Sociomathematical worlds: Investigating children's developing relationships with mathematics

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This paper describes the methodology used for a three-year ethnographical study of children's expanding awareness of mathematics and their growing mathematical identities during the middle primary years. It explains how the term 'sociomathematical worlds' was adopted to represent the network of social contexts within which children learn about mathematics, and how an understanding of these worlds was constructed by the researcher through a process of broad and detailed data-gathering, rich in triangulation.

In a concentrated bid to enhance mathematics learning outcomes, many countries have adopted programs of radical curriculum change in the form of numeracy initiatives. These projects have largely overlooked the impacts of reform on the lives of the recipients: children in classrooms. This paper describes a study that examined children's experiences of mathematics within the context of their everyday lives. As described in Walls (2003), many taken-for-granted classroom practices that for many decades have been accepted without question as effective teaching practice, can be demonstrated to produce profoundly alienating and marginalising effects on children. Ongoing research of this nature is crucial in mathematics education. There has been a noticeable omission of learners' perspectives in recent evaluations of numeracy project effectiveness for example Higgins (2001) and Whitburn (2002), supporting Pollard and Filer's (1999) claim that there is a predominant view of education as 'something which is done *to* children, not *with* children, and still less *by* children' (p. 23). This paper describes a methodology that afforded access to learners' views, exposing the relationships between school and home environments and learners' experiences of mathematics, with profound implications for the teaching of mathematics.

The research context

Schoenfeld (2002) provides an overview of the history of mathematics education research to demonstrate that differing perspectives and their associated research methods have competed for primacy throughout the twentieth century. He describes how, by the end of the last decade, there had been a 'proliferation of perspectives, of theories and of methods' (p. 443) used to study mathematics education, and notes the recent growing interest shown by mathematics education researchers in the interplay between cognition and culture. He raises a number of issues that he believes current researchers need to take into account, including the danger of compartmentalising research by maintaining a narrow focus that ignores other relevant perspectives.

This study began as an exploration of children's attitudes to mathematics. It aimed to shed light on a phenomenon recognised in many countries: that from a fairly young age, a significant proportion of children become disaffected with mathematics, that this alienation is often accompanied by a decline in their achievement, and that these effects are frequently more marked in girls than boys (e.g. Garden et Al, 1997).

For many decades, attempts have been made by successive waves of researchers to identify, describe, measure, quantify and compare students' experiences of learning mathematics. Much of this research has suffered from the kind of narrow focus Schoenfeld

describes, constrained by its heavy reliance upon so-called scientific method to provide incontrovertible evidence of correlated variables to explain the occurrence, distribution and nature of learners' responses to their learning of mathematics. Various forms of measurement scales have been devised to study learners' feelings and beliefs about mathematics. In the recent study of Valseki and Stipek (2002) for example, the researchers have developed a new instrument, the FAS (Feelings about School) to collect data and statistically analyse the links between children's feelings about school, environmental variables, and achievement in mathematics and literacy. It has also been commonly assumed that cognition and affect are discrete entities and can therefore be examined separately, that beliefs, feelings and values are measurable given the appropriate tools or instruments, and that learners can be studied as decontextualised beings detached from their broader social and physical surrounds. Although scales of measurement can be applied to a large number of subjects thus generating sufficient sample size to test conjectures for statistical significance, such methods provide a somewhat unidimensional view of learners.

Sociocultural views of mathematics

The concept of mathematical learning as an essentially social and cultural activity (Abreu, 2002; Atweh et al, 2001; Cobb, 1995), has changed the focus of mathematics education research over the past decade. Bishop (1991) has reasoned that mathematics, a value-laden cultural construct, and is learned within social environments. He views the classroom as a cultural site in which the learner is socialised or *enculturated* into a particular mode of thinking and doing known as *mathematical*.

