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QUESTIONING (IN) SCHOOL MATHEMATICS: LIFEWORLDS AND ECOLOGIES OF PRACTICE

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Questioning (in) school mathematics: Lifeworlds and ecologies of practice

Abstract

The nature and experience of participation in school mathematics classrooms is considered through the analytical frames of community of practice theory (Lave and Wenger 1991; Wenger 1998) and the lifeworld by focussing on interactions generated by verbal teacher questioning of the whole class.

The thesis reports on an explorative, personal inquiry that complements theoretical reflection with research material generated through interviews with learners of mathematics and by participant observation in school mathematics classes. The methodology is qualitative, hermeneneutical and engaged, and influenced by the principles of participative action research and co-operative inquiry in the context of post-modernist thought.

The concept of usual school mathematics is developed to describe dominant social practices in mathematics in schools. Through an analysis of teacher questioning and the learners' experiences of it, the meaning of participation is problematised. The nature of marginal rather than legitimate peripheral participation in usual school mathematics classrooms shows that they are not communities of practice and are better described as regimes of practice. 'Ecologies of practices' is proposed as more flexible construct that allows the diversity of networks and practice in classrooms to be theorised. The nature of particular ecologies can be described (and researched) using similar dimensions to community of practice theory and this is illustrated by a case study which contrasts usual school mathematics practices with those that foster greater engagement by participants.

The concept of the lifeworld supports understanding of the different experience of participants in ecologies of practice of mathematics and teacher questioning. The entities in mathematical lifeworld of learners of mathematics are not just simpler versions or a smaller subset of those in teachers' lifeworld but are existentially and ontologically different and this requires investigation. A case study of a mathematical lifeworld shows school mathematics can be deeply existentially alienating and marginalizing for learners. Students' views on ways of increasing engagement in questioning practices are presented and the implications of the research for engaged, transformative and democratic classroom practice with regard to teacher questioning is considered.

Key conclusions of the thesis are: The analysis of the participation of participants in usual school mathematics practices as marginal demands that such practices be questioned; An ecological perspective allows the complexity of the variety of forms of participation, enterprises and engagement in classrooms to be analysed; The concept of the lifeworld supports an understanding of the diversity of meaning that arises for participants in the same ecologies; There are questioning practices that foster fuller participation by learners.

1

Dedication

This thesis is dedicated to

John Kirkman

1st May 1965 – 10th December 1997

"An inspirational teacher and friend"

Acknowledgements

This thesis is rooted in a belief that we exist as part of web of being, a web that we both we live in and through. This thesis would not exist if I had not been supported by others. More than this, in so far as I make a contribution to understanding a little more about what happens in school classrooms and how it is experienced this is as much due to what I have learned in and from that wider connectivity as from the practice of research and in the academic world. It is not feasible to mention all of those who have stimulated ideas, shown an interest, provoked a thought, offered a story, given a smile or encouragement, but I am truly grateful nevertheless. Thanks are due to all my different teachers, these include:

My tribe of 5 Rhythms Dancers, some of whom 'pop up' in footnotes in my thesis but with a particular thank you to Ros for the chocolates that helped clear some final writing blocks.
Inspirational friends and family – I am very blessed with the amazing people who are in my life
To my dance teachers particularly, Ya'Acov and Susannah Darling Kahn and Gabrielle Roth.
Activists in the Earth First! network and other direct action communities for speeding my understanding of ecology and participation and particularly all those who I have been in affinity groups with.
Isobel Stephenson. a wonderful healer who supported my structural, muscular, emotional, chemical and energetic balance; literally helping me to continue to work at the keyboard.
Colleagues and student at the Mathematics Education Centre at Sheffield Hallam University.
Members of the Critical Mathematics Education Group.
Participants in research student methodology reading group.
Participants in the two Mathematics Education and Society Conferences that I have had the privilege to attend.
The members of the mathematics department at North School in London who made me feel so very welcome.
The various people who offered me beds or floor space so that I could actually carry out the research.
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PRELUDE

A dream: September 1999

A cartoon sequence. A child is in a classroom, a cartoon child. We see him from the back. It is a 'him', it's a me also, but it could be any child, any boy or girl. He has light brown hair. He is sitting at a desk. It's one of those old fashioned desks with a lift up top. The room is full of children at similar desks. At the front is a teacher in front of a blackboard. I am the teacher as well as the child; but it's any schoolteacher. Maybe it's a maths classroom, maybe it isn't.
The boy looks around the room. There is a sense of fear in his movement. As he looks around the room the other children turn into rulers. Each is a ruler upright on the chairs. All these children are there for him to be measured against. And he measures himself against them. All the children themselves are measuring instruments and daily measure each other. So it goes on, measuring and being measured.

At the front the teacher stands large and tall. He turns into the biggest ruler of them all. And the child knows that he can never be as large as the teacher is, he will always be smaller. Even if one day he becomes the teacher the boy will still be smaller than the teacher in his head. So it goes, on measuring and being measured. And always smaller than the internal measuring sticks that we compare ourselves and each other with; the measures that rule us.

Suddenly, the image changes. We are looking down on the room, down on the heads of the children. Each head begins to change, expand and colours with bright rainbow shades. There is an incredible complexity of ever changing patterns in the shape that each head becomes. Each shape transforms into a piece of a dynamic jigsaw puzzle, the pieces rise, they flow into each other, shaping each other until each finds its place in the pattern. Each unique, every one essential, significant in relation to the whole, immeasurable. The pattern that emerges changes constantly. As each shape shifts its colour and hue, the pieces rearrange themselves, as if they were dancing.

CONTENTS

9

PREFACE

FIRST PIECE: ABOUT THE PREFACE

Orderly and disorderly objects

> Ever since you can speak an orderly sentence you are beginning to compare everything that you perceive with this orderly sentence, so that the sentence becomes a model. Each object you perceive is that much simpler, the simpler sentence with which you can describe it: that object is an orderly object about which no further questions remain to be asked after a short simple sentence: an orderly object is one which is entirely clarified with a short simple sentence: all you require for an orderly object is a sentence of three words: an object is orderly when you don't first have to tell a story about it. For an orderly object you don't even require a sentence: for a normal object the word for the object suffices. Stories only begin with abnormal objects. (Handke 1997/1967, page 75)

Peter Handke distinguishes between normal, orderly objects and abnormal objects, that we might, therefore, assume are objects that are not orderly. If they are not orderly then perhaps they are disorderly. I suggest that the implication of this passage is that no objects are really orderly; single word names or even simple three word sentences will not suffice. This belief is supported by recent thinking about the nature of language and the rejection of meaning as an orderly correspondence between words and objects. Across a wide range of intellectual disciplines, it is now accepted that even the simplest of sentences and, what might appear to be, orderly simple objects, do invite further questions to be asked of them. Language and meaning are no longer modelled on an atomistic mechanical universe; we can think instead of webs of meaning and ecologies of language.

The 'objects' of this thesis include: the social practice of mathematics, interactions that follow teacher questioning of students, patterns of student participation in teacher questioning interactions, phenomenology, social practice theory, communities and ecologies of practice in mathematics classrooms, the life-worlds of learners of mathematics, and the means to understand or know about these. These objects, these theoretical and analytical constructs, are not orderly, and so simple sentences will not do. Moreover, the heart of my research project, the motivation for doing this piece of work, is a concern for the young people who daily experience the apparently ordered world of school mathematics. Young people, the breathing, living, learning, growing, individuals and groups, some of whom participated in the research, come to school

13

mathematics and respond to it with social practices that are often, in an apparently different sense, *disorderly*. This was certainly true of some of the research participants in the mathematics classrooms I worked in as a researcher in which a central conflict was apparent between the intended orderly social practices of school mathematics and the actual or desired disorder of the young people experiencing these practices.

Three meanings of 'thesis'

The thesis itself as the 'object' of this preface shares this quality of not being orderly. The thesis is not a simple object, about which a simple preface or introduction will suffice.

Indeed the very term 'thesis' itself has several meanings. I will distinguish between three of these: thesis as a report of a research project, thesis as text, and thesis as claims/story about the world.

Firstly, 'thesis' can refer to the research outcomes, the understandings, the new perspectives, or more traditionally the claims to knowledge or hypothesis, presented in the document about a particular subject matter. Generally, and unless otherwise indicated when I refer to the thesis, or my thesis, I intend this meaning.

Secondly, however, the thesis can be a report of a research project, or a research journey with distinct phases and moments that produced both the thesis as text and thesis as perspective or argument.

Thirdly, 'the thesis' can refer to the document itself, the text you are reading. The text, the research journey, and the thesis proper are informed by two methodological paradigms in which text and narrative are important: aspects of post-modernism and hermeneutics. Choices about textual forms are not arbitrary and not unimportant.

There are a number of different possible theses that I could have written and offered for examination based on the work of my research studentship. I could have focused on the research process itself or indeed, even more self referentially, on the form of text that might allow worthwhile communication and discussion about lifeworlds and ecologies of practice and researching them in the context of schooling. In either of these cases, either the research process or the text becomes the thesis, the argument, in the first sense described above. Yet, as interesting as this research journey has been for me and as

14

important as the question of text and narrative is, what I believe will be more interesting for you and a more worthwhile contribution to the world is what I have to say about school mathematics, teacher questioning, ecologies of practice and lifeworlds. However, because these are my primary concerns in the remainder of the document this preface focuses mainly on the research journey and on the text.

The pieces of the preface

The remainder of the preface is divided into three more 'pieces'. The next piece is the shortest of the three and expands on the description of the argument of the thesis given in the abstract.

The next piece of the preface consists of a research biography. This biography is not incidental to the claims in the thesis. Indeed, it is the background on which the analytical figures are drawn. Moreover, the story of the research gives insight into the nature and basis of the claims made. Including the research biography is congruent with the theoretical positions articulated later about the historical location of humans within and as being lifeworlds and the criticalist and hermeneutic methodologies employed. In addition to the biography a summary of research activities and a selection of material used during the studentship is contained in Appendix I.

The final piece 'How to read the text' discusses those textual forms that I employ, which are unusual in mathematics education research literature although more common in other academic disciplines. The two sections taken together introduce some of the concerns, perspectives, and methodological attitudes that are developed later.

PREFACE, SECOND PIECE: AN OUTLINE OF THE THESIS AS PERSPECTIVE

Thesis outlined

The title of the thesis is "Questioning (in) school mathematics: lifeworlds and ecologies of practice ". I will outline the argument of the thesis by expanding on and explaining the title.

One key element of the research was questioning the usual or commonplace practices of school mathematics. "Questioning school mathematics" here has a dual meaning. One aspect of this is questioning the practices of school mathematics in the sense of critiquing and challenging it. A second aspect is questioning how these practices are reproduced and are apparently so resistant to change.

"Questioning **in** school mathematics", is the particular aspect of school mathematics that I focus on. This is shorthand for the social practices of oral questioning by the teacher of the whole class and the forms in which students respond. Here, I am not chiefly concerned with the mathematical form or meaning of the questions or students' answers but the social meaning of questioning practices and students' experiences of them[1]. Such practices are embedded within, and inseparable from, the wider social practices of school mathematics: however, I focus on teacher questioning because it is both typical and productive of the social practices of school mathematics as a whole.

One aspect of the thesis is to report on and make claims about participants' experiences of teacher questioning and school mathematics and thus about the nature of these practices. I hope I add to the body of knowledge about school mathematics classrooms, teacher questioning and the learners' experience. In this regard, the empirical material contained in the thesis and my analysis of it, tends to support the socio-cultural research on learners' experience of school mathematics that I review in Chapters One and Three. The more novel claims of the thesis are theoretical.

However, I wish to distinguish between claims made and other contributions to knowledge where I aim to illustrate or display knowledge, or support greater

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[1] Here, I gloss over the way in which the mathematical meaning and the social meaning are not actually distinct or separate but the distinction is a useful one to enable discussion about the phenomena to take place at this point.

understanding. The thesis contributes to knowledge in three areas. This is summarised in Fig 1, on page 18.

Firstly, claims are made in the areas of the social theory of education and philosophy more generally. Secondly, I contribute to educational knowledge about the social practices and lifeworlds of school mathematics. Thirdly, I offer suggestions about engaged or transformative practice, or indeed more generally good practice, in the classroom. The diagram tends to suggest these three areas are more distinct than they actually are. Moreover, by distinguishing between social theoretical and educational research claims or practical knowledge, I am not intending to suggest that the latter two categories do not themselves contribute to theory. However, the distinction is useful in providing an overview of the nature of the thesis.

The thesis as text contains material gathered in a number of different research locations and with a variety of participants. In presenting this material I offer interpretations and analysis that contributes to educational research literature. Given the relatively small amount of research conducted in mathematics education from a socio-cultural perspective, I believe the material I present and my interpretations are significant in themselves. At the same time in order to make sense of the material I was forced to interrogate and develop the social-theoretical weave: the nature of the lifeworld and ecologies of practice. I attempted to conduct research that was engaged and transformative, particularly during the second year. An outcome of this aspect of the research is some "knowing in practice" (Reason and Torbert 2001) about teacher questioning and ways that might foster a more participative ecology of practice in the classroom. What is not documented explicitly in the thesis is the way in which the "first-person research" (Reason and Torbert 2001) or personal inquiry has changed my lifeworld and ways of being in the world.

In the diagram I indicate, with the connecting arrows, that the three different sorts of claims interpenetrate each other. There is a dialectical relationship between them. The educational subjects of the research and the material gathered generated theoretical reflections and analysis and this analysis helped further interpretations of the material to be made. As will be seen in the research biography a much wider corpus of research experiences and material was generated during the research and the material presented in the thesis (text) is only a proportion of this. I selected material for inclusion based on

17

its importance in generating the more theoretical claims and on the usefulness of the material in illustrating the theoretical perspectives.

Fig 1

Social theory/philosophy

Ecologies of
practice
and features of
ecologies of
practice in
classrooms

The mathematical
lifeworld and
features of
lifeworlds

Teacher questioning
practices and
students'
experiences.
Cases of ecologies
of practice
Cases of lifeworlds.

Questioning
practices that
encourage
participation

Engaged classroom
practice

**Educational
knowledge**

**Practical
knowledge**

I had not intended to produce such a social theoretical and philosophical thesis. However, I found that to understand my research experiences, the reported or observed experiences of participants and to guide action, I needed to interrogate the philosophical and theoretical constructs that I had adopted and to develop or find alternatives.

The social theoretical claims of the thesis are[2]:

- School mathematics classrooms are not generally communities of practice as described by Lave and Wenger, crucially because the nature of participation in them is different. This is evidenced by the nature and meaning of teacher questions in the lifeworld of participants.

