METAPHORS USED BY YEAR 5 AND 6 CHILDREN TO DEPICT THEIR BELIEFS ABOUT MATHS

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Student beliefs about mathematics are difficult to access and categorize. This paper discusses one method used in an attempt to mitigate this issue. As part of a larger study into Year 5 and Year 6 students' beliefs about the nature of mathematics as well as their self-beliefs about the domain, a subgroup of 185 students completed a drawing task. The metaphors used in these drawings are explored as a way of accessing, grouping, and understanding the range of beliefs held by these students.

Theoretical framework

This study of student beliefs about the nature of mathematics and how they view themselves in terms of mathematics—their self-beliefs about maths—is part of ongoing doctoral research into the beliefs of Year 5 and 6 children, aged between eight and eleven. "Beliefs about knowledge and knowing have a powerful influence on learning, and deepening our understanding of this process can enhance teaching effectiveness" (Hofer, 2002, p. 13). Further, students' beliefs about mathematics relate to their interest and motivation in the subject (Kloosterman, 2002).This paper examines some of the beliefs depicted in a drawing task that was implemented in order to address several of the challenges inherent in accessing and interpreting children's beliefs about mathematics.

Beliefs

Frank Lester (2002) defines belief "as a special form of knowledge—namely, personal, *internal knowledge,*" in contrast to "*external knowledge* which is knowledge resulting from the consensus of some community of practice" (p. 351). He maintains that teachers need to be aware of their students' beliefs because each individual's internal knowledge "directs her or his actions and subsequent learning" (p. 351). Even though the mathematics education community recognises the importance of researching and understanding beliefs about mathematics, questions remain about how to access and interpret these beliefs. Traditionally, belief data have been collected either by asking individuals about their beliefs through the use of questionnaires and/or interviews, or by observations. Both of these methods have inherent problems: inferring beliefs from classroom observations is controversial (Lester, 2002) as it is extremely difficult, perhaps impossible, to interpret what is an internal, private belief from external behaviour alone; and self-report measures are also problematic because individuals may respond in ways they think the researcher expects (Creswell, 2003). Moreover, young respondents may not know what they believe or may not be able to articulate their beliefs about mathematics (Young-Loveridge, Taylor, Sharma, & Hawera, 2006). One of the solutions to these problems is to collect data by using multiple methods (Lester, 2002; McDonough, 2004); for example, a combination of various self-report measures and observations at different times. A challenge, here, is to ensure the methods are of interest to the participants as well as allowing them control over how much of their experiences and beliefs are shared with the researcher (Christensen & James, 2008).

Metaphors

Studying beliefs about mathematics is difficult because they are not easy to categorise or analyse. One solution was to explore the metaphors used by the students in their drawings. A metaphor, a device for trying to make meaning of one thing by comparing it to something else (Chapman, 2002; Gauntlett, 2007; Lakoff & Johnson, 2003), is not merely a literary figure of speech but is fundamental to human understanding and to describing and making sense of experience: "[M]etaphor is pervasive in everyday life, not just in language but in thought and action" (Lakoff & Johnson, 2003, p. 3). Metaphors are used both in language and visual representations (Gauntlett, 2007; Lakoff & Johnson, 2003). Lim and Ernest (1999) describe images of mathematics that encompass both the cognitive and the affective by including "all visual or metaphorical images and associations, beliefs, attitudes, and feelings related to mathematics and mathematics learning experiences", some of which they classify as myths such as "mathematics is just computation" and others as metaphorical images of a journey, a skill, "daily life experience" or a game (p. 44). Picker and Berry (2000) also use the term "image" when looking at drawings that included metaphors associated with mathematics and mathematicians such as "maths as coercion" (p. 75), "the foolish mathematician" (p. 79) and "mathematicians with special powers" (p. 84). Young-Loveridge, Taylor, Sharma and Hāwera (2006) discuss students' beliefs about the nature of mathematics in terms of perspectives, some of which are described through metaphors of utility and problem solving.

Literature review

For the purposes of this research, it was decided to access children's beliefs through a drawing task because images are "a rich source of understanding the social world and for representing our knowledge of the social world" (Freeman & Mathison, 2009, pp. 109–110). Drawings are a vehicle for researchers to access children's lived experiences (Anning & Ring, 2004; Golomb, 1992; Hubbard, 1989; Veale, 2005) and image-making is one of the ways children make meaning of the world. Drawing is often viewed as an enjoyable activity that children choose both in and out of the of the classroom as a medium through which to communicate experiences, feelings and beliefs (Christensen & James, 2008; Veale, 2005).

