CATHERINE SOLOMON

8. ACCESSING CHILDREN'S BELIEFS ABOUT MATHEMATICS THROUGH THEIR DRAWINGS

INTRODUCTION

The research I discuss in this chapter is part of an ongoing doctoral study exploring Year 5 and 6[1] students' epistemological and self-beliefs about mathematics in order to develop a framework for analysing engagement in mathematics classes. Epistemological beliefs address the nature of knowledge and truth, as well as the sources of that knowledge. These beliefs overlap with and impact on self-belief, also termed ability or competence beliefs. Individuals identify and use these beliefs to predict their performance, competence or achievement in particular domains, including mathematics (Schunk & Pajares, 2002; Wigfield & Eccles, 2002). A drawing task is one source of data for my research, along with written responses, video- and audio-recordings based on Nuthall's method, and interviews. The focus here is on how children view the nature of the mathematical world and whether they see themselves as part of that world, as determined by comparing their responses on a writing and a drawing task.

First I discuss Nuthall's influence on my research, the aspects of his approach that I have included and those that are not necessarily suitable when considering children's beliefs. The next section examines the efficacy as well as the limitations of using drawings as a method of accessing beliefs. Finally, I analyse the drawings in terms of the themes the students have included.

NUTHALL'S INFLUENCE AND MY RESEARCH

Nuthall and his approach to classroom research, by focusing on individual children and analysing how they engage with the task, topic and their peers, and how this engagement affects learning, have influenced my research significantly. In particular, I am interested in how, through the use of fixed video cameras, individual microphones and careful observation, he accessed the three worlds of the child within the classroom: the public one of the teacher, the semi-private one of the children's peers and the private internal world (Nuthall, 2001, 2004, 2007). Through this window into children's private and semi-private conversations, researchers can learn about children's understandings of classroom tasks and activities as well as their social negotiations within the classroom. This method of data collection and the extremely detailed micro-analysis of these data are very useful for analysing

B. Kaur (Ed.), Understanding Teaching and Learning: Classroom Research Revisited, 145–158.

classroom behaviours and linking particular sorts of engagement to learning. Nuthall's methodology results in rich, detailed information about individual children's experiences, behaviours and learning in individual classrooms.

However, even though I used Nuthall's method for collecting data on what goes on in individual maths classes, my focus here is related not directly to learning but rather to exploring children's beliefs about mathematics. My experience with recording in classrooms suggests it is both expensive and invasive. Incorporating cameras, video-recording devices, microphones, technicians and observers into busy classrooms often alters their routines and behaviours (Abbiss, 2005; Hatch, 2002). Another limitation to the method, in this case, is that beliefs are not necessarily observable by examining classroom behaviour (Lester, 2002).

A major challenge to this research is how to access and describe children's epistemological and self-beliefs about mathematics as eliciting them is extremely difficult and complicated (Lester, 2002). Yet the mathematics education research community recognises the importance of this area of study (De Corte, Op 't Eynde, & Verschaffel, 2002; Leder, Pehkonen, & Törner, 2002; Young-Loveridge, Taylor, Sharma, & Hawera, 2006), providing a significant reason for undertaking this research, although epistemological beliefs are not explicitly included in the New Zealand mathematics curriculum (Ministry of Education, 1997, 2007).

Initially 848 Year 5 and 6 students from 17 primary schools in and around Christchurch, New Zealand completed a questionnaire containing both Likert-type and open-ended questions requiring written responses. However, even though a reader-writer was available to those who needed one, I was concerned that not all children of this age are able to express their beliefs through a method reliant on their literacy skills. Some children were reluctant to write much while others had genuine difficulty with the task. In addition, many children presented a very limited view of the nature of maths, seeing it only in terms of number.[2] To augment this information, I introduced a drawing task at two focus schools where eight classes were asked to draw "what maths or doing maths means to you". By combining information from a variety of sources, I intended to investigate whether the students' narrow beliefs about the domain would be confirmed or contradicted. To achieve this, I compared the drawings and written responses of 182 children.

