with each transcript.

This paper focuses on students' responses to the question "What do you think maths is all about?" If students didn't respond to this question, they were then asked "If you were going to tell someone about what maths is, what would you say to them?" If that yielded no response, students were then asked to imagine: "What if a spaceship landed on the field, and the people came into your school and wanted to know what is this thing called maths that you kids do, what would you tell them?"

Findings

Students responded to the question about the nature of maths in a number of ways. A notable group of students were unable to give any response at all. Those who did respond seemed to interpret the question in a variety of different ways. Some students appeared to interpret the question in terms of their immediate mathematics learning in the classroom, commenting on aspects of mathematical content or highlighting general learning and thinking processes. Other students interpreted the question in terms of the purpose of mathematics for them in the "here and now" and went on to mention ways that mathematics was useful. Another group interpreted the question with respect to the purpose of mathematics but also considered this in relation to their long-term futures. These students talked about the mathematics they thought was expected at more senior levels of the schooling system, "getting an education", and getting a job. One group of students, who seemed to have really thought about the nature of mathematics, commented on the intrinsic value of learning mathematics, such as for solving problems. They talked about challenges such as "figuring things out". A few students commented on the essence of mathematics as being about "having fun".

Once the coding categories had been determined, a systematic analysis was made of all 459 transcripts, noting which categories were referred to by the students. Cross-tabulation using SPSS (Statistical Package for the Social Sciences) allowed an examination of the frequencies for each category as a function of numeracy project involvement (NDP versus non-NDP). This quantitative analysis is presented here. In the section following, selected excerpts from the transcripts are presented to illustrate each of the coding categories. These excerpts allow the students' voices to be heard and help to bring the quantitative analysis to life.

Quantitative Analysis

Table 2 shows the percentages of students in each aspect of mathematics as a function of year group and involvement in the numeracy project (NDP vs non-NDP). It should be noted that the responses of students were coded in more than one coding category if they referred to more than one aspect of mathematics. Hence, the totals add up to more than 100%.

Table 2
Percentages of Students Who Mentioned Each Category as a Function of Year Group (years 2–4, 5–6, 7–8) and Project Status (NDP vs Non-NDP)

Aspect mentioned	Years 2–4 NDP	Years 5–6 NDP	Years 5–6 non-NDP	Years 7–8 NDP	Years 7–8 non-NDP
Mathematical content	48%	48%	44%	52%	49%
Learning	59%	35%	55%	16%	18%
Thinking	9%	3%	5%	3%	4%
Problem solving	0%	8%	5%	10%	16%
Utility – here and now	3%	12%	6%	4%	3%
Utility – in the future	9%	27%	44%	23%	16%
Enjoyment	6%	9%	3%	1%	3%
Non-responders	12%	19%	5%	17%	12%
Number of students	37	121	62	123	116

Mathematical content was mentioned consistently by students in all year groups. Although there was no breakdown of this overall category, it was noted that the majority of students mentioned number in their responses. Frequent reference to the learning process was made by the younger students (35% to 59% for students in years 2–6), but much less often by the older students (16% to 18% by year 7–8 students). Fewer students mentioned the usefulness of mathematics to them "here and now" than referred to the usefulness of mathematics for their futures. Future uses included later schooling, "getting a good education", and getting a job. Interest in the future was less of an issue for the youngest students (9% of year 2–4 students mentioned it), but by year 5–6, it was much more frequently mentioned (27% and 44% for NDP and non-NDP respectively). Enjoyment of mathematics was mentioned mainly by the youngest students (6% for year 2–4 students) and by year 5–6 students who had participated in NDP (9%). It was interesting to note that only 1% to 3% of the older students (years 7–8) spontaneously referred to enjoying mathematics.

Mathematical Content

One group of students referred to particular aspects of mathematical content in their explanations of what mathematics is about. Many spoke about aspects of number and/or operations. A few mentioned geometry and statistics:

> Maths is not just about numbers; maths is something that you can make really fun, especially with geometry and symmetry, because you can draw shapes and draw characters that you like. (Year 5–6)
>
> I would say maths ... has a lot of different strands like geometry and stuff, where you work with shapes and there's hard sums and easy sums and short cuts and such things. (Year 7–8)

One younger student mentioned patterns and explained how various operations and domains are interconnected:

> Patterns ... because plus is minus and plus is times and times is division and division is fractions and fractions is decimals and decimals is percentages and it goes on and on. (Year 2–4)

Some students' responses reflected the difficulty they experienced in trying to say what mathematics is:

> I know you use maths for everything in normal day life, but I'm not sure what it's about ... I'd just say it's about numbers and working numbers together and taking them away to work out stuff. (Year 7–8)
>
> Maths is like, you write down, you've got all these numbers and you've got all these maths symbols, so you've got numbers from 1 to 10. You have to try and squash them together, so like, for example, 1 plus 9 equals 10. (Year 2–4)
>
> Just memorising numbers, learning how to divide, subtract and stuff, 'cause if we didn't have the numbers then it would be totally different, you wouldn't be able to count things so you wouldn't be able to know how much you'd need for stuff, you'd put the wrong amount, there wouldn't be an amount. (Year 5–6)

Processes

A substantial group of students spoke about processes. These were further subdivided according to whether the focus was on general cognitive processes, such as learning and thinking, or on mathematical processes, such as problem solving specifically.

Learning

Some students commented that the nature of mathematics was about learning. These responses tended to be extremely brief and did not explain how mathematics was akin to learning. Instead, they tended to focus on a justification for being involved with mathematics. The following are just a few examples of responses that referred to learning:

> Just learning, for when you get older. (Year 7–8)
>
> Learning and education and finance, stuff like that. (Year 2–4)
>
> Learning and helping you get brainier. (Year 2–4)

Thinking

Quite a number of students commented that mathematics was about thinking or using their brain:

> Well, it's kind of like a challenge for your brain and stuff. (Year 2–4)
>
> It's about learning, helps kids think. (Year 2–4)
>
> Using your brain and thinking. (Year 2–4)

Problem solving

A small group of students said that mathematics was about problem solving but gave little or no explanation for their views:

> I think maths is about problem solving. (Year 7–8)
>
> It helps you so you can get smarter and when you're in a problem or something. (Year 5–6)
>
> Like, if you had to build a house or something and you have to find out the area and how much more you have to put in to make it bigger. (Year 5–6)

Effort and persistence was mentioned by one student, who responded that mathematics is about:

> trying your best on your work, like don't give up on your work and just do scribble, and just give it a try if it's too hard. (Year 2–4)

The Utility of Mathematics

Quite a large number of students talked about the usefulness of mathematics. This group was further subdivided into those that considered mathematics in terms of its immediate utility (in the "here and now") and those who were more concerned about their long-term futures.

Everyday life here and now

Some students focused on the usefulness of mathematics for their everyday lives, and many of these referred to needing maths to be able to work with money:

> Maths is, like, something you use every day. You need to learn it because it can help you in life, 'cause you use it like every day when you're doing stuff. Like money and stuff, you calculate your money. (Year 7–8)
>
> Trying to learn them for when you're older, for when hard questions come and stuff. Like paying bills and stuff, or loans and stuff. (Year 7–8)
>
> If you need some money out of your wallet, you might be able to use maths and equations, or if you work at a bank or at a dairy, maths would help you out – how much change you get. (Year 2–4)
>
> So when you grow up, instead of, when you go shopping, you know it straight away instead of going like that and using your fingers. (Year 5–6)

Life in the future

Quite a number of students chose to respond to the question about the nature of mathematics by talking about how worthwhile it was for the future. Some students' comments about the future were in relation to higher levels in the school system:

> I think maths is teaching me more so I can move on to the senior school and I can be ready to learn even harder maths questions. (Year 2–4)

> Learning and teaching about maths, like if you go to senior schools, they tell you about maths, and at senior schools, it's more harder and it's better. (Year 2–4)

Students in all age groups commented on the importance of maths for the future in terms of getting a job. Below are the responses of two year 3 and 4 students:

> Learning your maths so you get better when you are older for your job because you need maths. (Year 2–4)

> I think it is about learning new ... like if you want to teach other kids when you are an adult, when you want to be a teacher, you have to learn from your last teacher that taught you. (Year 2–4)

Year 5 and 6 children gave slightly more sophisticated explanations, including comments about handling money:

> Learning so you can handle with money so then you can grow up and get a job – you'll have to know how to sort out money. There's this kid called Mac in my class – he says that maths is stupid and he doesn't need maths to be a mechanic and stuff ... I say that you need maths for every job when you grow up because it has maths. You need maths to sort out the money. (Year 5–6)

One articulate year 6 student gave a response that showed considerable reflection on the importance of mathematics to him personally:

> Well for me ... the main thing in school for me because most jobs you go to, basically every job involves a bit of maths, quite a lot of maths actually, and so by learning maths, sometimes I don't enjoy it, but I know that's like a good thing to learn and so it's sort of like a goal setter for life. If you know it, it just helps you to become more independent in a way 'cause you're not relying on the teacher a lot ... If you don't do maths, you won't really get a good job, so ... it's sort of a thing that sets you up for life really. (Year 5–6)