Within the classroom, it can be unclear what individual children understand and believe about a topic or an area of study, particularly in situations where they have problems with articulating exactly what they know or mean. Because drawings or other image-making tasks involve a different sign system, however, children are given an alternative way to communicate (Sidelnick & Svoboda, 2000), an alternative medium for explaining concepts and experiences that are difficult to put into words (Golomb, 1992; Veale, 2005). A drawing task is also a familiar activity that is easy to administer in the classroom.

Recently, image-based data have been used in education research (Kilpatrick, Carpenter, & Loma, 2006; McDonough, 2004; Sidelnick & Svoboda, 2000) and in health studies (Backett-Milburn & McKie, 1999; Horstman, Aldiss, Richardson, & Gibson, 2008; Veale, 2005); however, few authors address the issue of how to analyse drawings in a systematic way (Rose, 2007).

As with any other one-off method of data collection such as questionnaires and single interviews, the researcher or classroom teacher needs to be aware of the extent to which the data are influenced by the context of the moment, bound both by time and place. As a result, it is important to use information from additional sources such as observations as well as written and spoken responses when interpreting drawings. Thus for this research, the contents of the drawings have been coded and interpreted by looking at the written text many of the students chose to include with their drawings, and in terms of classroom and school context observations as well as some interview content.

This use of mixed methods is not new. Picker and Berry (2000), for example, analysed images of 476 students in five countries in conjunction with questionnaire responses to identify images of mathematics and mathematicians as coercive (mainly domineering teachers), foolish, and overwrought, as well as brilliant, and possessing “special powers” (p. 75). Picker and Berry noted the words children included in drawings and writing about the drawings (particularly questions), the size of elements, and features of the characters and other aspects of images such as classrooms. They analysed common themes and concluded that “there is more agreement than disagreement across countries about mathematicians among pupils at the lower secondary age” (p. 91).

Research design

In contrast to Picker and Berry’s (2000) research, the participants in this research were primary students and more varied types of data were collected. The participants were 823 New Zealand primary school students from 17 schools who answered a mathematics beliefs questionnaire that included a combination of open- and closed-questions. In addition, a subsample of 185 students at two focus schools completed a belief drawing task, mathematics classes were observed, and video and audio-recordings were made in two focus classrooms. A year later, nine students and nine teachers were interviewed.

The data were analysed by the first-named researcher using a combination of quantitative and qualitative approaches. The data from these drawings were coded in terms of mathematical content, metaphors used, affect (Goldin, 2002) and utility, and entered into SPSS. Initial codings were discussed with teachers from the focus schools. Final coding decisions were checked with a colleague who is using a similar method for analysing data from children’s drawings for his research. The choice of the first three categories was based on the frequency of appearance (after Glaser & Strauss, 1967), while utility was included both because of its prevalence at the Blue School and the Young-Loveridge et al (2006) findings. Cross-tabulations enabled a comparison of the frequencies in terms of gender, ethnicity and school.

The beliefs that were of particular interest in the analysis of questionnaire and interview responses as well as the drawings were the participants' epistemological beliefs about mathematics. This was both in terms of the nature of knowledge and truth, as well as the mathematics self-beliefs that individuals use to predict or explain how well they achieve in a specific domain (Schunk & Pajares, 2002). Some of the questions, for example, asked participants to describe the nature of mathematics and how they viewed the world of maths; others asked them how good they thought they were at mathematics, or how they saw themselves as engaging and achieving within this world. For the drawing task, students were asked to draw "what maths or doing maths means to you". Both the nature of mathematics and doing maths were included because of Lim & Ernest's (1999) findings that participants have difficulty in discriminating between the two aspects.

The results section below focuses on the drawings, interpreted in terms of their content but also through background information from the some of the participants' written responses, interviews, and classroom behaviour.

Findings

All of the students chose to complete the drawing task; in addition, many of the participants wrote more on their drawings than they had on a written task about the nature of mathematics. A very brief quantitative summary is included first. In the following subsection, a qualitative summary of selected metaphors will be presented.