RATIONALE FOR INCLUDING A DRAWING TASK

An image-making task was selected because creating images is a modality that children often choose to communicate their experiences, feelings and beliefs. Even when children choose to draw with friends as a social activity, they present individual, idiosyncratic images representing their unique experiences (Greene & Hogan, 2005). Children use drawing to "reconstruct and assimilate the experiences they have had" (Barnes, 1987, p. 1); in other words, to make meaning of the world. Freeman and Mathison (2009) claim, "Images are a rich source of understanding the social world and for representing our knowledge of the social world" (pp. 109-110). Thus they offer researchers another way to look at or access children's lived experiences (Anning & Ring, 2004; Barnes, 1987; Christensen & James, 2008;

Golomb, 1992; Hanes & Weisman, 2008; Hubbard, 1989; Veale, 2005). Children use both signs and words to communicate, which frequently includes drawings (Vygotsky & Cole, 1978). In addition, by including different sign systems, for example both images and words, researchers gain opportunities to view the world in different ways, perhaps enriching the research with multiple interpretations of both belief and experience (Short, Kauffman, & Kahn, 2000).

Using a drawing task as a data source has the distinct advantages of being easy to administer and fitting comfortably into the normal daily activities and routines of the primary classroom. As many students see it as fun, drawing also qualifies as both an in- and out-of-school activity, outside the formal context of the classroom (Christensen & James, 2008; Veale, 2005). To avoid student concerns about being evaluated, this task was not presented as an art task thus students viewed it as a low-stakes, low-stress activity where peer conversations were acceptable. They had the freedom to draw using diagrams, words, colours, pens or pencil and to choose not to complete the task but to work on another activity instead.

A further advantage is that "[s]tudents' artistic expressions can provide teachers with additional ways of determining what they understand about facts and concepts as well as how they understand them" (Sidelnick & Svoboda, 2000, p. 176). Children may also find it helpful for explaining concepts and experiences that they find hard to put into words (Golomb, 1992). Within the classroom, it is often difficult to access what individual children know and believe about a topic or task, especially if they lack the language or verbal communication skills to convey their individual interpretations and understandings to the teacher; therefore, the drawing task was used to try to overcome this problem.

DILEMMAS WITH USING A DRAWING TASK

Although there is a long tradition of using images as data, criticism—or at least concern—has been levelled at image-based data sources and analysis. Traditionally the research community has accepted verbal accounts as more valid than non-verbal ones like drawings; yet many, like Kress & Van Leeuwen (2006), Mathison (n.d.) and Rose (2007), view them as equally valid. As Freeman and Mathison (2009) point out, "Images, like any data, can be used to lie, question, imagine, critique, theorize, mislead, flatter, hurt, unite, narrate, explain, teach and represent" (p. 110). One does not completely disregard a data source because it may have been abused or may have the potential to be misused. Much of the criticism of image-based data seems to apply equally to a variety of other data sources, including interviews, written responses and observations. Like any other research method, if due diligence is taken with the research questions, methodology, ethical considerations, data collection and analysis, the use of image-based data should be no less legitimate, reliable or valid than any other.

Despite this method's advantages, the researcher or classroom teacher needs to be cognisant that a drawing activity is a one-off task bound and influenced by the context—the time, location, interactions with people and history of that moment. It is a "smash and grab approach to collecting data" (Greene & Hill, 2005, p. 16).

What the children believed about maths when they were asked to draw was potentially affected by their peers, their teacher or how they were feeling, and what happened in class and in the playground that day, or perhaps even the day before and/or at home: the drawings were a response to the task but coloured by the creators' lived experiences (Van Manen, 1990). Thus a drawing in response to the same task at another time or place may be very different.

One of the more vexing questions when dealing with image-based data is how to analyse drawings systematically, explicitly and informatively (Backett-Milburn & McKie, 1999; Horstman, Aldiss, Richardson & Gibson, 2008; Rose, 2007). Rose (2007) points out that although many have studied images and other visual data, "there are remarkably few guides to possible methods of interpretation and even fewer explanations of how to do these methods" (p. 2). Historically, children's drawings have been used in intelligence tests, anthropology and developmental psychology (where they have been analysed in terms of a cognitive or developmental deficit) as an artefact of significance or a reflection of an emotional, usually troubled, state (Golomb, 1992; Hubbard, 1989; Rose, 2007). More recently drawings have been used in health studies (Backett-Milburn & McKie, 1999; Horstman et al., 2008; Veale, 2005) and education (Kilpatrick, Carpenter & Loma, 2006; McDonough, 2002, 2004; Sidelnick & Svoboda, 2000), yet very few authors include an adequate discussion of exactly how the data were analysed.