- School classrooms are better understood as ecologies of practices. This more flexible construct allows the diversity of networks and practice in classrooms to be theorised. The nature of particular ecologies can be described (and researched) using similar dimensions to community of practice theory.

- Usual school mathematics classrooms as particular types of ecologies of practice are best described as regimes of marginal practice.

- The concept of the lifeworld supports understanding of the different experiences of participants in ecologies of practice of mathematics and teacher questioning.

- The entities in the mathematical lifeworlds of learners of mathematics are not just simpler versions or a smaller subset of those in teachers' lifeworlds but are existentially and ontologically different and this requires investigation.

The educational knowledge claims of the thesis relate to particular cases of ecologies of practice and lifeworlds in relation to school mathematics social practices generally and practices related to teacher questioning in particular. These are many and varied and are found throughout the thesis. Though they do support greater understanding of the social practices and experience of school mathematics, the claims are made about particular cases and are not generalised. Some additional claims or descriptions are:

- The enterprise of learning mathematics is often marginal to students' participation in teacher questioning interactions (and other social practices) in usual school mathematics classroom. Such interactions can cause anxiety, as they did for many students in the cases in this research.

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[2] For brevity I do not include references at this point.

- A case study of a mathematical lifeworld shows school mathematics can be deeply existentially alienating for learners.

- Students' views on ways of increasing engagement in questioning practices are presented.

By its nature practical knowledge consists of both tacit and explicit understandings. Tacit knowledge in particular is very dependent on context and explication of that knowledge does not necessarily provide a set of strategies to follow. So I make suggestions towards the end of the thesis about ways that teachers can act and be in the classroom that may promote greater participation by students particularly in teacher questioning interactions.

The nature of the claims of the thesis

The notion of claim is one that I am suspicious of. Making a claim has resonances of securing territory or property. There is something competitive, definite, and fixed about it. Yet I do not feel this way about the contribution that I am making. 'Claiming' fits with a notion of knowledge that does not sit easily with the methodology I use, the methods employed, nor with the theoretical positions I argue for. In particular it is counter to a sense of knowing as a process.

Yet, I am making assertions about the way the world is. Knowing and knowledge may be a process but it is a process that entails adopting moment to moment positions that are definite and, in each moment, apparently absolute. At the same time there is a, perhaps, wiser part of ourselves who understands that all is provisional and subject to revision, that the hermeneutic process is not so much a circle but a spiral.

An underlying theme of the thesis is how unity in diversity may be achieved. For example, how ecologies of practice can be encouraged in which each unique individual lifeworld can contribute and be nourished. I believe that one means to enable this is for each person to communicate as clearly as they can what is true for them in a particular moment. As a dancer I know that the dance of any relationship calls for embodiment and presence in the moment by each dancer otherwise the dancers dance separately, even if in the same physical space.

In our day-to-day life, there is often a reluctance to say what we see, what we feel, and what we mean[3]. As Gabrielle Roth puts it, too often we say "Yes", feel "No", and act out "Maybe" (Roth 1999, page 195). This is often true in schools that almost seem purposefully designed to discourage emotional honesty. For example often in school mathematics classrooms, the teacher is bored, the students are bored, and sometimes it even feels that if it were possible, mathematics would be bored as well. Yet no one says it. Where someone does say what he or she feels or sees in a definite way apparently intractable situations can be transformed. At the very least it allows a conversation to begin. I return to this at the end of the thesis.

Thus, if I am to 'walk my talk', then I have a responsibility to put forward the perspectives that I have developed in a way that is certain, to stake a claim and defend a position. Even though in awareness of the greater dance, I know that the claims made and positions taken will change. Indeed, by making strong claims I do so as a way to paradoxically nurture that process of change. The phrase "It is so" needs to be reclaimed from dogma and this may be done without believing that your "It is so" needs to be the same as my "It is so".

The alternative is to lose ourselves in a formless swamp in which reflections on our knowing prevent us acting upon it. This is the shadow of the recent concern with text where too often the writer (and reader?) becomes lost in the discursive. An ecological perspective speaks of the way we are intimately part of each other and the world. But to speak of this intimacy and to attempt to begin to develop the ecological awareness to act within it requires boundaries to be drawn, ideas defined, tools honed, and stories to be told.

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[3] I leave aside the crucial issue of how hard it is for us to know what it is we see, feel, and mean.

PREFACE, THIRD PIECE: A RESEARCH JOURNEY

Part One: An overview

I make no pretence of neutrality or disinterest within the thesis. This is a piece of engaged research, which stems from a deeply held commitment to social and personal change. Informed by hermeneutics, my interaction with participants was subjective. I have struggled within the boundaries of the ecologies of practice of academic research to find a place for my heart to be in and behind the work I have done and what I have written.

> I came to theory because I was hurting – the pain within me was so intense that I could not go on living. I came to theory desperate, wanting to comprehend – to grasp what was happening around and within me. Most importantly, I wanted to make the hurt go away. I saw in theory then a location for healing. (hooks 1994, page 59)

I will not claim the same intensity of experience as bell hooks or the same desperation. Nevertheless, my decision to engage in the theoretical journey of a PhD arose from distress at the way I was living. I could not continue as a school mathematics teacher acting in the way that I had.

From the outset I conceived of my research as exploratory, both in terms of my own personal inquiry into the social practices of the mathematics classroom and in its relationship to already existing research. This exploration has been "a creative process, involving its own prolonged, complicated and unpredictable course" (Salmon 1992, page 10).

In Appendix II, I offer a piece of biography written in the third person that describes part of my personal background that I consider relevant both to my decision to engage in the research project and which has shaped, consciously and unconsciously, both my actions and analysis. The Appendix, if nothing else, underlines that this research is located at a particular point in a personal history; there was a 'before the research'.

In the description of the research journey, I outline the different phases of the research process in terms of time periods. In a sense, these are necessary fictions imposed to give some purchase on what was a much more fluid and continual experience. In the description of each of these phases I address a number of themes, though not necessarily

in the same order. These themes are: the research questions or focus; the research activities and related purposes – what I was doing and why I was doing it; what emerged as findings in process; the development of my methodological thinking; and the development of the theoretical framework that initially guided the research and later became an important subject of the research. At this point, my description of the development of the methodology and theoretical framework is brief and generally unrelated to literature. This is to avoid repetition in later chapters.

In choosing the parts of the journey and thinking to highlight there is inevitably a reading backwards to construct a narrative that tells a story. The dead ends, the possible routes, the convoluted and at times confusing process are not properly represented.

I have focused on the experiences that relate most closely to the collection and interpretation of research material. For brevity (a relative word here) other experiences important in a less obvious way are passed over. However, four are particularly worth mentioning. Firstly, the importance of meeting with and talking to other educationalists and researchers, especially at national and international conferences. Secondly, the influence of working with students in higher education engaged in developing their own mathematical understanding. Thirdly, observations of mathematics lessons conducted whilst supporting Initial Teacher Education students I was teaching or moderating. Fourthly, my increasing personal involvement in communities, ecologies of practice and networks, in the ecological and social direct action movement.

The early focus of the research

My statement of research interests when applying to begin the PhD focused on "intrinsic and extrinsic learner motivation". This arose from my experience as a school teacher of the demotivating nature of much of the content and teaching methods current in school mathematics. My first task as a researcher was to turn this general interest into a formal research proposal.

Before this preface, as a 'Prelude' I included a description of a dream that I had two nights before the official start date of the PhD[4]. I cannot underestimate the impact this experience had on me at the time nor the extent to which this dream has been a continual reference point or anchor to my research process. It represents, hermeneutically, what Gadamer would term my "prejudice" (Gadamer 1975) or for Heidegger "foreknowledge" (Heidegger 2000/1926). The research can be understood, in one sense, as an explication of this dream's meaning. You might find it useful to turn back and reread it (often).

One reading of this dream is as an answer to my early questioning about motivation. It stresses the importance of measurement in school classrooms and of being right or being wrong. The relationship of measurement is not simply with other people but with mathematics itself: "Smaller than the white maths on the blackboard". It underlines the way in which the experience of the school classroom for an individual is intimately bound to the social norms or practices of the classroom. There is not an individual experience even though it is experienced individually. The dream also offers the possibility of change, of a situation in which each child or person finds their place in the jigsaw puzzle and is free to find and to develop their own unique contribution.

The dream suggests a very wide concern, wider even than the initial broad topic of motivation. Yet a formal research proposal required a clear focus, research questions, a methodology and a research plan.

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[4] The inclusion of the dream and its importance to the development of the research is somewhat unconventional in educational or social research. Justification or discussion of the methodological implications would require more space than I can give to it, but I note that in other academic disciplines such as psychoanalytic theory dreams are the subject of research. I am also told by a psychotherapist friend that in process orientated psychotherapy particular attention is paid to dreams that occur the night before a first appointment or before a group workshop.

As one way of attempting to engage with the issues that I was concerned with I highlighted the issue of 'mistake making'. My initial research proposal title was "Changing ways of knowing: how learners experience 'mistake making' in mathematics classrooms". By 'changing ways of knowing' I intended to convey both the way in which mistake making might be important to our ways of knowing and the possibility of changing these ways of knowing.[5]

During the initial stages of the research I attempted to deal with three strands of the research issue separately. Firstly, how learners of mathematics experience mistake making in mathematics classrooms and possible relationships between this and the general experience of mathematics. Secondly, possible ways to describe a learning environment in terms of an identifiable mistake making culture. Thirdly, the thinking of teachers about the mistakes learners made and their responses to them. Although I initially explored these three strands separately, I intended to bring the three strands together at a later date.

First research activities

This period was one of relatively intense training in research methods and education about research methodology as well as encountering a much wider body of educational literature than I had previously experienced. I wanted to have practical experiences of research methods both to develop my research skills and not least because it was not clear to me at this stage what type of research practices might best support my research intentions, nor the most suitable research sites. Particular research methods that immediately appeared relevant were participant observational skills and interviews.

Thus activities in the first phase of the research aimed to begin to develop an understanding of the various strands of the research, to collect some research material on these strands, to develop research my skills and to be able to make later methodological choices on the basis of experience. These activities were deliberately eclectic.

I carried out observations in the classrooms of two primary teachers with contrasting teaching styles. These were Year Six (10-11 year old) and Year Five (9-10 year old) classes. I observed both National Numeracy Strategy lessons and other lessons

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[5] Though the research process has changed me much, I note that my preference for titles with double meanings remains unchanged.

experienced by the children with the same teachers, visiting the classes on three occasions each. In addition I observed a number of mathematics lessons taught by a secondary school teacher.

As a result of one observed incident in the secondary classroom, I arranged to interview the two girls involved. This interview consisted of asking the children to read through my notes of the incidents out loud, effectively playing their parts as actors. This was a starting point for a conversation about the incidents. One question I had in relation to this interview was about the question of gender and as a result I arranged to interview a small group of boys from the same class. Interviewing groups of children together foreshadowed later interview strategies with other research participants, as did using previously generated research material as to focus conversation and discussion during interviews.

My particular interest with the school based research activities was on interactions and behaviour that occurred in relation to mistake making. The theme of teacher questioning began to emerge at this time, particularly as a result of the primary experience in the context of an emphasis on whole class interactions in the newly introduced National Numeracy Strategy. In addition, mistake making in teacher questioning interactions was, at least to some extent, an observable phenomena.

I also attempted to see if it was possible to delineate or define a 'mistake making culture' in a particular classroom. However, the interview with the boys demonstrated that there might not be a single mistake making culture in a classroom and even if there was it was not experienced by all participants in the same way[6].

As a second strand of research I began a series of interviews with adult learners of mathematics involved in Initial Teacher Education primary mathematics courses. Four interviews were conducted in total during this phase. Three of these were individual interviews the last being a group interview. The interviews focused on the general experience of mathematics, the experience of schooling, teacher questioning and mistake making.

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[6] It appears naïve now to believe otherwise, and I think if asked before the interviews if I believed that classroom culture is experienced in the same way I would have said no of course not. However, there is something compelling when this theoretical knowledge becomes embodied in an encounter with living, complex beings.

The research participants were all students I tutored on a Third Year Primary Mathematics undergraduate course. The unit studied involved the students in extending their own mathematics and experiencing mathematics in new ways. I had planned to interview adult learners, and to some extent my choice to interview these undergraduates was because of ease of access. However, more compelling was the surprise that I felt when I realised that collectively this group of students (all women) were very unconfident about their mathematical ability in spite of the previous academic relative success of all of them (a requirement for entry to the course). When I talked about my work in encounters with strangers or with friends I had come to realise the extent to which many people carry the wounds of school mathematics into later life. But here was a group of academically successful learners who apparently shared many of these wounds.

The group interview with the students was significant because of the way that the students entered into dialogue with each other and perspectives emerged which might not have in a one to one interview situation.

A third strand of work begun during this phase was with three student teachers, Peter, Jill and Paul[7], on the professional year (second year) of a two year Post Graduate Certificate of Education course in mathematics. Here my intention was to begin to develop my skills in working with teachers attempting to change their practices and to engage with teachers' perspectives on mistake making. Although these students were on an initial teacher-training course all three had previous experience as educators in different contexts. The focus of our work together was teacher questioning. During this phase, this work did not move beyond discussion, observation of lessons and mentoring. However, two of these student teachers later played a significant role in the research.

Theoretical frame and exploring methodology

The main theoretical framework that I adopted to explain the observations, interview material and other research experiences was the form of social practice theory developed by Jean Lave and Etienne Wenger in their theory of learning in Communities of Practice (Lave and Wenger 1991; Wenger 1998). Communities of practice theory offered a theoretically developed means to understand and define what I had initially identified as a mistake making culture. It offered a means to unify consideration of

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[7] All names throughout the thesis are pseudonyms with the exception of 'Peter' as we co-authored papers together that are referenced.

classroom practice with the experience and identity of the learner. At this point, my adoption of community practice theory was relatively uncritical and unreflective.

I began the research as a schoolteacher with relatively little knowledge of research theory or methodology. The first phase of the research included intensive education both formal and informal in research methodology and methods. At the outset I chose to adopt an attitude of "methodological humility [which] requires that one operate under the assumption that there may be some concept or event that cannot be immediately understood" (Gruen 1994, page 33). Moreover, I suggest that sometimes such humility should be extended to recognise that even the means to understand or research a concept or event may not be immediately apparent. However, two of the methodological traditions quickly established themselves as important to my thinking. These were the critical research tradition and hermeneutics.