Mathematics classrooms have been increasingly viewed as possessing a distinctive culture. Voigt (1998) for example describes the mathematics classroom in the following way:

> …the culture of the mathematics classroom appears to have a life of its own…Everyday [sic] the participants in the classroom develop unreflected customs and stable habits that enable them to cope with the complexity of classroom life while functioning as a resistance to educational reform. (p. 191)

Nickson (1992) reviews the approach to education research which views the learner as situated within a 'culture'. She defines classroom culture as 'the invisible and apparently shared meanings that teachers and pupils bring to the mathematics classroom and that govern their interaction in it' (p. 102). She also warns of the danger of assuming that there is only one such culture. This research shows that classroom 'cultures' can vary markedly from classroom to classroom, that they change over time and that they differ from subject to subject. They are, in other words, fluid, dynamic and mutable.

A growing number of recent sociocultural studies of secondary students of mathematics have been reported (e.g. Boaler, 2002; Walshaw, 1999). However, few longitudinal ethnographic biographical case studies currently exist that construct a rich and detailed view of *primary-aged* mathematics learners situated within their school and home environments. Pollard and Filer's (1996) research focused on five case studies of children's learning of reading and mathematics over a four-year period. Their study failed to distinguish or analyse in any compelling way, the significant features of the learning environments of these children that may have contributed to the relationships between their understandings, feelings, opinions, and beliefs about *mathematics* as compared to *reading*, and their achievement in these subject areas. It can be argued that it requires the sharply-focused eye of the mathematics education researcher with an understanding of the subject

itself as well as familiarity with mathematics education from historical, political and pedagogical perspectives, to discern those elements of home, playground or classroom environments that may contribute to a child's sense-making about *mathematics* in particular within their social contexts.

Framing the research

This study sought to broaden our current understanding of primary children's developing relationships with mathematics. From a range of possible theoretical perspectives, symbolic interactionism was chosen. Its suitability in describing the relationship between the individual and his/her environments in the primary school setting has been convincingly demonstrated in the research of Pollard and Filer (1999) who compiled detailed strategic biographies of individual children as they progressed through seven years of their primary schooling career in England.

Symbolic interactionism explains how, through their interactions and negotiations with others, individuals respond to and make sense of their world, create, and recreate personal identities, and develop what we commonly term *attitudes*, consisting of *feelings*, *values*, *opinions* and *beliefs*. Central to the theory of symbolic interaction is the concept of the process of sense-making by which individuals are believed to construct views of self and of 'reality' through interactions with others. Objects, both physical and abstract, may be mutually recognised by all the members of a social group, yet assume meanings unique to individuals. Part of each individual's world is the 'object' we call mathematics. Of interest to the symbolic interactionist researcher is how each individual comes to 'know', 'understand', and position themselves in relation to, this object.

Ethnography was considered to be the most appropriate methodology for a study of children's development of attitudes over time. Anderson (1990) describes ethnography as consisting of 'participant observation, description, a concern with process and meaning, and inductive analysis' (pp. 148-149). He maintains that because 'they [ethnographers] go looking, rather than looking for' (p. 150), detailed research questions often emerge after the researcher becomes immersed in the situation. Accordingly, as the research progressed, the social world of children's learning was increasingly seen as a complex web of human interaction in which 'attitudes' could neither be easily defined, nor easily isolated from their social context, let alone measured. The original questions about attitude and achievement were reframed to become: 'What does the mathematical world of the child look like, how do the interactions within that world contribute to the child's negotiation of meaning about that world, and what aspects of that world appear to enhance or inhibit the child's learning of mathematics? The challenge was to capture the flavour of typical everyday social life of the mathematics classroom and home environment from a child's perspective and to interpret this in light of current mathematics education research.

A model of the mathematical lives of the children was developed in which the child's experiences of mathematics in everyday life were viewed as constituting a part of the child's social world. The *mathematical* dimension of the child's life was named the *sociomathematical world*, represented diagrammatically in Figure 1 below. The model was intended to define the research domain, to direct the data-gathering, and to focus the analysis and presentation of findings.