Rose (2007), as one of these exceptions, critically examines a range of methods for analysing visual images such as compositional interpretation, content analysis, semiology or the study of signs, psychoanalysis and discourse analysis. The other exception, Freeman and Mathison (2009), developed a framework for analysing visual data by focusing on the subject matter, the creation of the image, and the audience.

MAKING SENSE OF THE DRAWINGS

The ways of addressing and making sense of drawings are as varied as the research questions and the researchers' theoretical prejudices which can act as lenses or filters for analysis. Whichever method or methodology is chosen, the researcher still needs to select images, devise categories for coding or making sense of them and finally distil themes. Coming from a complementary methods approach (Green, Camilli & Elmore, 2006) and based on my research questions, I had the benefit of looking at the drawings in numerous ways: how the content children included in their drawings reflects their beliefs about what constitutes mathematics, how they view themselves as part of the world of mathematics, their unique representations of their individual experiences of the classroom, and their position in the classroom. Throughout the process of examining the drawings, I needed to be aware of the challenges associated with this type of interpretation of conflicting readings and of the trustworthiness of my analysis. I tried to mitigate these risks by considering other evidence such as what the children wrote and said, their classwork, as well as my classroom observations and field notes.

The two approaches I used to analyse the drawings were Nuthall's (2007) three worlds of the classroom, and the subject matter section of Freeman and Mathison's

(2009) framework for analysing visual data. The framework includes five levels for the reading of the content which are, in ascending order of the amount of inference required: literal (features included), biographical (identities and social settings), empathetic (common experiences), iconic (relation to culture and values) and psychological. I initially concentrated on a literal reading as it required the lowest level of reader interpretation, and the results confirmed my concern that the view of mathematics was largely limited to number. Once I began looking at how the students positioned themselves in the world of maths, I used the biographical, empathetic and iconic levels by combining what was being presented on the page with other sources of data about the students and classrooms. The drawings that obviously included affective elements or metaphors that indicated an individual's state of mind lent themselves to psychological readings. Nuthall's three worlds of the classroom offered an alternative method of reading the same images by looking at which of these worlds the students choose to include in their drawings:

- the public world that the teacher sees and manages
- the semi-private world of ongoing peer relationships, where students establish and maintain their social roles
- the private world of the child's own mind, where "children's knowledge and beliefs change and grow; where self-beliefs and attitudes have their effects; where individual thinking and learning takes place" (Nuthall, 2007, p. 84).

The two approaches complemented each other and presented me with two perspectives in my analysis of the complex content of the image-based data.

However, before beginning any type of analysis, one needs, where practicable, some sort of confirmation or explanation from the creators themselves. As Hubbard (1989) explains, "When adults look at the world of children, they are necessarily outsiders examining a land they cannot be part of. And yet the terrain seems familiar" (p. 11). Ideally each student would be interviewed about her/his drawing (Freeman & Mathison, 2009; Veale, 2005). In practice, however, such as with a large group of students, this is not always possible, in which case it is helpful if students write about their drawings or to use a "draw-and-write" protocol (Backett-Milburn & McKie, 1999; Horstman et al., 2008).

I excluded developmental, psychological trauma and deficit interpretations from the analysis. From my perspective, these discourses have inherent problems when applied to this drawing task. Certainly, taken out of context, many of the drawings would seem to encourage these interpretations; for instance, many included stick-like, cartoonish characters that could be interpreted as indicating severe developmental delays. However, such drawings can also be interpreted in terms of a culturally mediated "… symbolic system learned in later childhood as a kind of shorthand and which is used when shapes or recognizable features are unimportant … they serve as a handy way to rapidly express the idea of the picture" (Johnson, 1993, pp. 154–155). Children often incorporate cartoon-like images, stick figures and images from popular culture when they draw, especially in informal situations when communicating with each other.