Quantitative results

Most of the drawings (90%) included some depiction of the content of mathematics: in particular, number and basic operations (83%), geometry (25%), measurement (22%), and algebra (11%). However, this information was communicated in very different ways. Overall, 67% of the students included metaphors in their drawings to explain "what maths or doing maths" means to them, 59% included some aspect of affect, and 13% used metaphors of "maths as useful". Fewer girls than boys used metaphors (61% as opposed to 73%), or included affective elements (53% c.f. 65%), but more girls than boys included notions of utility in their drawings. Asian and Pakeha students more frequently included metaphors and affective elements in their drawings than did Maori and Pasifika students. Under affective elements, students included images, metaphors and words to indicate concepts like "maths is fun", " maths is exciting", "maths is boring", "maths is terrible": 70% of these suggested positive feelings, 40% negative, and for 42% a combination of positive and negative feelings. There was a marked difference between the drawings at the two schools, which is summarised in Table 1.

Table 1. Percentages of students who include metaphors, affective elements, and utility, compared by school.

School	Metaphor	Affect	Utility
Blue: N= 42	74%	26%	45%
Red: N=143	65%	69%	4%

Although more students at the "Blue School" seem to include metaphors in their drawings (74%) than at the "Red School" (65%), if the numbers are adjusted by removing metaphors that only refer to the utility of mathematics, then only 45% of Blue drawings include metaphors. This suggests that the students at the Blue School view mathematics in a much more utilitarian way than the students at the other school do (45% and 4%). This difference, as well as the difference in including affective elements, suggests that there are major differences in how the students at these schools view mathematics.

Reading the metaphors

One of the problems with a quantitative analysis of drawings is that the complexity of the metaphors and the distinctness of the individual voices tend to get lost. If metaphors are viewed as an essential to understanding of concepts, then it is important to explore them as a way to access what individual students believe and understand. All of the drawings were analysed, but, because of space constraints, only a small sample of the students' metaphors can be included here.

The nature of mathematics

A wide range of beliefs about the nature of mathematics, from the extremely narrow to a universal view, appeared in the drawings. For some students, number and/or the utility of maths were important: Ella[1], for example, includes a long explanation on the back of her drawing, and incorporates images of money, a person working as a "cashier", a calendar and "a teacher [who] is teaching the child so she can get a job involving numbers."

Other children depicted mathematics in universal terms, "as life", as something that underpins all of existence. For instance, Zach's picture included a volcano, the sky, sun, and fishes in the sea with a sprinkling of algorithms and symbols. He explains, "Well, you know maths is everywhere. It's in the sky, in the volcano, and under the sea".

Katia used the sea to reflect her understanding of the never-ending universality of mathematics. She also views mathematics as a separate culture or world with its own language and symbols.

Other students use geographic metaphors like "Numberland" or "Mathsland".

Self and mathematics

In many of the drawings, especially the more complicated ones, notions of the nature of mathematics become entangled with the individual students' views of themselves and mathematics. Tom (Figure 1) views himself in "Mathsland" as if on a quest, with words and concepts reflecting metaphors associated with computer gaming. "It is raining numbers in Mathsland. I almost fall into a new equation." He leaps over "the hurdle of maths … A new strategy comes flying at me. I get to know it later on". There is a sketch of Tom patting a purring strategy, and there is the "Evil Textbook" to avoid. Other students also use gaming imagery by portraying themselves as figures of power, the holder of knowledge, a king, or "Plus Man" in the world of maths.

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[1] All names of students have been changed, usually to an alias of their own choosing.

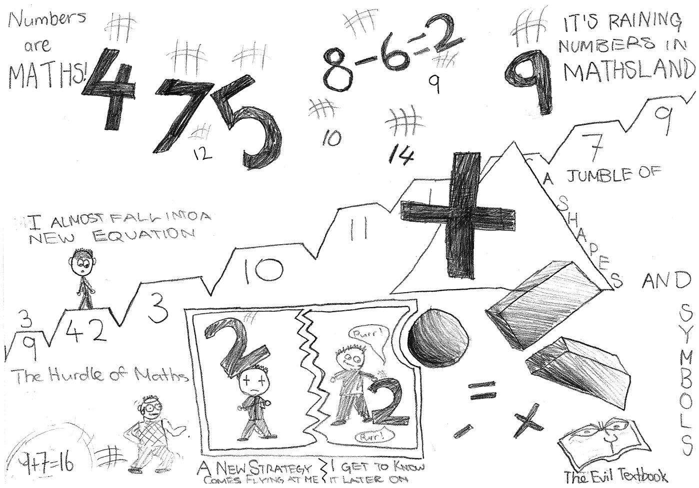

Figure 1. Tom's drawing.