As I have described, when I began the research, I already had strong axiological commitments with regard to education. I was concerned about the practices in schools, a concern that was deepened by the early practical research experiences. In addition, I had already come to identify myself with a critical education tradition through participation in a Critical Mathematics Educators group. For years my social activism had been guided by Marx's famous maxim that the point was not to interpret the world but to change it. It was natural to turn to the critical research tradition as a key influence. In particular, the approaches and methods of critical ethnography appeared suitable for researching the 'mistake making cultures' I was interested in.

I was also concerned with the individual experience. Educational ethnography appeared to speak about culture, but did not, I felt, get to the heart of the experience of such cultures for individuals. Nor did it appear to fully address the fundamental existential questions of purpose, value, and relationship to self, world, and others, that I felt were important in the question of the experience of mistake making in mathematics or the experience of mathematics more generally. Here, I was drawn to phenomenology as a philosophical and research tradition that offered a means to address these concerns.

I conducted the early individual interviews with adult learners within the phenomenological tradition. However, I soon found that my identity as teacher, my knowledge as an educator and my desire to enter into dialogue with the research participants precluded a strictly phenomenological approach. This led to an

investigation of Gadamer's hermeneutics as a model for both the interview process and for interpretation of the material gained (Gadamer 1975).

I was aware that these different research traditions had very different philosophical bases. However, it did not seem to me that this necessarily precluded the use of seemingly contradictory approaches. In any case they both seemed to reflect, in a theorised form, common and legitimate means by which we come to know about the world. A methodological pragmatism began to develop. I sought justification for this in post-modernist critiques of grand narratives.

As stated earlier, the research methods that I employed were eclectic. During a period of intellectual ferment I explored different approaches to research and different methods all within the qualitative research traditions. I attempted to conduct each individual research act according to the relevant protocols and habits of the research tradition I was drawing on.

Part Four: Summer 2000

Overview – Defining the work

The research activities and thinking during Summer 2000 were an edge between the early flow of the research and the later period of sustained action and intervention in a school classroom. At this point key issues began to be identified and concepts defined.

The early research experiences introduced two issues that affected the focus of the research. Firstly, the importance of teacher questioning of the whole class as both formative and indicative of the classroom community of practice[8]. By this point the issue of mistake making had become secondary to teacher questioning in the classroom. The second was the difficulty of describing this aspect of the experience of school mathematics separately from the experience of school mathematics generally and issues of identity. These two factors tended to suggest contradictory possibilities for advancing the research.

At the same time, the early research experiences reinforced my desire to explore the possibilities of changing practice through the research project. Both theoretically, through my study of hermeneutics, and more concretely through the experience of

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[8] At this point the idea that classrooms were communities of practice was a premise of the research.

29

interviewing, the possibility of dialogue about the experience of school mathematics began to emerge. Entering into conversation with learners about their experience and facilitating dialogue between teachers and students appeared to offer emancipatory possibilities.

I continued to work with and analyse the material gathered during the first phase of the research and began to report on some of the research outcomes (see Anderson and Boylan 2000).

Two key episodes occurred during this period. Firstly, the research activities with Peter at East High School, described more fully in Chapter Three, and secondly the interview with Louise, the subject of Chapter Four. The context of these research activities is described extensively in the two chapters. Here I will only summarise them and describe their relationship to the research project and history, before describing the way in which these two very different research experiences influenced my thinking and the directions of the research.

Peter, teacher questioning and dialogue

Peter was one of the student teachers I had begun to work with during Spring 2000. I visited him to spend time with him observing him in the classroom and giving feedback. By this time I had largely put the project with the student teachers to one side. The experience of observing them in schools and discussing with them their classroom practice had been informative and useful but I did not see that the way I was working with them was a useful model for future work. When I visited Peter in East High School on the occasion that gave rise to the case study, I did so out of my desire to fulfil the commitments I had made to him and the value I found in spending time in as wide a variety of classrooms as possible rather than to 'collect data'. However, as often happens in life, it is the unexpected, unpredictable or unintentional encounters with the world that teach us the most or change our direction or understanding.

From one initial incident in the classroom when I intervened and prompted a discussion about the students' experience a further discussion, survey, and interviews arose. I had unexpectedly found an opportunity to open dialogue in a concrete way about the experience of school mathematics and had employed methods that seemed to facilitate this.

The case study both strengthened my interest in teacher questioning and also underlined the complexity of the issues surrounding the student experience. It pointed to the importance of considering more than the individual classroom but also both the general social practices of school mathematics and the social practices of the school as a whole. It was at this point that the theoretical means of describing school classrooms in terms of communities of practice began to become a subject of the research for the first time.

Methodologically, fostering dialogue not only appeared practical, but also Peter confirmed the way it might support changes to practice when he told me that although he had read academic texts on students' experience it was different when, as he put it, "You hear them yourself".

Issues of power in the relationships between researcher, teacher participants and students, began to emerge as lived experiences, which posed a number of difficult questions for me. The group interviews appeared to give students, particularly the girls, confidence to speak about their experiences. Yet there were clearly issues of power and rank within the groups themselves. I attempted to theorise about the way that I was giving "voice" to the students, yet was also aware that my analysis of their views was made from within my particular lifeworld and that there was an element of performance and presentation of self on the part of all of us.

However, the case study with Peter seemed to offer a model for discrete interventions in classrooms in which classroom practice might be observed and then such practice be the basis for dialogue between researcher, teacher, and student. I had explored the possibility of a sustained critical ethnography but had not found a suitable location. I was aware of how pressured teachers were in schools and short research interventions such as the one with Peter, seemed to be more practical and ones where teachers might be able to see a more immediate 'pay off'[9]. The case study pointed to the value in facilitating dialogue between different students within a class especially if the social practices of the classroom became, reflexively, one of the subjects of the dialogue. Methodologically, within the wider critical research tradition I was drawn to the protocols of participative action research and co-operative inquiry (see Chapter Two).

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[9] One aspect of my lifeworld revealed throughout the research process, is the extent to which I was bound by the principle of exchange. Such values permeate schooling.

The interview with Louise was of a very different nature. Here I engaged in a single conversation with one person over a relatively long period of time. Louise's candour led to an intimate experience of hearing for the first time the testimony of someone who felt she had been severely wounded by the experience of school mathematics. More than this, I felt that I encountered Louise as if she came from another country or even another planet in terms of her relationship to mathematics. This was another concrete experience that began to make sense of an important theoretical concept, the lifeworld.

Attempting to understand, hermeneutically, Louise's lifeworld raised issues about the nature of the relationship with self, others, and the world in totality. At this point my reading of phenomenology as a philosophy was limited but I was aware that at the very least the application of such philosophy to explain Louise's lifeworld as interpreted from the interview was problematic. At the same time, similar themes emerged in this interview as with the interviews with school students.

This also led to the realisation of the extent to which the interviews with school students at East High School only gave a very partial insight into a class of learners each within their own lifeworld. I was struck by the fact that I must have taught students with a similar experience to Louise without realising it. The experience was humbling and sobering.

Part Five: Summer 2000– Autumn 2000

Towards the second year

As I neared the end of the first year of the research I had a wide range of research experiences both in schools and through individual interviews. I had developed my methodological skills and had encountered a wide body of educational literature and theory. However, I needed to develop from these experiences and reflections a more focused and manageable research project. I had explored three strands of the research, one of which, the interviews with adult learners, relied on a very different methodology to the other two, and called for an exploration of a difficult and demanding philosophical tradition. I felt I needed to make a choice.

The interviews with adult learners, particularly with Louise, were very rich in terms of informing my thinking about school mathematics. However, emotionally their contribution strengthened my desire to engage in more active critical or emancipatory research. Put crudely, whilst it felt worthwhile to listen to and analyse the ways in which school mathematics damaged learners' sense of identity and relationship with the world it felt more important to do something about it. Moreover, my encounter with hermeneutics led me to begin to theorise about dialogue and conversation not only with participants but also as a metaphor for the research process itself. I felt a richer conversation could be had in the prescient world of schooling. Somewhat reluctantly I decide not to continue with further extended hermeneutic interviews.

Research aims

I formulated a research design that built upon the research activities with Peter. I quote from my RF2 report that formed my application to transfer from MPhil to PhD.

> I intend to re-title my research "Opening dialogue about the experience of learning school mathematics".
>
> My aim over the next two years is to conduct a series of short interventions into two or three secondary mathematics classrooms with the intention of facilitating dialogue between members of the class community and between the class and teacher about the experience of learning mathematics and to record what happens as a result.
>
> The research will consist of two or three collaborative inquiries with classroom teachers about aspects of their classroom practice and a connected reflection on these inquires as a whole. This reflection is the main focus of the research. In addition particular foci for each class will be negotiated and this collaborative work may be reported on separately.
>
> The aims of the inquiry are to:
>
> - explore the conjecture that dialogue about the experience of learning mathematics can help to change the social practices of the classroom and in particular encourage greater dialogue about learning mathematics
>
> - explore how teacher beliefs and practices change as a result of engaging in dialogue about social practices
>
> - explore if and in what way the participants' characterisation of the social relationships within the class community change

- explore the value of socio-cultural approaches to mathematics education research, in particular focussing on the usefulness of theories of social practice and communities of practice

- explore the limits and opportunities for change within mathematics education and to reflect on the ways research might contribute to this

In this thesis (text) the outcomes of the research with respect to the first three aims stated above is largely omitted although these themes are addressed in the concluding chapter. This is not because such outcomes do not exist, rather that the question of how to theorise the nature of social practices and the experience of participants within these practices became more pressing. Reflecting on the research aims I note the way in which my interest in teacher questioning does not appear. The reason for this was that I intended the research to be collaborative and so envisaged that the exact foci with each teacher would be negotiated. In the event teacher questioning did become the focus of the one collaboration that occurred with Jill as she identified communication between herself and students and between students as a pressing and important issue for her.

Methodology

I based my research practice on principles drawn from Co-operative Inquiry (Reason 1988, 1994a, 1998; Reason & Bradbury 2001a) and Participatory Action Research (Fals Borda 2001, 2002; Reason1998; Reason & Bradbury 2001a). I located the research in the critical tradition (Carr and Kemiss 1986; Kincheloe and McLaren 1998). I did not characterise the project as action research due to both the relative brevity of the collaborations and my interventionist intentions as opposed to supporting attempts to change classroom practice that arose from the teacher's own reflections. As a central methodological tool I drew on Renuka Vithal's concept of "hypothetical", "actual," and "arranged" situations (Vithal 1999, 2000). Vithal suggests that one way of approaching critical research is to posit an imagined, desirable, hypothetical situation, to pay attention to the actual situation and, based on these two descriptions, to seek to create an arranged situation. Together the three situations form a methodological triangle to guide action and interpretation through research cycles.

As a desirable hypothetical situation I posited the notion of co-operative co-reflective learning communities. This concept was a development of the notion of communities of inquiry (see Cobb et al 1992; Goos, Galbraith and Renshaw 1999; Groves, Doig and Splitter 2000) and learning communities (Rogoff et al 1996; Wenger 1998) in the

34

context of seeking an engaged and transformative pedagogy.   A co-operative co-reflective learning community is one that:

- is aware of itself as a community –it is co-reflective
- has ways to reflect on its social practices through dialogue
- is aware of the formatting environment
- social practices are transparent. Roles maybe different but are open. Power is productive
- author/ity (Burton and Povey 1999) is shared and its distribution negotiated
- participation is exercised consciously and with autonomy
- diversity is valued
- conflict that arises from this diversity is used creatively
- members recognise an ethic of care for others – mutuality.

However, the arranged situation would be more limited, facilitating dialogue between the teacher and students about particular practices of the mathematics classroom. Further discussion of the methodology of the research during this year is included in Chapter Two.

Jill

Jill was another of the ITE student teachers that I had worked with earlier in the year. She had impressed me with her interest in the views of her students. During her final teaching practice she provided the children with feedback and evaluation sheets so they could comment on aspects of her teaching. In general she was concerned to know about the students' experience of her teaching in order to improve it[10].

Jill had obtained a post at a school in London and her description of the mathematics department led me to believe that they might be willing to allow her to cooperate with my research.

Over the summer we discussed working together and sought and obtained the agreement of her Head of Department for the project. Jill and I agreed that initially we would work mainly with her Year Seven class and possibly one of her Year Eight groups.   In addition I would observe other classes.   During our discussions she identified the issues she wished to work around with the Year Seven class – communication in the class, in particular changing the 'shouting out' behaviour of some and increasing participation of others. She was already intending to do an end of half

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[10] Aspects of Jill's approach to teaching and of her lifeworld are included in Chapter Six.

35

term questionnaire for the students as feedback to inform her teaching and I suggested some possible questions.

After my first visit to the school to discuss the research, Jill communicated her enthusiasm and excitement about the prospect of us working together but she also felt daunted not least because of the pressures she already felt as a Newly Qualified Teacher in the "daily panic of school life" (from email). Whilst I was going to great lengths to attempt to include Jill fully in planning our work together, Jill asked for me to take a greater lead and not to hold back on advice. She also sought support from me in terms of specific positive feedback on her practice.

Jill was unusual in her mature and thoughtful approach to classroom practice and her concern to engage with the students' experience of her teaching. Nonetheless, in retrospect the possibility of a fully collaborative inquiry with a novice teacher by a novice researcher was probably unrealistic. I discuss this further in Chapter Two.

We agreed on a plan of visits, observations, and interviews for the Year Seven class, Seven Blue. After initial observations we agreed on some possible new approaches to Jill's teacher questioning practices and the norms she attempted to encourage in interclass communication. The plan was to interview students at a later date.

Part Six: Autumn 2000-Summer 2001

Changing research practice and role

Very quickly the planned research activities had to be revised. It became clear that the idea of conducting a series of interventions, working with a number of different teachers was unrealistic. I had not anticipated the amount of time needed to develop relationships with both Jill and with the children in the class. Moreover the planned activities with Jill alone were overly ambitious. It became apparent that Jill and I interpreted the meaning of important issues in our discussion differently, thus the process of collaboration required frequent re-discussion of issues and direction.

Importantly, regardless of any consequences of the research project, social practices in the classes changed rapidly. Partly this was a natural feature of the development of a class as an ecology over time and partly due to Jill's quick development as a teacher.

Jill had focused on the Year Seven class because of difficulties with communication in the class, many of the students particularly the boys, would "shout out", often at the same time. We had discussed possible ways of approaching this, but before these had begun to be acted on, the dynamics in the class changed. Difficulties in communication increased. Jill came to focus on managing the class. I had carried out a survey, similar to the one done with Peter's class that is detailed in Chapter Three. The intention was to use this as a basis for a first round of interviews as a step towards 'opening dialogue' with the class. However, these interviews were delayed at Jill's request because she felt they would be "unsettling".