READING THE STORIES FROM THE DRAWINGS

Reading through a Quantitative Lens

To compare the written task ("how you would describe maths and what it is about") with the drawing task ("what maths or doing maths means to you"), both tasks were coded in terms of what the students drew and wrote about in answer to what mathematics is, and what they believed belongs in the domain of mathematics. Categories emerged through multiple readings and coding, first of the writing and then of the drawing tasks, by attending to both patterns and idiosyncratic responses. I tried, where possible, to compare the emerging codes with those developed by Young-Loveridge et al. (2006) and Lim and Ernest (1999).

Many of the children wrote at least as much on their drawings as they did on their written responses: between 0 and 50 words (mean 13.27, standard deviation 9.80) for the written task, and between 0 and 83 words on the drawing task (mean 12.74, standard deviation 16.64). Twenty-eight children chose either to skip the written question or to write, "I wouldn't"; whereas, everyone chose to complete the drawing task. The responses to both tasks were coded and compared in table 8.1.

Table 8.1. Comparison of analysis categories on the writing and drawing tasks

Writing	*Number*	*Drawing*	*Number*
Content	128	Content	163
Teaching/learning	48	Classroom context	136
Thinking	2	Thinking	44
Problem-solving	40	Problem-solving	83
Utility	18	Utility	19
Feelings/affect	29	Feelings/affect	109
Attitude	11	Metaphors	55
Difficulty (+/–)	48	Difficulty	48
Other	18	Games	17
Wouldn't	28	Books	41
		Computers	10
Total	370	Total	725

Overall, the drawings included many more coded elements (725) than the written response (370). Interesting differences emerged in the content area, the classroom context, thinking, feelings and the extensive use of metaphor in the drawing. In both tasks the number of children conveying utility and how easy or difficult they find the subject was almost identical.

To explore whether the drawing task reflected a broader vision of mathematics than the written task, the "content" category was broken down into different strands or subsections. In both tasks, children overwhelmingly identified number as the dominant strand of mathematics, which reflects the current New Zealand emphasis on numeracy (see table 8.2). However, the drawings present a much more varied and extensive picture of the domain than the written data do. A quarter of the drawings include geometric concepts as opposed to 4% of the written responses; a significant proportion also indicated measurement (22%) and algebra (11%). Therefore the analysis of both data sources revealed a more comprehensive picture of what students believe the domain of mathematics encompasses.

Table 8.2. Content breakdown for the two tasks by percentage

Writing	*N = 128*	*Drawing*	*N = 163*
Number	87%	Number	92%
Geometry	4%	Geometry	25%
Measurement	4%	Measurement	22%
Statistics	1%	Statistics	1%
Other	5%	Algebra	11%
		Graphs	8%
		Money	13%
		Symbols	64%

Reading through a Qualitative Lens

Although the quantitative approach to reading the drawings answers the concern arising from the children's written responses, it does not illustrate the richness, coherence and integrity of the drawings (Rose, 2007). The seven drawings[3] presented as examples in this section were all analysed in terms of their mathematical content. All depict mathematics as number, yet each tells a more complex story about individual idiosyncratic beliefs, feelings and lived experiences of the mathematics classroom.

Although both Bob (figure 8.1) and Michael (figure 8.2) deal with number in their drawings, the effect and what the drawings say are very different. Bob includes only the number strand in his pencil drawing, yet he places a boy with whirring eyes in the centre, explaining without any words how maths affects him: this is an expressive depiction of his lived experience of mathematics.

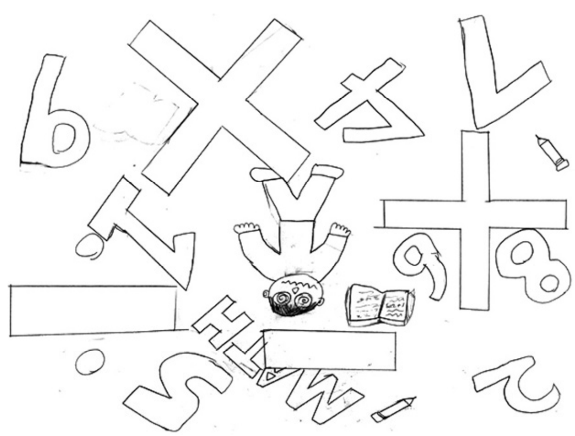

Figure 8.1. Numbers and boy with the whirling eyes (Bob, Year 6)

Michael's picture is much calmer but equally interesting. His page is filled with an array of numbers, symbols, and three- and two-dimensional geometric forms, and he incorporates colour. For him maths is number, and more.