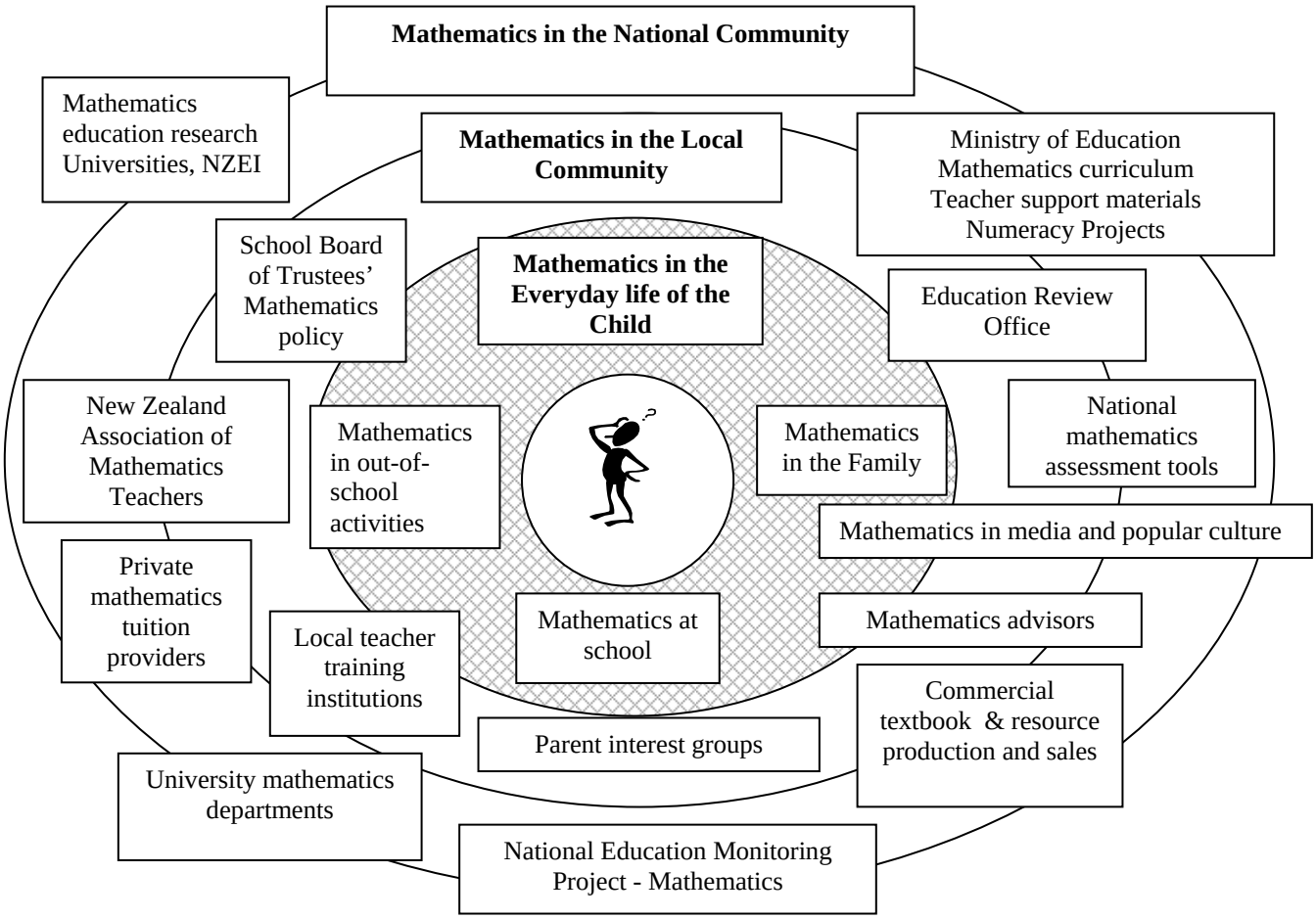

Figure 1: *The sociomathematical world of the child within its wider context*

Developing a methodology

Data gathering methods were required that would describe as fully as possible, the sociomathematical worlds of children. They needed to uncover the meanings given to the activities within these worlds and look for ways in which these meanings might contribute to the formation of children's ideas and feelings about mathematics.

Biography has been used as the key instrument in sociological investigation (e.g. Berger and Berger, 1972; Denzin, 1989). Smith (1994) suggests that 'biography, with a concern for the way a specific individual perceives and construes the world…moves the sociological interpreter towards the subject's point of view rather than that of the observer' (p.299). As Weigert (1981) argues, biography 'is the proper source of unity in human existence' (p. 62).