I felt a number of different influences affecting my actions. Firstly, I had embarked on a co-operative inquiry with Jill. This meant that I was not in control of the research process but had to be led by Jill's concerns and needs[11]. One of the principles I had adopted was that the research should be worthwhile for all involved or at least I should act to try to bring this about. I keenly felt a duty of care to Jill and her students and that their situations and experience should not in any way be affected negatively by my research work.

Secondly, simply observing and participating in the unfolding process was very educative. Spending time with the class and Jill was fascinating. Not least because much of the hidden tensions identified in my earlier research activities were here transparent and on the surface. As a site of social inquiry this was important. I felt it was important to record and witness this collection of individuals contest social practices both with the teacher and with each other. In the fast changing situation in Seven Blue issues of power and contestation of power were strikingly manifest. I had identified that the issue of power as not adequately addressed by community of practice theory or at least in some interpretations of it (see Contu and Willmott 2003).

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[11] Care and concern for the other was not one-way. A repeated theme of conversations with Jill was her concern that I was gathering material or having experiences that would allow me to complete my PhD.

Thirdly, I was attempting to complete a research studentship, which needed to lead to a credible and productive thesis. I was not sure if dialogue in the sense of a conversation between the class and the teacher was going to be possible at all.

As a response to these three different concerns, I redefined my role. In relation to the students in the class, the balance shifted for a time, from being an action researcher to being an ethnographer and participant observer. However, with regard to Jill, my intervention became greater, I was working with a new teacher, who was fast becoming a friend, who was finding one of her classes very difficult to teach. As part of my role as teacher in my last post, I had mentored student teachers; I felt a responsibility to respond to her requests to offer advice as an experienced teacher. The concept of engagement (see Chapter Two) emerged as a means to guide and theorise about my actions.

In addition to the methodological issues I encountered, a parallel concern was the extent to which the theoretical framework I was employing, community of practice theory, was inadequate for understanding the changing practices within the class.

Surrender

To some extent at this point I had to surrender to the research process, acting in the moment with little time for reflection and theorising. I sought solace in Gadamer's notion of a conversation in which neither participant can control the outcome but the conversation leads both on. I drew on my experiences as a dancer and trusted in allowing the dance to unfold. Sometimes when we find ourselves in situations that are caused in part from a naïve foolishness, we need to drop more deeply into the Fool as an archetype available to us and give ourselves over to the impulses of the artist, the actor and the clown rather than the planner and analyst.

The above metaphor not only resonates with my experience as a researcher but also I believe, with that of teaching school children. Particularly, where changes are made to classroom practice that inevitably have unintentional and unpredictable consequences.

Towards dialogue

Towards the end of the autumn term, the situation in Seven Blue had become a little calmer and I did a first interview with a group of girls in the class. The interview gave

insight into the negative experience of some of the girls in the class who felt excluded by the social practices of the boys. I was faced with the dilemma of whether I should share my early analysis of what I thought was happening in the class and the understanding that I had gained from listening to and observing the students and the extent to which I should more actively support Jill in seeking to change the social practices of the boys. This was a key moment for me in the research and I came to the view that firstly, 'engagement' in the situation required me to 'take the girls side' and secondly, that for Jill to be able to share authority she first of all had to establish it. This issue and episode is discussed more fully in Chapter Seven. In any event, I shared this material and other material with Jill[12]. As a consequence, I was able to start a process of becoming a conduit for the class's views to Jill. This was not what I had intended by "opening dialogue" but did mean that her practice began to be informed by the students views and experience. I also changed the nature of my support for Jill from more general advice about classroom practice to specific suggestions related to strategies to work with individuals, groups of students and particular social practices.

By January 2001, a first round of interviews were complete. By February, the nature of the social practices in Seven Blue had changed. In Chapter Five I use material from two typical lessons from early December and February to illustrate aspects of the changing ecology in Seven Blue. In the thesis I make no strong claims about why these changes occur as it is not possible to separate out the different factors involved in any systematic way, but rather I focus instead on the nature of ecologies of practice in school mathematics classrooms that are highlighted by both episodes. Further research material was gathered in relation to Seven Blue over the course of the year, through discussion, surveys, interviews, and observations. This generated a corpus of material which, I believe, supports the claims I make about the class and about the lifeworlds of individuals in Chapters Six and Seven .

Apart from work with Seven Blue, I undertook other research activities at North School. I conducted a number of formal interviews with Jill and had more informal discussions that were taped or notes taken. I was a participant in the life of the department in various ways. I spent time with Jill in other lessons, sometimes participating in lessons and at others more formally observing. In this process I adopted various "complementary and conflicting roles" (Ainley 1999).

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[12] The students' had been informed that the interviews were not confidential though as far as possible I would avoid identifying comments with individual students if they asked me not to.

Towards the end of the year we applied some of the research methods used with the Year Seven group with her Year Nine group. We conducted a survey about attitudes to mathematics and teacher questioning and this became the basis of interviews with approximately half the class. In many ways, this was the sort of intervention that I had originally envisaged at the beginning of the year, but which neither Jill nor I were ready for at that time. An outcome of this work was collaboration on a set of teaching materials and activities that aimed to develop a sense of community within the classroom. The introduction to these activities is included as Appendix V.

Part Six: Autumn 2001 Onwards

Writing as research

Perhaps, it is unusual to include this period as being part of the research. Finishing a thesis is commonly referred to as "writing up" which implies that research findings are simply presented. However, as the research took a more theoretical turn, the research activities became more in keeping with those found in social theory research or philosophical research.

Also writing itself is a method of inquiry:

> ...a way of finding out about yourself and your topic. Although we usually think about writing as a mode of "telling" about the social world, writing is not just a mopping-up activity at the end of the research project. Writing is also a way of "knowing" – a method of discovery and analysis (Richardson 1998, page 345).

Adopting this attitude, the process I am currently engaged in is research and this chapter is not a precursor to the 'main event' where I tell you about what I did and what happened as a result. The text is both an outcome and a process of the research.

Theoretical breadth

During my work at North School I was aware that the theoretical model I had initially started with did not provide the tools needed to make sense of the phenomena I participated in. When I came to reflect, review, and crucially write about those phenomena I was compelled to interrogate the theoretical framework more rigorously. This led me to consider an ecological perspective to think about the social practices of the classroom. The evidence from interviews and observations of the different meaning

that participants placed on what appeared to be shared social practices, encouraged me to once more investigate the phenomenological concept of lifeworlds and to reanalyse the interviews I had conducted in the first year – particularly Louise's lifeworld.

This necessitated broadening the scope of my analysis to draw more fully on social theory, philosophy, sociology, phenomenological psychology, and ethnography. Indeed in a sense the inquiry has become an inquiry concerned with those disciplines. At the same time, I am not 'trained' in those disciplines.

Other researchers writing about their own research into the social, cultural and political in mathematics education have also identified the way in which a socio-cultural approach can lead to outcomes that do not easily fit the label of mathematics educational research. This leads to the dilemmas of "specificity", whether the research is mathematics education research, and of "scope", the need to consider matters beyond the field of what is usually seen as pertaining to mathematics education (Valero and Matos 2000; see also Adler and Lerman 2001 for a discussion of the challenges this can create for PhD students in particular).

Nevertheless, I believe that broadening the scope of mathematical educational inquiry in this way is important not only to understand the mathematics classroom and learners' experience of it, but also to develop strategies for changing it.

Being a classroom teacher again

During the period of writing and theoretical development, I suspended my studies for a period of eight months, to return to the classroom. The reasons for doing this were primarily financial. However, it does mean that theoretical perspectives that I develop have been informed by reflection as a practitioner. Simply put, I have had the opportunity to ask the question as to whether what I have written in the thesis makes sense or is useful in understanding the school mathematics classroom. I believe it does and is.

PREFACE, FOURTH PIECE: READING THE TEXT

Telling stories

We are part human, part stories (Okri 1983, page 114)

> As researchers we want to see 'what is there' but this implies a commitment
> to something being there to be seen. An alternative, which corresponds
> more closely to the experience of data collection and analysis, is that events
> consist of the multiple stories that are woven out of observation (Mason
> 2000, page 317)

I began the preface by suggesting that the objects of the thesis are somewhat disorderly. One way of reading this text is as a story or a series of stories about these disorderly objects. Stories which will help you to understand more about both the objects and subjects of the thesis, these things and beings in the world. However, these stories are unlikely to leave matters "entirely clarified". Partly this is a necessary condition of writing about matters that are complex rather than simply complicated (Davis 1996). Describing social complexity requires the sort of infinite (and thus uncreatable) map envisaged by Giles Deleuze and Felix Guattari (Deleuze and Guattari 1987). Perhaps one of the few agreed truths of social research is that any social situation or phenomenon can never be described or analysed fully – there is always more to say.

However, the thesis is also incomplete in a more prosaic sense. I have selected from the range of research experiences and material these experiences generated to construct a set of stories. But many other stories are left untold. I believe that all research reports leave stories untold; certainly the sort of research presented in this thesis is not conducive to neat parcelling and tying of loose ends. My criteria for selecting which stories to tell has partly been what has seemed to be worth saying, but also what needed to be said first. And perhaps they are simply the stories that I am capable of telling.

By describing the thesis as a story or stories I also seek to alert your scepticism to the fact that what you will read, indeed are reading, is not the truth; as the apocryphal saying from journalism has it 'don't let the truth get in the way of a good story'. Paradoxically, identifying myself as a storyteller also invites you to suspend your disbelief, engage your imagination and enter into the world that I will spin for you.

My desire to tell a series of connected but independent stories is undermined by the linear nature of the text. Firstly, a linear text, unless it is a piece of automatic writing, is

likely to be a fiction in one respect at least. It creates the impression that what comes first was written first. This is unsurprising given that this reflects the subjective temporal experience of a reader who begins at the beginning and reads to the end.

Of course, once the text is in the reader's hands it may not be read in that way. I, as an author, have no way of knowing how you, an actual reader, may choose to read it, how much you may choose to read and in what order. Indeed, do not feel obliged to read it sequentially chapter by chapter. There is much material in early chapters that is, I believe necessary and important or I would not included it. Yet if you are most interested in, for example, the application of community of practice theory to the classroom then it may be more interesting for you to begin reading at Chapter Five.

Nonetheless, the sequence of text creates the impression that what comes after is only a development of what comes before and the influence of different parts of the text on each other is only in one direction. However, if you reflect on your own writing you know that this is not generally the case. In the case of this thesis I am not simply commenting on the process of redrafting where any part of the text may be changed up to the moment of completion. In a more important way what comes before has been shaped by what comes after.

The adoption of a narrative form, the telling of a story is dissonant with the sort of knowings that I wish to communicate. A story calls for a plot, characters, dramatic tension, and resolution. In most narrative genres there is an outcome that the story leads to, whether it is the finding of the buried treasure, the completion of the journey, the reuniting or marriage of the lovers, the revealing of the criminal, or the discovery of the secret. When the outcome is realised we can then, post hoc, look back at what came before and see the way in which everything in the story appears to lead to the ending.

Yet the outcome of this research is not a single finding or even findings but rather a number of changed and incomplete ways of understanding the world. The thesis is both about the everyday practices of school mathematics, the theoretical means to understand these practices, and I hope at least some ideas about how to change these practices. Even the coinages in the thesis such as ecologies of practice are not the 'most important thing' or 'the key idea'. However, the linear nature of the text means that the thesis starts here and finishes there, and a narrative is easier to write, and probably understand,

if there is a sense of progression. Yet this does not mean that what comes at the end does not explain the beginning as much as the beginning explains the end.

I am suggesting that you, as reader, bring to my text the same attitude or disposition as I have tried to my research. Firstly, a suspicious attitude (following Ricoeur 1970) that what appears to be put forward as *the truth* is inevitably a story told and so to wonder what other stories might be told, both from the material presented and about the subject matter. Secondly, an indulgent attitude that this is a story and for a story to work on us we have to open ourselves to it and believe that it has some wisdom or pleasure for us. Thirdly a playful disposition and fourthly (and certainly not lastly) a remembrance that...

> Ecology, for example, presents us with an image of our lives and the life of the Earth as involving a vast, vibrant, generative, ambiguous, multivocal, interweaving network of living interconnections. We are living *in* this web of interrelations and these interrelations are always at work *before* the task of writing about those relations has begun. In this sense, therefore, if we take the example of ecology seriously, it is not enough to simply write about these interrelations. This sense of vastness and vibrancy and generativity and ambiguity and multivocity and interwoveness must somehow inform the character of the writing itself
>
> From Speaking with a Boneless Tongue, by David Jardine (page 6)
>
> [For me the key here is to 'somehow inform the character of the writing', which must 'somehow' be informed by many other concerns]

Metaphors for knowing/writing the world

Laurel Richardson points to the way in which researchers use, often unconsciously, a central metaphor of "Theory is a building" (Richardson 1998, page 352 following Lakoff and Johnson 1980). In this metaphor, early chapters on theoretical framework and the methodology are foundations on which the structure of the thesis is built. Such metaphor points to "a traditional form for articulating theory, method, and 'findings/results'", one that "fails to signal the embeddedness of theory in the entire research task, or to make evident the extent to which the research ought to be generative

44

of theory rather than merely 'objective findings'" (McWilliam 1993, page 202, quoted in Povey 1995, page 8).

The recurrent images that you will find in this thesis are of cloth rather than buildings. I add to these metaphors ones that are biological, spatial, and kinetic: ecology, webs, place, circle, emergence, dance, and field. These words are used to invoke a sense of the circularity and complexity of social relationships and of the means by which we know about them; the co-emergence of the world in relationship to itself and the co-emergence of one part of the world, the knower, and so knowledge, in relation to rest of the world.

If the traditional, implicit, metaphor for the formulation of knowledge is often the construction of a building then the metaphors for the ways in which we know are often "heliocentric" (Derrida 1982; Richardson 1998). We see the truth; it is uncovered and revealed. This metaphor gives pre-eminence to visual sense. Thinking of other senses expands our appreciation of coming to know. Brent Davis uses a central metaphor of listening, not just for his own process of inquiry in mathematics education, but as an alternative way of understanding how we come to learn mathematics itself (Davis 1996). Davis creates a typology of types of listening: evaluative, interpretive, and hermeneutic. Peter Applebaum welcomes this but describes ways in which in the prevailing circumstances evaluative listening is most likely. He calls on us to widen further the range of senses we use as models: "More challenging to current institutional expectations and in need of further investigation, are the nose and the tongue as models and scenting and tasting as metaphors" (Applebaum 1999, page 13).