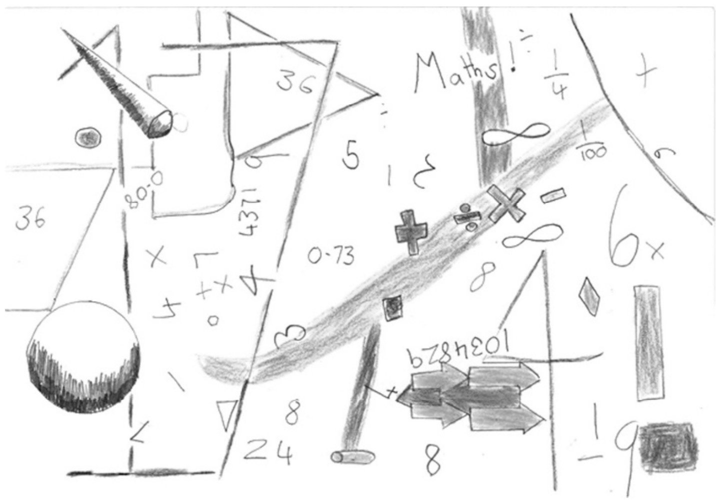

Figure 8.2. Composition of numbers and geometric shapes (Michael, Year 5)

Other children depicted the content and their experience of mathematics in terms of its utility. For Ella (figure 8.3), her experience and belief about the domain are firmly rooted in the usefulness of the subject: being able to use money, read a calendar, get a job. Even her description of the public world of the teacher and the classroom is couched in terms of the utility of the learning.

At the other extreme are the children who view mathematics in universal terms, as life, as something that underpins all of existence even though many of them still describe maths in terms of number. When I asked Zach to tell me about his picture (figure 8.4), he responded with a loud sigh and rolling of eyes, "Well, you know maths is everywhere. It's in the sky, in the volcano and under the sea." The subtext seemed to be, "You're an idiot if you don't know that", yet only one classmate[4] depicted a universal view and then not to quite the same extent.

Many children drew their experiences of the mathematics classroom or of doing maths. The drawings represented teachers, single figures such as an identified or unidentified child, small groups at work, and the whole classroom as in figure 8.5. Fred's maths classroom includes the public world of the teachers and their set work, the private world of the participants and their feelings, and his position in the classroom. He divides participants into teachers, "freands", "random kides" and "me" as the knowledge holder: "Only I know the anser becose im relly good at It" (sentence on the back of the drawing). One friend is asking him for help. Some "random kides" appear stressed, in tears, puzzled, as if wanting to leave or saying, "my brans exploding". One teacher, in tears, indicates the problems are too hard.