A sample size of ten children was chosen for its manageablility, given the complexity of material that would be gathered, and the time and resource limitations placed on the researcher. The research was planned to extend over a period of three years, from the beginning of the children's third year at school, to the end of their fifth. The schools and children were randomly chosen from primary schools in the greater Wellington region of New Zealand.

Choosing appropriate ethnographic 'tools'

Anderson (1990) lists the main sources of data in ethnographic research as the *physical setting, situations or events, informants,* and *archival material*. This study drew strongly on all of these sources. Information about the relevant *physical settings*, classroom, home, school environments, was gathered through the use of field notes Classroom video footage provided an accurate record of children's seating arrangements, wall displays and mathematics equipment storage. Significant *situations or events* in the children's sociomathematical worlds consisted of daily mathematics sessions in the classroom, special mathematics events such as tests or competitions, special needs classes, or mathematics homework routines. These were either observed and recorded using field notes, camera or videotape, or reported and described by the *informants* themselves - the study children, teachers, parents, siblings, classmates, and principals. Useful a*rchival materials* were children's mathematics exercise books and work samples, mathematics task sheets, children's self assessment sheets, homework sheets, teachers' planning and assessment records, and school policy documents.

In order to construct a consistent picture of the everyday mathematical lives of the children, a balance had to be found between gathering sufficient firsthand data, and ensuring that the presence of the researcher did not significantly alter the subjects or their environments. To minimise the effect of the research process on the children's lives, a maximum of three yearly visits was made to each school to observe the mathematics classrooms in action, and to interview the children, teachers and principals. Parents were also interviewed three times each year. Between contact periods, life went on much as usual. Because of the limited visit time, other methods of gathering data were necessary to build a detailed and reliable picture of what usually happened in the mathematical worlds of the children through the use of rigorous triangulation. For example, it sometimes happened that what was observed in the classroom was far from typical. The children would invariably comment on this departure from routine and describe what usually took place in my absence. This was corroborated by classmates and supported by evidence from their mathematics exercise books where records of daily mathematics sessions were often to be found. In explaining everyday classroom routines, children would occasionally imitate the voices of their teachers to demonstrate exactly how instructions were delivered or feedback provided. In this way, compelling data was compiled that provided vivid glimpses into life behind the classroom door. It was significant to observe that while informants may have shared a common recollection of the form of classroom events, there was wide variation in the ways in which individual participants interpreted and made sense of these everyday happenings.

Becoming a participant

Woods (1983) argues that everyday life is best studied through participant observation:

> 'The key method of interactionsist research is that of participant observation. It involves taking part in the ordinary everyday life of the group or institution under study in an accepted role, and observing both the group and one's own self… close observation and sympathetic interviewing over a lengthy period … construction of meanings that is at the heart of social life.' (pp. 16-17)

Engaging with informants

Classroom observation formed a key part of the data gathering process. Initially it seemed that researcher as detached observer would minimise possible 'contamination' of

the everyday routines, and reduce the imposition on the observees – the teachers and children. As the study progressed, however, it seemed that not only was absolute detachment impossible to achieve, but that 'detachment' often equated with 'distance' from research subjects so that important opportunities to 'see' or make sense of events in the classroom were being missed. Field notes were used to record as much of the action and discourse in the classroom as possible. Weigert (1981) urges the ethnographer 'see the familiar as strange' as, and for this reason even the most seemingly 'ordinary' details were recorded, including, where possible, teachers' exact words when engaging with the children. Because classrooms are sites of enormously complex simultaneous social activity, this was often difficult to achieve. While the priority was the target child, information was also needed that would describe the social context of the classroom. This included interactions between children and teacher, children and children, everyday routines of the mathematics lessons, and the teacher's specialised use of language when teaching mathematics. Details such as teacher instructions and explanations to the whole class, teacher comments to other children that could be heard by the whole class, or children's incidental talk near or around the target child, were also recorded where possible. So rich were the data that I found I was often writing almost constantly during classroom observations. As I became more familiar to the children, I began to 'engage' in the mathematics activities alongside the children, asking questions about the task, and the approaches they were using. Such interaction added to my awareness of each study child's mathematical learning processes and understandings which helped me to make sense of how the child was feeling about mathematics and why. When I stepped out of the 'detached observer' mode and became more of an 'interested participant', the children visibly warmed to this kind of communication and talked much more openly about mathematics. The children seated nearby would often join in the conversation and these discussions generated important insights into the mathematical 'culture' and peer perspectives in classrooms. This was the most valuable part of the data gathering process and led me to believe that in order to understand a child's world one has, in a sense, to become part of it.