Given the images of cloth and fibre that I use, I call also for the inclusion of the sense of touch and of feeling. This is also a challenging metaphor for knowing. The sensation of touch is both paradoxically elusive and immediate. Our vocabulary for what we feel through our skins is limited. We talk in polarities of rough and smooth, hot and cold and there are few words to talk about the subtleties, and the uniqueness of different textures. The skin as sensory organ has different sensitivities and capabilities depending on which part is touching or being touched. The same stimulus can be felt as a comforting contact or exquisite stroke depending on the part of the skin touched and circumstances. At the same time our skins are the boundary between our embodied selves and what we perceive as the world. Touch brings us back to the knowledge that we are our bodies as much as our minds.

45

When we say we feel something we can mean both the physical sensation that arises from touch and also the more elusive, subjective feeling of emotions; "I feel it" as a signifier of the 'in the guts' embodied knowing. In a post-positivist paradigm or even some areas of interpretive science, to say "I feel it" in relation to truth, is taken as something less certain than "seeing it". Yet it is precisely this integration of emotion and intellect that we need to recognise as an intrinsic part of coming to know. The phrase "I feel that," means more than a belief. Take it more as a first sensing, a feeling of the quality, or the texture of an idea or belief.

There are places in the text where I do implicitly or explicitly use the more traditional architectural metaphors and terms that model knowing as seeing. I also contradict my professed relativistic and subjective notion of truth in the language I use and speak about truth in a much more solid way, for example earlier in the preface when I considered the notion of 'claiming'. This is hardly surprising since such metaphors are part of discourses of everyday life. This is in part because they are in reality (sic) very useful ones. Deconstructionist thinking and post-modernist thinking create a space for new metaphors, they do not necessarily make more established ones redundant.

Imagine that the thesis was not a rigid building but rather a space fashioned out of cloth or similar materials, like a large tent. Not the rather simple tents found on European campsites. Tent itself is an inadequate word. Think of the homes created by nomadic peoples who have a more sophisticated technology of moveable dwellings. These can have multiple 'rooms', be attached together, and have their internal spaces quickly transformed. They are in their nature transient, moveable, and less fixed in their relationship to the landscape they are located in[13]. You might think of an ornate Arabic tent or more pastoral Mongolian yurt[14].

Using this metaphor, we might ask what sort of tent it is, what it is for, or in literary terms, its genre? Secondly we can look at the type of material it is made from, the warp and the weft of the cloth, its texture, and the colours and patterns that are woven in. Thirdly, in contrast to thinking about the structure of the thesis as building, we can now consider the ways in which the different pieces of cloth are connected to each other and

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[13] In Chapter Two, I allude to the way in which Deleuze and Guattari's thinking about nomadic culture influenced my research practice; my textual metaphors are conversant with this (Deleuze and Guattari 1987).

[14] After actually reading the text you might think that a more suitable metaphor would actually be the humbler, more thrown together shelter like the 'benders' that can be found on road protest sites. These are made of 'tatted' (meaning found, borrowed or recycled) materials. They are made out of whatever

46

how they have been fastened in relation to the artefact's purposes. This may be called its fabrication[15]. The distinction between these aspects is somewhat artificial. However, the distinction is useful for explanatory purposes and a discussion of these three aspects forms the remainder of this chapter. At the risk of stretching the metaphor too far and risking tearing its fabric, we might also inquire as to the thread and fibre out of which the cloth is woven. Or indeed whether the cloth is woven at all; felts, for example, are formed by intertwining and entangling fibres producing a cloth that does not have a top or bottom (Deleuze and Guattari 1987).

The metaphor of text as cloth is carried through in subsequent chapters with their arrangement into 'Pieces'.

Genre(s)

One way of thinking about genre in academic texts is the forms of writing found in different academic disciplines. This thesis is concerned with what happens in school mathematics classrooms. However, in places it departs from the form or style of much mathematics education literature.

It is not possible here to fully explore the various ways in which mathematics, learners, and researchers are constructed within different strands of mathematics education research literature. Nevertheless, different strands of mathematics education research do construct the subjects/objects of the research in significantly different ways. From the perspective of an engaged, hermeneutic inquiry into social practices and experience of school mathematics, mathematics education research literature, and theory is itself part of the area of inquiry.

Surveys of the methodology of papers in international mathematics education journals show that the dominant paradigm in mathematics education research is based on individualist-psychology and a post-positivist research methodology (Valero and Skovsmose 2002). Through their absence from the text, the researcher is constructed as a neutral applicator of objective methodologies.

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can be found.

[15] "Fabricate...*v/t* manufacture, construct, put together; state falsely, invent, forge (document)" (Garmonsway 1999/1961, page 275).

47

The construction of mathematics in this paradigm tends to support the conceptualisation of mathematics as a subject of discrete components that can be learnt by internalisation of examples. The learner is considered as an individualised ahistorical and acultural object. Where the social identity and culture of the student is considered this tends to be done by thinking of these things as separate variables. The teachers' practices are often constructed in relation to beliefs and knowledge, with "deficient" beliefs and knowledge related to "deficient practices" (Valero and Skovsmose 2002).

Importantly, these constructions also accord with and reflect the dominant social practices of school mathematics. Thus mainstream mathematical education research and school mathematics both tend to reflect a particular conception of the nature of knowledge, one in which people are constructed as lacking historical and cultural positioning. This research project has attempted:

> ...to create a space in which we (teachers/learners/researchers) define/redefine what it is to be a mathematician/researcher. Such a redefinition would be one in which identity norms are questioned and challenged and communities of practice are both opened up and jointly constructed and critiqued within the mathematics classroom and research arena (Cotton 2002).

Such ambitions influence the choice of subjects of the research, the research practice, and the text used to communicate the research.

A second aspect of the genre of the text is that it is a PhD thesis. This creates freedoms that I would not have if it were written for an academic journal or to be published as a marketed book. It leads to limitations that might not exist if I was a tenured professor with an extensive publications list (Richardson 1998). One of its central purposes is to pass examination. This has undoubtedly affected the choices I have made in creating the text. I am conscious of some of these and probably unconscious of others.

A third way to think about genre is in terms of the narrative form associated with different research methodologies. Researchers have analysed the forms associated with different research traditions (see for example Creswell 1998; Lather 1990, 1991; Denzin 1997; Denzin and Lincoln 1998; Richardson 1998; Van Manaan 1988). Yet my research has not adopted a single research methodology. In Chapter Two (and more extensively in Appendix IV), I argue that various research paradigms reflect legitimate ways that we come to know the world. From this stance, I have drawn on the critical and hermeneutic traditions as re-interpreted in the context of post-modernism.

Happily, the forms through which the world is written in social research have been expanded. Researchers have used new experimental forms of text to disrupt and challenge realist views of the social world (Denzin 1997, Richardson 1998). Denzin talks of the emergence of "messy texts" which break with conventions using techniques such as montage. Congruent with the way in which the research draws on different methodologies it also adopts different genres in different parts of the thesis. It is best described as a mixed text[16] (Richardson 1998). I share the belief that "by writing in different ways, we discover new aspects of our topic and our relationship to it. Form and content are inseparable" (Richardson 1998, page 345).

I hope that by reading different sorts of writing the reader too will discover new aspects of the topic and their relationship to it. My intention is to firstly, create a mirror of the legitimacy of the many ways of knowing that we use to create our life-worlds. Secondly, to ground your reading of the text in awareness that this is a text, the product of social practice. When I describe the different chapters I will indicate the genres that you can expect to find in each part. The overall intention is the creation not of a 'messy text' but a 'rich text'. However, although I have tried to avoid creating an overly messy text, some 'messy thinking' has been unavoidable.

in praise of messy thinking
i know i   ask a lot from you,
the way i share my messy thinking ,
my (nested (bracket) way of talking, in sub clauses and tangential, yet important, qualifiers)
the   pauses
i do have a reason (or may be reason(s))
to start but then find i
retrace
to the beginning because i now understand where this sentence might end up (at least i have an idea) and realised that i should have started with a "speaking metaphorically" so that you might …
because after all don't we all fill in the gaps in our…
but then again
i started with messy thinking
and maybe i should have
begun with the messiness of the world,
not messy like dirty,
but messy like "so much of it that it overflows, spills out, Everywhere"

existence clutters my sentences
as i try to express what i most want to say:
"It's all related"
"We are all related"
Mark Boylan, January 2000 – January 2002

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[16] Though deference to academic norms and personal caution means that it is more conventional than I would like

The textuality

The idea of thinking in terms of textuality, and the metaphor of research as fabric are inspired by Brent Davis' discussion of the etymology of text. He explains that "Originally, ... 'text', like 'web', was used to describe things woven" (Davis 1996, page 20). We can find a residue of this original meaning in the word 'texture'. The textuality is thus the texture, the feel, the grain, and the weave of the text. As might be expected given the mix of genres employed, the texture changes. I highlight here some of the more common features and relate them to a desire to interrupt and challenge some of the conventions that prevail in mathematics education research literature.

The 'discursive turn' in social theory has emphasised the way in which knowledge and language are inextricably linked:

> The social sciences conceive of themselves as representing the real whereas what they are doing is 'writing it'. Social reality does not exist as an extra-discursive context, rather the real and the discursive are intimately woven. (Usher 1996, page 30)

Post-modernist authors warn that the way we write about the world and so create the world cannot be separated from social power or what should be more properly seen as a power/knowledge nexus (Foucault 1972; Lather 1991). Feminist, criticalist and other writers have long challenged the elitism and exclusivity of academic discourse (hooks 1994). The ways we write are not neutral, objectivity is not realisable; thus we are called on to be sensitive to, and reflexive about, the language we use (Usher 1996). In qualitative research, the self of the researcher is presented as a dispassionate neutral authority and the subjects of the research are "othered" (Fine 1998). The experimental modes and messy texts that I have discussed have, in part, emerged from a concern to find ways of writing that might 're-invent the self and other' (Fine 1998).

Post-modernist texts may seek to de-centre the author and undermine their authorship and thus their universalising authority, through the effect of layering of quotation and other pieces of writing (see for example Lather 1991). However, as Lather points out about her own book, such texts may not be particularly "readerly" (Van Manaan 1988) and post modernist discourse could be "easily dismissed as the latest example of theoreticism, the divorce between theory and practice" (Lather 1991, page 8). She

50

states that the form that gives rise to this charge of theoreticism arises from the very "desire ... to "interrupt" academic norms by writing inside of another logic, a logic that displaces expectations of linearity, clear authorial voice, and closure" (Lather page 8). A highly inaccessible textuality can arise and, ironically, attempts to undermine a traditional hegemonic academic discourse can serve to create another that is even more alien:

> But that is the sort of thing we can expect from the Abstract Owl, the dried-up Western descendent of the Confucianist Dedicated Scholar, who, unlike his Noble but rather Unimaginative ancestor, thinks he has some sort of monopoly on –
> "What's that?" Pooh interrupted.
> "What's what?" I asked.
> "What you said – the Confusionist, Desiccated Scholar."
> "Well let's see. The Confusionist, Desiccated Scholar is one who studies Knowledge for the sake of Knowledge, and who keeps what he learns to himself or to his own small group, writing pompous and pretentious papers that no one else can understand"
> (Hoff 1982, page 26)

I think that those of us who write knowledge should listen to Hoff's scolding and reflect on the language we use. We should also recognise the extent to which those who do not write social theory are excellent theorists. They must be so to participate in the social world.

I think also of the perceptions of educational research literature of the teachers who have participated in this research. Jill, who I collaborated with during the key phase of work in schools, expressed some disappointment when I told her that the parts of our research experience together that I would focus on were the more theoretical aspects. For her the relevance of the research has rested more in the extent to which it has generated identifiably 'better' social practices for the classroom. There is a demand from pressurised teachers for other educationalists to speak in clear terms and in understandable ways about what they can do in the immediacy of school life to make the experience of schooling better both for their students and themselves.

However, I share Morris and Lather's resistance of a "blackmail to urgency" to demonstrate practicality (Morris 1988, page 180, Lather 1991, page 9). The need to change schools and schooling is urgent. Too much of our children's and teachers' time is spent in ways that are neither worthwhile nor appropriate. Schooling is co-emergent with, and embodies, social relations that increasingly jeopardise our future as a species

51

on our endangered planet. But it is precisely because the situation is urgent, that we need to find news ways to understand/create the world and each other rather than looking for technologically rationalist 'fixes'.

Above I included a poem that arose from the research process titled 'in praise of messy thinking'. In the poem, I offer a pastiche of my own, somewhat confusing, style of speaking about the world. The process of writing allows me to seek greater clarity of expression. However, it can mislead the reader (and writer) into thinking that the world is more structured than it actually is.

You may have already noticed the way in which the author of this poem, a seemingly post-modern intrusion into the academic text, includes as its end point a 'grand narrative' - "We are all related":

> Ecology tells us that there is no centre or foundation to this web of living interconnections, just small, lateral, interlacing relation of this to this to this, splayed in moving patterns of kinship and kind. (Jardine 2002, page 6)

I suggest that there are two approaches to expanding the textual forms that we use to write the world. One is to lose ourselves in the labyrinth of reference to texts about texts and so to create texts that are impenetrable (and irrelevant?) to our kin and kind. The other is to find in the labyrinth a map back to the complexity of our selves, relationships and world and with the spirit of play, (and luck) find ourselves a-mazed.

Ian Stronach and Maggie McLure write of the way in which post-modernism is written of in monstrous terms by those that are shaken by its anti-foundationalism (Stronach and McLure 1997). They identify a whole range of writers whose embrace of post-modernism is at best ambivalent. In using the metaphor of the labyrinth I am aware of the association culturally with the myth of the minotaur, just such a monster as Stronach and McLure find in the language used to talk of post-modernism. However, the labyrinth is not the natural home for the minotaur. The Labyrinth of Crete was originally the creation and reflection of the celebration of the goddess, the feminine and the earth. The minotaur, the monster in the Labyrinth, was a later addition as society moved into patriarchy. As a myth it arose at the same time as rationalist thinking took hold, as the 'mastery of reason' (Walkerdine 1988) began. It is part of the 'climb up into our heads' (Jardine 2002) and represents a fear of the body and the Labyrinth as earth. This earlier Labyrinth is one that twists and turns but if we trust and follow it leads us in and then out. There is a possibility of a post-modernism that is decidedly

pre-modern. One where the world and our relationship to it is accepted as the heart of the complexity of existence rather than the stories we tell about the world and our relationship to it.