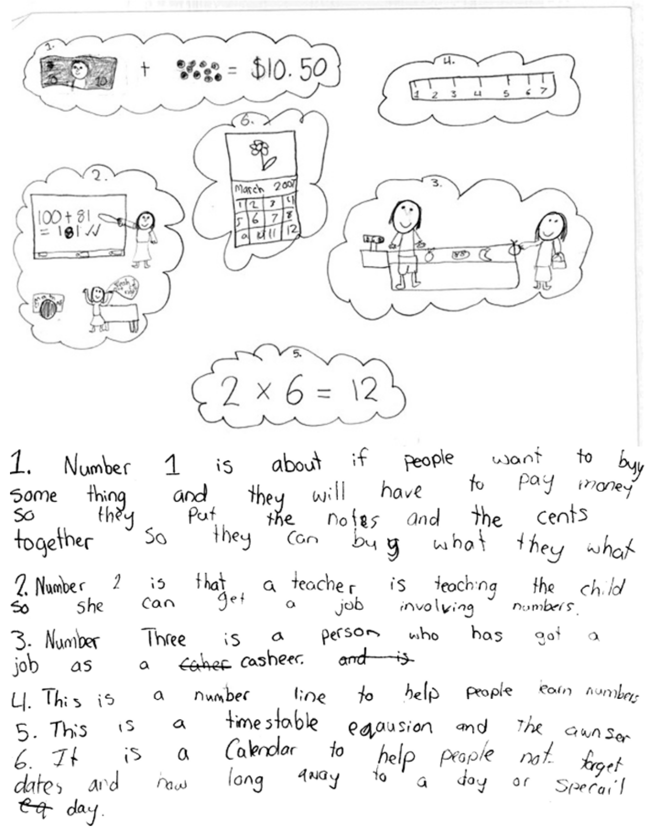

Figure 8.3. The two sides of a "maths as useful" drawing (Ella, Year 5/6)

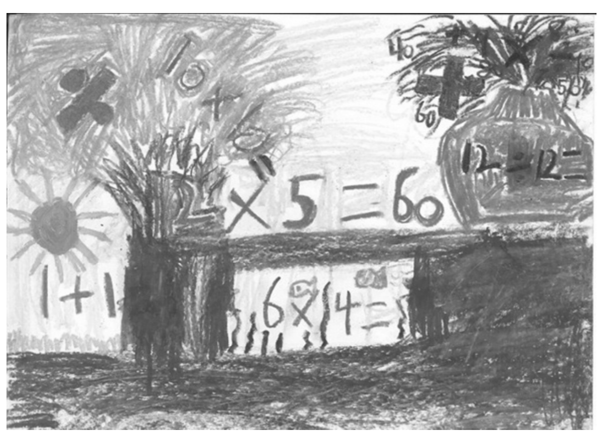

Figure 8.4. A universal view of mathematics (Zach, Year 6)

Fred's drawing represents his idea of the "maths classroom" as traditional and rather old-fashioned, which differs from my experience as an observer in his classroom, where children sit in groups at large tables, on a comfortable couch or on a mattress or play maths games on the floor. In addition, his hard problems are much easier than the problems his maths group was working on. Many other drawings also present examples of maths as simple arithmetic problems rather than the much more advanced work they were doing. Like the stick figures and the cartoon-like drawings, this type of depiction seems to be a shorthand or an easily communicated schema of "the maths classroom". Nevertheless, his drawing tells a story of maths being a hard subject for many people although he finds it easy.

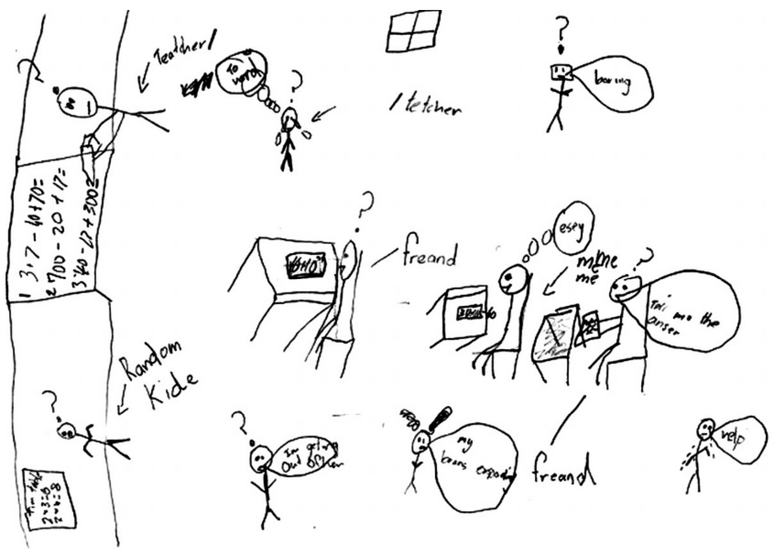

Figure 8.5. The artist positions himself as the knower in a stereotypical maths classroom (Fred, Year 5)

The next two examples, also set in the maths classroom, depict the children's individual experiences with Room 6 maths, their feelings about the subject, and their responses to an incident. The context of their classroom and their experience are important to understand before analysing their drawings. Orange's (figure 8.6) and Harry's (figure 8.7) drawings include both the group of friends and the teacher.