Heads and brains

One of the most common metaphors—albeit used in different ways—is of the head or brain. The first way of expressing this indicates thinking, learning, knowledge, and improving one's intellectual capacity. More complex drawings include actual algorithms, concepts, and notions either within the head or streaming out. In contrast, negative drawings depict brain-burn and stress (Figure 2), with drawings of the tops of heads hinged off and numbers spewing out, or flames leaping from heads—and accompanying legends like Jason's, "Maths gives me brain burn," or Lyle's, "Kill me now with numbers".

Feelings positive or negative

A range of feelings are portrayed through metaphors in the drawings from maths is fun and exiting, through boring, to stress-inducing, as well as a mixture of feelings. Positive feelings are displayed through smiling faces, hearts, flowers, words, and other happy images. For Chloe, it is a combination of fireworks, bombs, and "Maths makes me feel as good as an icecream tastes". Lucy has positive brains, smiling girls, tunes, and a bottle of maths pills: "Dosage: Take a lesson a day to get you going happily." Hamish includes "fun with games", but "boring as in a subject without colour", and a tombstone inscribed with "R.I.P Famous Mathmatician dude". Hazel uses black and red to show how much she finds maths boring, "Hates it". and that it gives her a headache. Harry (Figure 2), one of the brain-burn artists, has students hanging from the light fixtures, throwing up, or calling for "Mummy".

Figure 2. Harry's drawing.

Discussion and implications

This drawing task allowed students to portray their idiosyncratic beliefs and experiences through a medium that they viewed as fun and non-threatening (Christensen & James, 2008; Veale, 2005). It permitted those with weaker literacy skills to present as much information as their more literate peers. Although many of the students view mathematics in terms of number and basic operations (as found by Young-Loveridge, et al., 2006), they communicated this view of the nature of mathematics through a variety of metaphors in their drawings: for some, numbers and symbols; for others, notions of usefulness for future employment, measurement, the ability to use money for shopping; or in terms of the fabric of life, a more universal approach.

The majority (70%) of the students who include affect position themselves as belonging to a world of fun, excitement and challenge, while the remainder feel boredom, hate the subject, or seem stressed by their experiences of the mathematics classroom.

Even though the students include a great range of metaphors in their drawings, it seems that the greatest difference between responses can be explained by school rather than by gender or ethnicity. In particular, a greater percentage of children from the Blue School included metaphors of utility, and affect metaphors were more prevalent in the Red. Teachers, the school context, as well as socio-economic status (Blue School middle, Red high) seem to have influenced the responses (Hattie, 2009). For example, Mr R's class[2] (Blue School) represented utility most frequently, which reflects his beliefs about mathematics as useful[3]. Ms McG's class (Red School), an accelerated group, had the most complex representations of affect and content which were probably influenced by the teacher, their high decile school, and perhaps their ability; although in no other group did ability seem to account for differences in metaphors.

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[2] Blue School.
[3] Based on a questionnaire and interview.

Conclusion

In summary, it was found that the majority of students picture mathematics largely as number and basic operations. Metaphors and affective elements were common in their drawings. It seems that schools, and specific teachers in particular, affected these primary students' understanding of the utilitarian nature of mathematics, and this finding has implications for practice, suggesting that it is possible to convey to young children the usefulness of what they are learning and its applications in many aspects of their environment and lives. Further, the children expressed a range of strong feelings about mathematics as well as both positive and negative images of its nature, and it seems that these can also be influenced by schools and/or teachers—a point that would need to be researched more deeply.

Lakoff and Johnson (2003) and Gauntlett (2007) discuss the notion of metaphor as conceptual, essential for abstract thought, and based on the individual's experience. It is clear from this research that by looking at the metaphors children use, teachers may gain valuable insight into what their students believe and understand, which in turn could help explain differences in engagement and learning in mathematics. They may also become aware of what their students feel about mathematics and/or about students' experiences of learning mathematics. This information has the potential to assist teachers in making decisions about classroom practice (McDonough, 2004) in terms of the next steps for individual students as well as for groups. However, it is important to interpret the content of drawings in terms of additional information such as other tasks, discussions, or interviews (Freeman & Mathison, 2009; Lester, 2002; McDonough, 2004), as well as to recognise that teaching behaviours and biases—as well as classroom and school contexts—may affect what students portray. Despite these cautions, the use of a drawing task to access students' beliefs and understanding about mathematics proved an effective means of collecting complex and varied data from a large group of students.

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