I have attempted to describe two different impulses that influence my choice of textual forms; firstly, the desire to speak simply about the world as it is and in a way that is accessible, secondly, the need to break the bounds of our understandings through theorising and welcoming the embrace of complexity. As a result of the research journey that this thesis is based on and is part of, I have given up on trying to synthesise such polarities, to find neat solutions or compromises. Instead, I let both influences inform the textuality.

Frequently, I weave other pieces of text into mine to create interruptions and counterpoints to the reading of an academic discourse. Sometimes I put these texts in boxes, paradoxically as bolder intrusions into, but also apart and separate from the text. They are akin to glacial erratic boulders, memories of the forces that created the landscape. Often when I do this I do not refer to them in the main text. These come form a variety of sources, including academic texts, extracts from research notes and interviews. With these, I highlight the dialectic between research theory and research practice, conversant with "research as praxis" (Lather 1991). I also include extracts from non-academic sources, poems and literature, and personal anecdotes. I acknowledge in footnotes conversations with researchers and others that have informed my thinking. By bringing in these other voices I underline that as a writer of educational research, I exist in a web of relationships that holds and creates a multiplicity of selves. I give a hint of the way in which it has been as much the time that I have spent away from books, school, or the computer that has shaped my thinking as those when I have been 'researching'. By personalising the text in this way I disrupt the notion of the academic expert and the impersonal claim to authority[17]

A second way that I personalise the text is through how the self and reader is presented. In this chapter in particular I have used the personal pronoun and adopted the device of addressing you directly. Though of course, such approaches still construct the author

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[17] This is a little disingenuous as the insertion of these other pieces of text establishes a different sort of authority and rank. I present myself as someone who reads more widely than academic texts, as perhaps a more rounded, more interesting individual. Thus I claim rank over the mere 'academic expert' who does not have the same wide interests as myself.

and reader in particular ways even if different ones from conventional academic discourse.

The devices that I use are intended to go someway to alerting the reader to issues of authorship and authority. The question of how to avoid the 'othering' of the participants of my research has been more difficult both in the research process and, perhaps consequently, in this text. However, one aim of the research has been to contribute "to a developing tradition that seeks to listen carefully to what students have to say, inviting them to contribute to the construction of knowledge about their schooling" (Boylan, Lawton and Povey 2001, page 202). An outcome of the research has been to recognise the validity of the individual lifeworld. As a consequence, I have attempted to find spaces where the learners' contribution is privileged. In particular in Chapter Four I present a long constructed monologue of one research participant's experience of school mathematics.

In spite of my intentions to conduct a co-operative participative inquiry, the students, and to an extent the teachers involved, have been 'studied' and 'othered'. Partly to address my concern about this I attempt a rebalancing by othering myself. I do this in a number of ways. For example in Appendix II, I describe my teaching career in the third person. This device is also a prelude to a later discussion of the multiple nature of the self.

One of the conventions, which establishes authority and can serve to exclude, is the use of references. Following Van Manaan (1988) we can think of the 'referencing game' where the citation of others texts establishes the importance of our own. Arguably at times researches claim rank by how many others we cite and who we cite, and by how often we are cited. Indeed, in the UK currently the number of citations is an important quasi-market tool in allocating research funding. The exclusivity of the referencing game is subtler; it rests in the feeling, that unless we are familiar with the sources cited we cannot really understand what is being said. I quote from a friend who I suggested might find reading some of my writing useful:

> The next thing I thought was how valuable your research or the bods [people] you have been reading could be in informing what I am doing with xxxxxx - but then I realised that was drawing me into the academic framework of: I have to read everything about everything to be able to say anything (Roussopolous 2002).

I too have felt like this. I remember going in to the university library on the first day of my research studentship, walking through the shelves of books, relishing the freedom that I could read anything in there. I remember too the feeling of disappointment later when I realised that no matter how much I read I would never be able to read everything that might conceivably be relevant to my research.

Yet referencing serves other purposes than establishing authority and rank. It also inscribes the way in which all of our knowings are embedded in and arise from a community; that what we produce is always created in relation to others. Therefore, whilst I have tried to be aware of my motivations, the referencing that you will find here is done in a conventional manner. However, when I introduce, or reintroduce authors in the main body of the text for the first time I use both the family and given names. I do this primarily out of respect but it also allows in most cases for an English speaker to identify the gender of the writers referenced.

A final note on textuality relates to a concern for the aesthetic of the text and a duty of care to the reader. I have striven to make the thesis engaging and enjoyable to read, qualities that can be lacking in social research texts (Richardson 1998).

> With her fine thread Spider makes connections. Her threads are delicate but tough and strong. Spider spins and twists and weaves, working at the mesh, connecting place to place; and soul to soul; and life to life. She is ever binding, winding, wrapping, overlapping. From the warmth of ashes where the fire has burned, Spider forms the loops and hoops of company, family, community, other people's circles overlaid. All of these tied together in one intricate chaotic lace...
>
> ...The threads of Spider are not always spun together. The pieces may be scattered, frayed and snapped. Where is Spider's sense of continuity, connectedness, when around her there lay many broken threads? Her lace is crumbling as the fibres disintegrate and fall. And maybe the ashes of the fire that once was burning with the flames of human kinship, are long cold. Spider is lonely and alone.
>
> (Hillyer 1999, pages 25-26)

Stitching the cloth together: the fabrication

In this section of the preface I describe briefly the content and purposes of each of the chapters. All of the chapters begin with a First Piece titled "About the Chapter". These sections act as signposts or navigation aids.

The thesis opens with a Prelude, short piece derived from a dream that I had two days before beginning the research studentship. As a narrative device it aims to capture the readers attention.

Chapter One is titled "Areas of Inquiry". Here I review literature on mathematics in schools and the learners' experience of it, community of practice theory and the lifeworld in educational research. In terms of giving a complete picture of what the thesis is about it should be read in conjunction with the third piece of Chapter Four on teacher questioning.

Chapter Two is "Methodological Yarns". Its aim is to "posture" (Wolcott 1992) or position in relation to various research paradigms. It describes the ways in which the post modernist context, and critical and hermeneutic research traditions have influenced the methodology. The genre here is a conventional discussion of theoretical literature. The various parts are described as theoretical and methodological yarns. The tone is discursive and in places polemical.

Chapter Three is called "Teacher Questioning and Students' Participation". In this chapter I take teacher questioning as a typical and important aspect of the social practices of school mathematics. I review literature about teacher questioning and then describe a single case study that gives insight into some of the factors that influence students' participation in teacher questioning of whole classes. I use this material to return to a discussion about the nature of the social groupings and forms of participation introduced in Chapter Two and argue that the nature of questioning in school mathematics classrooms indicates that school mathematics classrooms are not generally communities of practice.

Chapter Four describes the lifeworld of school mathematics of one person " Louise". I first describe the research context, methods and forms of interpretation. I then provide a description of Louise's lifeworld in the form of a constructed monologue. The aim here is for an enriching mode of interpretation (Ashworth 2003). I then conduct a more analytical interpretation that seeks to understand the nature of the entities and relationships within Louise's lifeworld of school mathematics in relation to Heidegger's ontology of the lifeworld. The outcome of this interpretation is a revision of Heidegger's ontology of the lifeworld in relation to school mathematics. Finally, and as a shorter end piece, I offer one perspective on why Louise's lifeworld is as it is. The

mode of interpretation here is akin to that of Ricoeur's hermeneutics of suspicion (Ashworth 2003; Ricoeur 1970)

Chapter Five, "Ecologies of Practice and Participation", is a theoretical bridge between Chapters Three and Four, based on research activity in the first year of the research project and Chapters Six and Seven, reporting on material gathered in the second and third years of the project. In Chapter Five, I propose a more general analytical construct to community of practice – ecology of practice, and identify usual school mathematics classrooms as regimes of practices in which participation is marginal.

In Chapter Six I focus on one class, Seven Blue, and discuss the interactions and forms of participation that occur during teacher questioning of students as an example of an ecology of practice and consider issues of power in the ecology. In Chapter Seven I consider the lifeworlds of some of the participants in Seven Blue in relation to teacher questioning interactions. I discuss the implications of the ecology and lifeworlds of Seven Blue for democratic classroom practice.

In Chapter Eight, I organise my conclusions by reflecting on the research and its limitations, the analytical value of ecologies of practices and lifeworlds, the implications of the research for teacher questioning practice, and finally conclude by returning to my personal starting point for undertaking this research "Questioning school mathematics".

The thesis has a number of appendices. Appendix I summarises research, research material collected and a sample of documents used during the research (here I select those that are most directly relevant to those activities directly reported on in the thesis). Appendix II presents something of my personal background with respect to mathematics and mathematics teaching. Appendix III is additional material discussing socio-cultural approaches to mathematics education research. Appendix IV gives some theoretical justification to methodological pragmatism through considering research paradigms. Appendix V is an extract from a document co-written with a teacher collaborator on creating community in the mathematics classroom.

CHAPTER ONE

THE AREAS OF INQUIRY

> Our decisions about what to research...are, at root, value-based decisions
> which we expect to have to defend (William 2000, page 124-125)

FIRST PIECE: ABOUT THE CHAPTER

The claims made in this thesis are both about particular instances of the social practices of school mathematics and particular learners' experiences of them, and about theoretical constructs that help to understand these practices and experiences. Thus, I discuss school mathematics as a social practice and the learners experience of it and two theoretical tools used to investigate what happens in school mathematics classrooms: community of practice theory and lifeworlds.

The thesis is particularly concerned with teacher questioning in school mathematics and learner participation in, and experience of, teacher questioning practices. However, in order to avoid repetition of material the main discussion of the literature on this is in Chapter Three.

The second piece 'Mathematics in Schools' introduces the term 'usual school mathematics' to describe the dominant form of mathematics teaching in schools. It goes on to describe alternatives to this tradition that influenced the research intervention in the second year of the research. It acts as introduction to the discussion of teacher questioning in mathematics found in Chapter Three. The persistence and form of school mathematics is undoubtedly related to wider questions of ideology. There are many analyses that take up these questions (see for example Boylan 2000; Cabral and Baldino 1998; Chassapis 2000; Dowling 1998; Dowling and Noss 1990; Ernest 1991, 1999; Mellin Olsen 1987; Powell and Frankenstein 1997; Segarra 2000; Skovsmose 1994; Skovsmose and Nielsen 1996; Skovsmose and Valero 2002). Unfortunately, there is not space in the thesis to consider these important questions in detail.

In the Third Piece 'The Experience of School Mathematics', I review relevant literature to describe some of the ways mathematics in schools is experienced by participants. It acts as a reference point for all of the later chapters.

In the Fourth Piece of the chapter, I discuss Lave and Wenger's theory of learning as participation in communities of practice[1]. The idea of school mathematics classrooms as communities of practice was taken as a theoretical starting point for my research. However, as I discussed in the preface an important outcome has been to question the applicability of the notion of communities of practice to school mathematics classrooms. As Lave and Wenger recognise (1991), theoretical tools developed by considering ethnographies of apprenticeship situations of learning may not be easily transferable to other situations.

The Fifth Piece, 'The Lifeworld and School Mathematics', introduces the notion of the lifeworld as developed in phenomenology and discusses its relevance to educational research.

This Chapter is concerned with setting out the formal 'Areas of Inquiry'; however, this tends to obscure some of the more personally important themes of the research. One of my central concerns is to explore the space that exists for more democratic and humanising classroom practice in the context of current schooling practices or more poetically, 'finding spaces to dance where none can be seen'. At a more abstract level I am interested in how it is possible to move from hierarchies to heterarchies and more horizontally structured networks. These themes are addressed in the later chapters of the thesis.

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[1] In addition Appendix III reviews socio-cultural approaches to school mathematics research and so contextualises the discussion of community of practice theory.

Part One: Usual School Mathematics

A typical lesson

The children are sitting in rows facing the front, two to a desk. The teacher is at the front of the classroom standing at a whiteboard or blackboard. The first part of the lesson consists of an explanation of the content of the lesson by the teacher. The teacher shows the students how to carry out the necessary procedures to answer the questions they will practise later. The teacher works through examples that are graded in order of difficulty.

During this first part of the lesson the teacher will ask questions of the class. Students indicate that they wish to answer by raising their hands or the teacher may select students by naming them. Generally closed questions are asked. The teacher will know the answer to them and they are asked in order to help construct the explanation of the procedure to be followed. In order to do this the teacher evaluates the students' responses, if the response is not the one required then the teacher asks additional questions in order to funnel the students toward the required answer.

After the procedures have been explained, the students practice similar written questions written on a whiteboard or OHP, worksheet or more usually from a textbook. Whatever medium the practice questions are given in, they will either be all of the same level of difficulty or will be graded, later questions requiring more procedural steps to be followed. Whilst the students practise, the teacher gives help to individual students who ask for it by repeating the explanation or offering additional or alternative procedures to be followed. The emphasis is on learning individually.

At the end of the lesson, the teacher gives the students answers to the questions practised. The next lesson is likely to be aimed at learning additional procedures related to the same topic or will move on to new procedures. The students are assessed on their ability to reproduce the learnt procedures through class exercises, homework, and informal tests. The students are given tests regularly, (generally every half or full term) which are use to group the students by ability.

This is a description of a typical lesson of mathematics in secondary schools in the UK. The description is derived both from my experience as a teacher of mathematics, as a teacher educator and researcher. Its essential features have been described, as being the prevailing style, in research literature both in the UK (see for example Boaler 1997a, 1997b 2000; Boaler, Wiliam and Zevenbergen 2000, Cotton 1998, Ernest 1998b) and in the US (see for example Anderson 1997; Cobb et al 1992; Gregg 1995; Stiegler and Hiebert 1997).

This represents a "transmission orientation" (Askew et al 1997) to teaching mathematics. Actual lessons are likely to differ in detail but the essential nature of the teaching and learning style described above is commonplace and appears to be highly persistent[2]. In the early eighties it was noted how mathematics teaching had changed little over the previous twenty-five years (Cheek and Castle 1981, cited in Boaler 2000) and it appears that the same patterns still dominate twenty years further on.

Although there is no large-scale survey research on the prevalence of different types of pedagogy over time, I offer the following anecdotal evidence of the current dominance of the approach described above. As part of units for Initial Teacher Education secondary mathematics courses that I have taught over the last three years I have asked students to describe the nature of teaching in the schools visited. Of approximately 30 schools visited by students for 'School Experience'[3] only two were reported to have a departmental practice that was routinely different from the practice of school mathematics as outlined above.

Naturally, practices do vary in different settings, however, where particular instances of different practices were reported they tended to be a slight adaptation of the typical model. It is possible for a blend of practices with different pedagogical roots to be found in the same classroom without the dominant practice being altered (Boylan, Povey and Lawton 2001).