Talking with informants

In the early stages of the research, interviews were guided by a carefully structured list of questions, but as rapport was established between researcher and informant, a flexible 'chatty' approach was successfully adopted. Connolly (1997) and Walshaw (2001) caution that in search of the 'authentic' voice of the learner, interviewers inevitably influence their subjects, suggesting that critical reflexivity is required to acknowledge and offset researchers' blindness to infiltration of their own values and assumptions into the research process. The informal nature of the later child, teacher and parent interviews yielded rich and compelling views of the participants' beliefs about mathematics. They showed how and how and why the children's perspectives changed over time. The authenticity of child responses was supported by interviews with teachers, parents and classmates.

Self assessment questionnaires

A self assessment questionnaire sheet was included in the child interview - *How I Feel About Maths* - from Beesey and Davie (1991, p.3). This was used at every child interview throughout the study. The sheet provided the children with scales for rating themselves according to how they felt when doing mathematics, and how good they thought they were

at mathematics. This provided valuable quantitative data tracked over the three years. Because these questions were incorporated into the interview, children were given opportunities to explain their self-ratings, thus providing important insights into how children perceive themselves as mathematical beings, and why.

Self Assessment Recording Sheets

It seemed important to involve the teachers in some simple data-gathering about the children's attitudes about maths between my visits, so it was suggested at first that they encourage the children to write about their maths in some way. One teacher liked the idea of a recording sheet that could be easily completed by the children so he and the researcher designed a sheet together. Class sets were copied for all the other teachers in the study. Some teachers used these more consistently than others. Where they were used regularly, they provided a useful record of the topics the class had been studying in maths, and the study child's response. The sheets later became a helpful talking point when I was interviewing the child and the teacher.

Analysis

It was originally envisaged that the stories of the case study children be presented as ten separate sociomathematical biographies. This seemed not only the most straightforward option but appeared to link most readily to the research questions. During the ongoing open data coding process following the grounded theory methods described by Strauss and Corbin (1990), the startling emergence of common themes from classroom observations, participants' accounts, and archival material, dictated the final form of the analysis and presentation of the research. Prus (1996) claims that 'by drawing comparisons and contrasts across settings, we not only arrive at a richer understanding of each setting, but of similar processes across a wide range of settings…indeed, only by being acutely attentive to the ways in which people experience and shape their worlds and drawing parallels across situations can we hope to achieve a theory of action that reflects group life as it is accomplished' (p. 164). So distinct were the commonly-found patterns uncovered in this research of everyday taken-as-shared mathematics teaching practice across the thirty-seven classrooms in the thirteen case study schools visited during, and reinforced by home expectations and interactions, that four predominant features of the sociomathematical worlds of the children emerged as demanding particular attention: speed activities, catering for perceived mathematical 'ability', establishment of distinctive protocols of 'doing' maths, and construction of mathematics as a dichotomous subject of 'right' or 'wrong' facts and procedures.

Conclusions

This study has created and developed the concept of the *sociomathematical world* of the child in an attempt to define and represent the complex and dynamic social environments within which children experience, internalise and reflect socially constructed meanings about mathematics, about learning and knowing mathematics, and about their mathematical 'selves'. Using this model, the research placed the child learner at the centre of the investigation, and employed methodological tools that provided a much-needed 'voice' for the child's lived experience of mathematical learning. Such an approach regards

'cognitive' and 'affective' dimensions of learning as inseparable. This concept of *sociomathematical world* offers many possibilities for further investigation.

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