Not surprisingly, year 7 and 8 students expressed the most sophisticated ideas, commenting on their future roles as adults, jobs, getting on in life, and other activities reflecting independence and autonomy:

> Future jobs, you need to use it a lot. You can't just go through school without maths, you need to know how it works to see, like statistics with graphs and stuff, you need to be able to read them and understand them to see other things. (Year 7–8)

> Figuring out and adding for lifestyle for when you're an adult ... If you're a person at the shop, giving the person back their change, figure out how much they get back. (Year 7–8)

> Maths is in every average day in everything you do, and I think maths is just helping you for the long run. And when you'll need to use it, and it's also a good general knowledge thing, just to know what to do, 'cause it's everywhere, maths. (Year 7–8)

Enjoyment

A small but notable group of students considered the nature of mathematics to be about having fun:

> Having fun and trying to get your numbers and answers right, and just try and learn quicker and easier. (Year 2–4)

> It's actually quite fun. (Year 7–8)

Non-responders

A considerable number of students (between 5% and 19%) appeared to have no view at all about the nature of mathematics. These students said things such as:

> I've never thought about it. (Year 7–8)
>
> I have no idea. (Year 7–8)
>
> I'm not completely sure. (Year 7–8)

Discussion

It was evident from the responses analysed that it was difficult for some students to talk about the nature of mathematics. These findings suggest that many students do mathematics without much thought or opportunity to discuss what it actually might be.

Many students who offered ideas about the nature of mathematics referred to aspects of the number domain. This is consistent with Grootenboer's (2003) finding that children's views of mathematics tended to revolve around number concepts and arithmetic. Like Fuson et al. (2005), we found that many of these students' responses reflected the view that mathematics is about computation. This is not altogether surprising, given that the NDP emphasises number and mental computation, particularly in the early years of school.

We were interested that a large number of students chose to comment on the usefulness of maths. We found, like Masingila (2002), that these students' perceptions of what mathematics is were linked to how they thought they used it. We were intrigued to find that many students talked about the usefulness of maths for their futures. This is consistent with much of the rhetoric about the importance of mathematics for the "knowledge society" (see Commonwealth of Australia, 2000; Ministry of Education, 2001; National Council of Teachers of Mathematics, 2000).

Despite the 1992 curriculum document devoting a strand of the mathematics curriculum to mathematical processes such as problem solving, developing logic and reasoning, and communicating mathematical ideas, we noted that few students talked about the nature of mathematics in this way, although some students spoke about general cognitive processes such as learning and thinking. This may reflect the relatively narrow views of mathematics held by many people, which in turn may impact on children's views. It was interesting to note that NDP students did not differ markedly in this respect from those who had not yet participated in the initiative. Perhaps this reflects the strong focus on the number strand that is a key aspect of the NDP. It might be valuable to remind teachers that mathematical processes become increasingly important once students get through the first four years of school.

Mathematicians such as Holton (1993) have written about the pleasure people get from doing mathematics for its own sake. It was heartening to see that some students saw mathematics as being about having fun, but it seemed to be the younger students who described mathematics as an enjoyable pursuit. It was interesting to note that more of the year 5–6 students who had participated in NDP spontaneously referred to having fun in mathematics than same-aged peers who had not. However, this pattern was not evident for year 7–8 students. The analysis suggests that there is an age-related decline in students' enjoyment of mathematics. Analysis of students' response to other questions may help to throw light on this issue.

We were interested in those students who did not appear to have a view about the nature of mathematics (the non-responders). As Presmeg (2002) has pointed out, beliefs about the nature of mathematics are important because they can either help or hinder the making of links between school mathematics and everyday practices. If children don't have a view about what mathematics is, that may make it difficult for them capitalise on the mathematics they encounter at home and in other out-of-school settings.

Much of the data seems to indicate that children do perceive mathematics in dichotomous ways. Some students considered that mathematics was an external body of "stuff to be learned". Others suggested that they needed to make sense of the mathematics in order to make connections between related mathematical ideas. Many students were aware of the significance of mathematics in society, but others had a more mechanistic view.

Given that mathematics is part of the core curriculum, we think it could be important for teachers to help students engage with ideas about the nature of mathematics. In preparation for such discussions, teachers might benefit from examining their own beliefs about what mathematics is and reflecting on the subtle messages they might convey to students about the nature of mathematics. This is an issue that numeracy facilitators could address as part of their professional development with teachers.

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