Setting

An important variation from the usual practices results from setting practices. A central aspect of usual school mathematics, indeed arguably one of its prime purposes, is the

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[2] In the 1970s and 1980s individualised learning schemes were used widely in the UK. The pedagogic basis of these schemes varied. Such schemes are used less now than previously.
[3] School Experience Units are part of undergraduate and converting postgraduate secondary mathematics teacher training courses at Sheffield Hallam University. They are pre-professional year.

ranking of learners according to mathematical ability by attainment largely as measured by timed tests. In the UK this is frequently used to group children into sets by ability. Setting tends to reinforce the dominant teaching practices with less variety in teaching and learning styles employed (Boaler, William and Brown 2000). 'Top' and 'bottom' sets are taught differently, with top set students experiencing a faster pace with less time for discussion or explanation. Bottom sets students receive a more limited curriculum and often find the work unchallenging (Boaler, William and Brown 2000). Importantly, not only does setting change teaching but also affects how students are expected to participate and even who they are expected to be differs for different sets (Bartholomew 2002). Nevertheless, the type of classroom social practices described above occurs across all sets.

Given the dominance of this model of teaching, in this thesis I denote it with the label 'usual school mathematics'. Further description of the practices of usual school mathematics, particularly with respect to teacher questioning strategies can be found in Chapter Three.

Part Two: Alternatives to usual school mathematics[4]

Whilst usual school mathematics dominates classroom practice, various alternatives have been offered and developed and implemented.

Since the late 1960s in the UK there has been an alternative current of 'progressive' practice in secondary classrooms, developed through the two mathematics teacher associations, the ATM (Association of Teachers of Mathematics) and MA (Mathematical Association) and connected to these two bodies, through the work of mathematics educators in higher education.

A common theme of this approach to mathematics teaching developed and encouraged by these educationalists is to emphasise investigation and exploration of mathematics by the learner. Some educationalists have emphasised group investigation of topics in which there is considerably less interaction between the teacher and the whole class (for an example of a department with this approach see Boaler 1997).

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[4] Necessarily, this brief review of alternatives to dominant practices does not survey the complete range of alternative classroom practice described by teachers and researchers. In particular it is focussed on approaches that have influenced classroom practice in the UK and other English speaking countries.

Individualised learning schemes have formed another significant alternative to the dominant pedagogy. The underlying mathematical epistemology and implicit theory of learning in such schemes varies. Some, such as the SMP booklet scheme for Year Seven and Eight, are based on very similar pedagogy to dominant practices. In contrast the SMILE scheme, was developed by teachers concerned with issues of equity (Lerman 2000) and who were committed to an investigative approach to learning mathematics. However, the use of this scheme can vary widely in the extent to which it offers an alternative experience for the learners in practice.

Others have developed more complex investigatory pedagogies, ones in which the teacher maintains a central role in the learning of the class but aims not to transmit knowledge but to guide students' learning (see for example Burton and Povey 1999; Brown and Coles 2000 , Mason 2002; Watson 2002). The practices of these teachers vary considerably and it would be misleading to describe it as a single pedagogy. Common to their different approaches are pragmatism, variety, and flexibility about teaching and learning styles. Another shared characteristic is an emphasis on mathematical engagement rather than reproduction of procedures. In such approaches discussion about mathematics is highly valued and the teacher aims to encourage such discussion between the students themselves.

Inquiry Mathematics

A description of, and advocacy for, a similar approach to learning is found in the research reports of influential US researchers (see for example Cobb et al 1992, Cobb and Yackel 2000; Cobb, Wood and Yackel 1990; Wood 1994).

Typically they identify the possibility and existence of "inquiry mathematics" as an alternative to what they term "school mathematics". The inquiry classroom is based upon a constructivist approach to learning, which involves "teacher and students together acting in and elaborating a taken-as-shared mathematical reality in the course of their ongoing negotiations of mathematical meaning" (Cobb and Yackel 1998, page 163). The teacher does not uniquely hold mathematical authority: instead the teacher and students together constitute a "community of inquiry" (Cobb et al 1992; Groves, Doig and Splitter 2000). Such a community is established in part through a process of negotiating or renegotiating social and sociomathematical norms. These ideas have been a significant influence on the US reform movement (Gregg 1995).

Critical Mathematics

The critical mathematics tradition offers a radical approach to curriculum change. This tradition has sought to link a critique of the way mathematics is taught and the content of the curriculum to a more general concern for social change. Critical mathematics education has been based theoretically on the critical pedagogy of Friere (see for example Frankenstein 1990, 2000; Knijnick 2000) and the critical theory of the Frankfurt School (Mellin Olsen 1987; Skovsmose 1994; Skovsmose and Nielsen 1996; Vithal 2000). A central idea in this tradition is a concern with education for democratic citizenship (Christiansen 2000; Valero 2002; Vithal 2000). This concern prompts the inclusion of alternative curriculum content, which promotes mathematics as a tool for understanding society. However, democratic concerns also imbue the preferred approach to classroom practice:

> Critical mathematics education is concerned with the development of citizens who are able to take part in discussions and are able to make their own decisions. We should take into consideration the fact that students will also want and should be given the opportunity to 'evaluate' what happens in the classroom (Skovsmose and Nielsen 1996, page 1267).

Whereas in the inquiry mathematics described above, the teacher still has a monopoly on social authority, critical mathematics educators seek to disrupt this authority by democratising the classroom. Critical mathematics educators are concerned to recognise mathematics learners (and teachers) as historically and culturally situated beings and to find ways for this to find expression in classroom practices (Skovsmose and Valero 2002, Valero 2002).

Democratising the classroom

Educators influenced by feminism focus more fully on ways to democratise relationships within the classroom (see for example Angier and Povey 1999; Burton and Povey 1999; Noddings 1993; Povey and Boylan 1998). Here an interest in social relationships is more fully realised and put at the centre of the pedagogy. Corinne Angier and Hilary Povey have posited the notion of "spacious mathematics" where interpersonal relationships and learners' relationships to mathematics are less constrained than in dominant practices. Students in Corinne Angier's class talked of relationships within the class being like a family in which learning mathematics is a

means for personal expression and development of the ability to be part of a learning community (Angier and Povey 1999).

Part Three: The persistence of usual school mathematics

I have briefly surveyed various alternatives to what I have termed usual school mathematics. These have had varying degrees of influence on classroom practice. However, even where these alternatives have gained hegemony amongst influential groups such as policy makers and teacher trainers they have not generally been widely taken up by classroom teachers.

Recently in the US there has been an attempt to encourage an "inquiry" approach to mathematics outlined above. This has developed into a major reform movement, led by the NCTM (National Council of Teachers of Mathematics) and supported by influential mathematics educationalists. Yet these attempts have been frustrated at the classroom level (Gregg 1995). It is generally recognised that it is difficult to sustain or create changes in everyday classroom practice (Voigt 1998).

In seeking to explain the persistence of usual school mathematics, many have pointed to the ideological nature of the practices of school mathematics and the way they are embedded in wider social relationships (see for example Boylan 2000; Cabral and Baldino 1998; Chassapis 2000; Dowling and Noss 1990; Ernest 1991, 1998, 1999; Mellin Olsen 1987; Powell and Frankenstein 1997; Segarra 2000; Skovmose 1994; Skovsmose and Valero 2002; Walkerdine 1988). Others have noted the nature of the curriculum and assessment arrangements, and the overall teacher workload that frustrates thoughtful planning, and pervasive ideas about classroom control and productivity (Boaler 2000; Boylan 2000; Zevenbergen 2002). Such explanations only go some way to help us to understand the way in which the practices are reproduced locally and the processes that inhibit attempts to change pedagogy in particular classrooms.

Educational changes in the UK over the last twenty years, in particular the National Curriculum, national testing and inspection, have tended to reinforce the traditional approach to teaching. They have also increased setting and have had a homogenising effect on practice (Boaler 1997a; Boaler, Wiliam and Brown 2000; Boylan 2000; Brown et al 2000; Ernest 1991; Dowling and Noss 1990).

Current developments suggest that the dominant mode of instruction is being further reinforced and is becoming increasingly common in primary schools. While the National Numeracy Strategy, a major curriculum initiative in UK primary school mathematics, does legitimise a wide range of practices including more collaborative modes of learning, however, it also emphasises 'whole class teaching' and 'direct instruction' (Boylan 2000). Thus 'usual school mathematics' may increasingly become the norm in primary as well as secondary schools.

CHAPTER ONE, THIRD PIECE: THE EXPERIENCE OF SCHOOL MATHEMATICS

TEENS DEPRESSED BY MATHS

Teenagers find maths tedious and irrelevant and study it out of duty to their school and parents, according to a new survey. Maths lessons make pupils feel isolated, the study suggests, as there is little opportunity to work with classmates.

The findings will worry government advisers already struggling to bring down high failure rates in maths AS-level and the numbers dropping the subject.

The report funded by the Economic and Social Research Council, said many pupils resented the rote-learning in maths.

Study director Elena Nardi said: "Grey, depressing, boring were words often used to describe lessons." Seventy 13 and 14-year olds in three Norfolk schools were observed and interviewed over a year. *Times Education Supplement, June 21st 2002.*

A negative experience

Experiencing school mathematics is an almost universal part of the experience of childhood in western society. The legacy of that experience for many is a strong negative emotional relationship to mathematics. When asked about my work, I have become used to the reactions that follow the mention of mathematics. Some people show their dislike physically: mention mathematics and some will involuntarily pull a face as if they were tasting or smelling something very unpleasant. The strong negative reaction to mathematics has led to the suggestion that some people develop "maths phobia" as a result of school experiences (Buxton 1981).

Research on affect and mathematics

In mathematics educational research there is a large body of research devoted to affect and mathematics (see McLeod 1992 for a review)[5]. The term 'affect' is used in mathematics education research literature to refer collectively to moods

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[5] I suggest that the very existence of this research area, points to an implicit recognition by the mathematics education research community that many learners find learning and engaging in mathematics a negative experience. It appears that there is no other school subject that has developed such an area of research interest. However, this is not to say that mathematics is the only school subject which causes strong negative reactions – other examples are Physical Education and Art. Undoubtedly, one shared reason is the experience of public failure.

and emotions and similar phenomena. Such research, often conducted in an individualist-psychological paradigm, is generally concerned with accounting for success or failure of learners in terms of expected or required achievement (Walls 2002). Such research is premised on a pathological attitude to mathematical learners: if the learner fails to 'achieve' then the problem with the learner is investigated. It has tended to posit the existence of discrete variables such as attitude and motivation as causal explanations of individual learner achievement and has measured these variables through decontextualised surveys.

Research on mathematics and affect has given insights into aspects of the learner's experience, for example in the development of the notion of mathematics anxiety (see for example Newstead 1998; Hembree 1990). However, such research tends to treat affect and cognition as discrete and separate areas of human experience with one-way causation between affective elements and cognitive outcomes (Evans 2000).

Socio-cultural research

More recently some research of affect and mathematics has embraced the importance of understanding social and cultural context and understanding affect through and in the process of mathematical engagement (McLeod and Adams 1989; McLeod 1992; Evans 2000).

Jeff Evans poses an alternative model of understanding emotions in mathematics based on psychoanalytical and discursive theories which firstly, does not reduce emotions to the measurable variables of researchers, and secondly recognises emotional and cognitive aspects of experience as inseparable parts of meaning making in discursive contexts (Evans 2000). This points to the necessity of understanding the emotional experience of people engaged in mathematics as part of social experience.

There is little research on the *social experience* of learning mathematics or participating in mathematical practices. The term social experience is intended to underline the importance of the learners' experience of mathematics within social settings. This experience cannot be easily separated into predetermined 'affective' categories. Such research requires investigation of the experience of

learners in socio-cultural context that links the nature of classroom practices and identity.

Importantly, it means asking participants to describe their experience in their own terms. Jo Boaler's comparative ethnographic study of two schools with contrasting pedagogies is an important example of research that has attempted to do this (Boaler 1997). In one of the schools in her study the practices of usual school mathematics dominated and here she found that most learners described their experience as including:

- Lack of enjoyment.

- Lack of engagement. Even when learners appeared to be 'on task' they were frequently not engaged with what they were doing.

- Boredom, particularly with the repetitive use of textbooks.

- Dislike of a fixed 'pace'. Learners had to proceed at the pace of the class, which most found either "too slow" or "too fast".

- Experience of mathematics as being about following rules and procedures, with success based on ability to memorise rather than understanding.

A very similar profile of "disaffection" emerged in a study of students in three different schools. Elena Nardi and Susan Steward characterise the students experience by the acronym T.I.R.E.D, standing for tedium, isolation, rote learning, elitism, and depersonalisation (Nardi and Steward 2003). Studies in other settings suggest that these experiences are common for learners in usual school mathematics classrooms. (Boaler 2000; Boaler and Greeno 2000; Boaler, Wiliam and Brown 2000; Breen 2000; Mendick 2002). This experience of mathematics generates a deep alienation from mathematics for many (Boaler 2000; Boaler and Greeno 2000).

There is a great deal of dissatisfaction even amongst those students who attain highly in mathematics, and whom we might expect to be most supportive of the pedagogic practices. Students in 'top sets' complain of a fast, pressurised and procedural pedagogy. More generally setting appears to be a cause of negative

experience for many learners, with most students being unhappy with some aspect of their placement. 'Bottom set' students experience low expectations and limited opportunities (Boaler 1997; Boaler, Wiliam and Brown 2000).

The negative experience of school mathematics for many is not confined to secondary schooling but is reported in those primary classrooms where the social practices of usual school mathematics are practised (see for example Anderson 2000; Anderson and Boylan 2000; Walls 2002). Negative experiences are reported even amongst high attaining students who have chosen to continue to study mathematics after sixteen (Boaler and Greeno 2000; McMahon 2002; Mendick 2002).

The experience of alternative practices

Generally, students are more positive about the alternative practices described above. Jo Boaler compared the experience of students in the school with a closed pedagogy with one where the mathematics was more open. Here students learnt mathematics through the investigation or exploration of topics and had greater autonomy over their learning. As a result they experienced greater independence and opportunity for creativity. Enjoyment of mathematics lessons was greater and these were described as less boring than textbook based lessons at middle school. Importantly, the students' experience of the nature of mathematics was different, with many regarding it as "a dynamic, flexible subject that involved exploration and thought" (Boaler 1997, page 63). The greater autonomy that the students experienced meant that levels of engagement varied, with students effectively exercising choices about their degree of involvement in tasks presented to them.