Orange's drawing captures some of the spark and mischief of his small group working together. He positions the group, especially Pink with his horns and trident, as naughty. They cannot or do not want to answer the teacher's simple maths question. There is also an indication of stress, at least for Harry who has "spewed".[5] The "Smarty pants" child, the antithesis to the group, is smiling and has all the answers. Although he uses stick figures, Orange includes sufficient detail, such as the fashionable brand names on his teacher's t-shirt and shoes, halos, horns and moustaches,[6] to communicate his experience of the maths classroom.

Harry's drawing presents the extreme stress that he and his friends Orange, Pink and Richie experience in maths. It is a more troubled and troubling drawing than figure 8.6. All of the children and the teacher are depicted as traumatised: Richie is hanging off a light fixture, Orange has his eyes closed as if he has passed out while calling for his "mummy", Pink has spewed and has to go home, while our artist, Harry, sits at his desk yelling "ahhhhhhh"; all of the boys have flames shooting from their heads. In contrast to his drawing, Harry is usually a cheerful, enthusiastic boy who is an average maths student.

Figure 8.6. The artist and friends, the "dunno'ers", in their maths classroom (Orange, Year 5)

Figure 8.7. "Brain-burn"—the artist and friends in their maths classroom (Harry, Year 5)

In conversation with the boys after they completed their drawings, I discovered that they had become extremely stressed the previous day in maths when they had an end-of-unit test on fractions. Both their classroom teacher, Mr H., and I had been present in the classroom on the day of the test; however, we had failed to notice their distress. They all seemed to behave as they normally did without any outward indication of "brain-burn". This example demonstrates how accessing the children's semi-private and private worlds through their drawings can produce information that would otherwise have been inaccessible. In an interview a year later, Harry could not remember the incident that sparked the "brain-burn", yet he could remember how the stress of maths felt as he commented on his drawing.

Harry: My head always used to get hot, like my forehead, and I just imagined my brain going on fire if I did too much … Maths. (laughs) That's funny.

Cathy: So do you think that's a, not a very happy picture?

Harry: I find it quite funny (laughs).

Cathy: It is, it's a very funny picture.

Harry: Yeah, but … yeah, not too happy.

All of these examples were examined in terms of Nuthall's three worlds, as well as Freeman and Mathison's "Focus on subject matter". They were all read literally, with biographical, empathetic, iconic and psychological readings of the drawing content (Freeman & Mathison, 2009, p. 161) made when appropriate: Fred's drawing (figure 8.5) is an example of both biographical and empathetic readings; iconic readings include Ella's view (figure 8.3) of the utility of mathematics and the use of drawing shorthand and imagery in many others; and a psychological reading, describing children's feelings, was used for figures 8.1, 8.6 and 8.7. In terms of Nuthall's (2007) three worlds of the classroom, figures 8.6 and 8.7, for instance, present personal interpretations of the public world of the teacher, the semi-private world of their group and their individual reactions to a difficult fractions test.

FINAL COMMENTS

The themes emerging from the drawing task helped me understand the range and complexity of these children's beliefs about the nature of mathematics, what constitutes mathematics and how they view themselves within this world. They not only drew what they believe mathematics is about, but also how they fit into the culture of the mathematics classroom and how they feel, both positively and negatively, about the subject in general or a specific activity. The more I consider drawing, the more I realise how much of the complexity and richness of children's experiences and beliefs we miss by using a single modality when collecting data (McDonough, 2004). It is the complex weaving together of a variety of sources that creates a more intricate picture of what goes on in children's experiences of mathematics classes.

ACKNOWLEDGEMENTS

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NOTES

1. Between 9 and 11 years old.
2. Number is one of the strands of the New Zealand mathematics curriculum, along with measurement, geometry, algebra and statistics (Ministry of Education, 1992).
3. These examples were selected because they illustrate some of the common themes, answer the research concerns, have the potential to be misinterpreted without contextual information, and are easily reproduced.
4. Although only two students in this class portrayed a universal belief, a number of students in other classes took a similar stance.
5. An informal word for vomited.
6. The month was "Movember" when the teacher and some of the fathers were growing moustaches to raise awareness of and money for prostate cancer.

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