Interestingly, students at the usual school mathematics school also identified times when they were given more freedom and opportunity to explore mathematics as the most enjoyable part of their experience. GCSE coursework was identified as one such situation. In spite of students viewing coursework as demanding, they enjoyed the cognitive challenge and the opportunity to explore mathematics for themselves. When asked to choose their favourite mathematics lesson an overwhelming majority chose open-ended tasks (Boaler 1997). In Elena Nardi and Susan Steward's study, students also appreciated those times when they experienced a more varied curriculum, including games and open–ended

mathematical tasks such as coursework, projects and investigations (Nardi and Seward 2003).

A review of literature on enjoyment of school mathematics indicates that enjoyment and confidence is often linked to factors such as the experience of a challenging learning environment within which the learner has a degree of control over their own learning (Middleton and Spanias 1999).

Earlier I discussed Corinne Angier and Hilary Povey's notion of "spacious mathematics". Again students link enjoyment and positive experience to the possibility of exploration and autonomy in relation to mathematics. In addition they stress the importance of spacious social relationships. Such relationships allow students to choose to work together, support each other's learning and importantly to have the opportunity to discuss mathematics. Many students are very positive about the possibility of more democratic and personable interactions with the teacher (Angier and Povey 1999; Boaler 2000).

It appears that the opportunity to discuss mathematics with others and so to experience an alternative to the atomised and atomising individualism of usual school mathematics is widely valued by learners. Many studies with learners of different ages and situations report that discussion of mathematics is highly valued and related to positive experiences and the importance of social relationships stressed (Angier and Povey 1999; Boaler 1997a, 2000; Povey and Boylan 1998; Mendick 2002). In addition there appears to be a connection between gender and the way different pedagogies are experienced, with girls particularly preferring alternative practices and opportunities for discussion (Boaler 1997; Mendick 2002).

Clearly, individual learners will have different experiences from these, with some experiencing usual school mathematics much more positively and finding alternative practices unsatisfactory. In a brief review such as this, I gloss over important discussions in the literature about differences in students' experiences and relationship to identity, context, and background.

However, what is clear is that firstly, many learners experience usual school mathematics in a negative way. Secondly, that the experience of school mathematics requires further research and discussion. In particular, how learners

71

experience particular aspects of the social practices of school mathematics requires further exploration. Moreover, research in this area requires further development of theoretical tools that allows for both the social practices and experience of school mathematics to be more fully understood. In the next two pieces of this chapter, I survey and offer an initial critique of some of the theoretical tools that can support this type of research.

CHAPTER ONE, FOURTH PIECE: SCHOOL MATHEMATICS AS SOCIAL PRACTICE – CRITIQUING COMMUNITY OF PRACTICE THEORY

Part One: Community of Practice Theory

Learning as participation in communities of practice

Jean Lave and Ettienne Wenger developed the framework of situated cognition through legitimate peripheral participation in communities of practice by examining various examples of situations of apprenticeship learning. Their theory was based on analysis of existing ethnographic studies of examples of apprenticeship learning in diverse settings: Yucatan Mayan midwives in Mexico, Vai and Gola tailors in Liberia; U.S. navy quartermasters, butchers in U.S. supermarkets and "non-drinking alcoholics" in Alcoholics Anonymous (Lave and Wenger 1991). Wenger subsequently developed the theory through empirical research into the practices of health insurance claims processors in a large US corporation (Wenger 1998).

Learning as/through social practice[6]

Central to community of practice theory is the idea of learning through, and as engagement in, social practice. When we learn we learn to do. However, engagement in social practice is more than just doing: "It is doing in a historical and social context that gives structure and meaning to what we do". This applicability of the term is wide ranging: "such a concept of practice includes both the explicit and the tacit" (Wenger 1998, page 47). Social practice refers both to formulated actions, those participants have developed a means to talk about, and unformulated practices, those that occur but are not explicitly referred to. An overlapping, but slightly different, distinction is between the practices which participants are conscious of and those that they are not aware of.

For Lave and Wenger, practice not only refers to the practical and concrete but includes the mental and abstract; for example plot-fixing by Quartermasters, or telling a personal story for a member of Alcoholics Anonymous. Indeed the

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[6] There are of course other notions of social practice than the ones discussed and used in the thesis including the significant contribution of Bourdieu (1977). In the thesis the terms 'practice' and 'social practice' are used synonymously. They are to be understood as being distinct from 'behaviour' which is used to indicate particularly individuals way of engaging in a social practice.

concept of social practice allows for a resolution of what is, in other paradigms, viewed as a duality. Wenger (1998) introduces the idea of duality as distinct from a dichotomy, stressing the interrelationship of the concrete and the abstract[7]. Indeed, it appears from Lave and Wenger's perspective all social practices involve both a practical and mental aspect. Similarly, practice is not counterposed to theory; theory and theorising itself is a form of social practice.

From this perspective, the fundamental relationship between the concrete and the abstract is between participation in practice and its reification. These are at the heart of production of meaning and of social learning. Meaning and learning always have two aspects. Meaning as participation "refers to a process of taking part and also to the relations with others that reflect this process. It suggests both action and connection" (Wenger 1998 page 55). Reification refers to the process by which social practices take form as material objects or abstract concepts:

> the process of giving form to our experience by producing objects that congeal this experience into "thingness". In so doing we create points of focus around which the negotiation of meaning becomes organized (Wenger 1998 page 58).

Participation and reification are both "forms of memory" (Wenger, page 88). Reification of practice gives rise both to conceptualisations as a form of memory but also, importantly, to artefacts and tools of various kinds.

The negotiation of meaning

Meaning emerges from the dynamic of participation and reification within the social world, and as such it is negotiated. This negotiation may be, but is not necessarily, linguistic. For Wenger the choice of the term 'negotiation' is intended to convey two senses of negotiation. Firstly, in terms of people reaching agreement and secondly, it is also used to suggest an accomplishment that requires sustained attention and readjustment. The creation of meaning is a dynamic, historical, and active process that is always tentative, incomplete, partial, and specific to a situation (paraphrased from Wenger 1998, page 53). Thus individuals are involved in a process of 'negotiating' meaning through

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[7] In Wenger's illustration of duality (1998, page 66-69), the following features are put forward: two aspects of a duality are not opposites, they interact and do not define a spectrum, they imply each other, their conceptual importance is to understand the phenomenon rather than as a means of classification. I suggest that Wenger is using the term duality in a similar way to the Marxist notion of dialectical relationship, though without the notion of synthesis of opposites.

participation in the social world, regardless of there being a negotiation with any particular other or others. Wenger suggests then that knowing itself arises for participants through negotiation with the world[8].

Learning, from this theoretical perspective, is a normal, usual, and inevitable feature of being engaged in social practice. Learning is part of the general condition of being human.

Legitimate peripheral participation

Up to this point my discussion of learning as social practice has been quite general and many of the concepts discussed would apply to any theory of social practice. The concept of legitimate peripheral participation is, with the notion of communities of practice, a distinguishing feature of the Lave-Wenger perspective.

The means by which learning occurs in their model is through legitimate peripheral participation. This somewhat opaque and unwieldy phrase stresses two aspects of apprenticeship learning. Firstly, any learner engaging in the social practices of a community must do so in a way that is recognised by the community as legitimate; this assures that they are engaged in the same set of social practices. 'Peripheral' is a positive term that suggests relatedness and relevance; newcomers are not disconnected and on the outside but legitimately participate in the practices of the community (Lave and Wenger 1991).

The trajectory for a learner is from peripheral to full participation: from participation as an apprentice or newcomer to the fuller participation of 'a master'. In Lave and Wenger's analysis of apprenticeship situations an important intermediate role between apprentice and master is that of the 'journeyman'. The journeyman, or established member of the community, plays an important role in the learning of the apprentice. Thus, the theory of legitimate peripheral participation entails a triadic learning relationship (Lemke 1997).

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[8] Wenger's concept of negotiation is very similar, I believe, to the hermeneutic conception of knowing through circles of interpretation, when interpretation is understood as an active way of being in the world, rather than merely receptive.

Communities of practice

Participation in social practice and its reification gives rise to communities of practice. These are an emergent, and necessary feature of learning in and through practice. The use of the term community is not intended to convey necessarily any experience of harmony, or even collaboration, nor that communities of practice are in any essential way emancipatory (Wenger 1998, page 85). A community of practice may not be institutionally acknowledged or be formally constituted. The essential features, and signs of the existence, of a community of practice are joint enterprise, mutual engagement, and a shared repertoire.

A precondition for a community of practice is the existence of a joint enterprise. Although a community of practice may be constituted externally, for example institutionally, the enterprise of the community in practice is "defined by the participants in the very purpose of pursuing it. It is their negotiated response to their situation" (Wenger 1998, page 77) and so is local and situated. Local here means local to the community rather than necessarily spatially.

The joint enterprise of the community necessitates mutual engagement in social practices. Thus membership of the community is not defined by labels, or simply by personal relationships or by locality. That there is mutual engagement does not necessitate homogeneity. For mutual engagement to take place, various social practices that are not part of the central practice or definition of the community need to occur. Practices that support community maintenance are intrinsic to a community of practice.

Engaging in practice over a period of time develops a shared repertoire that:

> ...includes routines, words, tools, ways of doing things, stories,
> gestures, symbols, genres, action, or concepts that the community has
> produced or adopted in the course of its existence, and which have
> become part of its practice. (Wenger 1998, page 83)

In their early formulations Lave and Wenger theorise in terms of 'overlapping' communities of practice (Lave and Wenger 1991). Wenger extends this idea to think in terms of 'constellations of communities of practice'. Thinking in terms of

constellations of practice allows for an analysis of the way in which different constellations relate to each other and interconnect.

When considering the relationship of individuals to the community of practice it is important to think in terms of multi-membership of communities of practice. This is particularly so when considering the issue of identity.

Identity

This view of learning places identity and its development at the heart of the learning process. The trajectory of participation in the social practices of the community is also a trajectory of changing identity:

> Because learning transforms who we are and what we can do, it is an experience of identity. It is not just an accumulation of skills and information, but a process of becoming – to become a certain person or, conversely, to avoid becoming a certain person. Even the learning that we do entirely by ourselves contributes to making us into a specific kind of person. We accumulate skills and information, not in the abstract as ends in themselves, but in the service of an identity. (Wenger 1998, page 215)

However, because we are members of multiple communities of practice, for Wenger identity has an aspect of plurality. However, he considers that the experience of single identity is an ongoing process of reconciliation:

> Multimembership may involve ongoing tensions that are never resolved. But the very presence of tension implies that there is an effort at maintaining some kind of coexistence. ...I am suggesting that the maintenance of an identity across boundaries requires work ...This work is not simply an additional concern for an independently defined identity viewed as a unitary object; rather it is at the core of what it means to be a person. (Wenger 1998, page 160-161)

Part Two: Applying the theory to school mathematics

Lave and Wenger's analytical constructs have proved powerful tools for understanding certain aspects of school mathematics. In addition to these specific areas, their work is cited more widely as helping to provide a theoretical basis for socio-cultural approaches to understanding mathematical learning. The theory shifts the focus from teaching to learning (Adler 1998); that is what becomes most important is not what the teacher does but the activities of the learner. Important

areas where their theoretical concepts have proved fruitful have been issues of the situatedness of mathematical practices and connected to this the transfer (or lack of it) of learning, the nature of the learning that occurs, learners' experience of mathematics in school, and their identities.

The situated nature of mathematical practice

In mathematics education it has long been noted that learners of mathematics do not always or readily 'transfer' knowledge from one area to another (Evans 2000; Lerman 1999). For example, there is a discrepancy found between what people are able to do in school contexts and outside of school (see for example Lave 1988; Nunes, Schliemann, Carraher 1993). Lave and Wenger's theory contends that knowledge is situated within particular contexts and thus helps to explain why this should be so. Moreover, the analytical framework has been used to analyse mathematical practices in informal settings (see Watson 1998) and gives theoretical support to the project of ethnomathematics (Powell and Frankenstein 1997).

The nature of learning

The acquisition (Lave 1993) or representational model (Seely, Brown and Duguid 1989) of learning school mathematics, distinguishes between what the students are to learn or to 'acquire', and the means by which this learning occurs. A division is made between subject and pedagogy. Furthermore other activities that take place in the classroom are seen as only tangentially relevant. These activities include: how people enter the room; who speaks and when; how do they gain attention to speak and who chooses who will talk; how are people addressed; how people sit; how are the various artefacts customarily present used; what happens if the normal social practices are breached; and myriad other forms of practice. On the acquisition model, such practices may influence the *amount* of mathematics learnt but they do not influence *what* the mathematics is that is learnt.

From the social practice perspective, in contrast, there is no firm border between those practices that might, more usually be, considered to be central to the learning process and others that might be seen as more peripheral. This implies that the mathematical practices, pedagogical practices, and other types of schooling social practice found in different classrooms are inextricably linked and

interwoven. Thus the distinction between these three categories is not an absolute one, they merge and fold into each other. All are constituent parts of the social practices of school mathematics. The distinction between them can be one that is useful analytically as it helps to distinguish, for example, between those social practices that school mathematics communities of practice share with other mathematics communities of practice and those that they do not[9]. However, usual school mathematics, as a typical form, consists of all these social practices.

This theoretical standpoint helps to explain the way in which different pedagogies develop different sorts of mathematics. For example, Jo Boaler found in the ethnographic study discussed earlier, that there was not so much a difference in the amount the students' learned but in what they learned. She contended that the nature of mathematics learnt in the two cases was different; a closed pedagogy led to closed, decontextualised mathematics, an open pedagogy to a more open mathematics (Boaler 1997).

Adopting a view of learning, as participation in social practice, does not entail a view that mathematics is necessarily best learnt by lots of 'practising'. If by this it is meant repetition of similar exercises to practise algorithms. Such a pedagogy means the learner will learn, at best, how to engage in the social practice of practicing algorithms:

> even when students learn mathematical ideas in the classroom, if their engagement in the practice of interaction, adaptation, and reflection were absent then learning is likely to be of little use in situations that require these practices (Boaler 2000, page 380).

Indeed, considering school mathematics as social practice helps us to understand the ways that departure from reliance on procedure and algorithm creates the possibility of the learner developing a different sort of mathematics. Indeed Jo Boaler contends that "the union of knowledge and activity central to situated theories provides the greatest challenge to traditional models of teaching that has ever been made" (Boaler 2000, page 381).

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[9] This is different from the equivalent forms in the socio-constructivist perspective where mathematical norms, socio-mathematical norms and social norms are treated as distinct categories (see Cobb et al 1992; Cobb and Yackel 2000).

Part Three: Community of Practice Theory and school mathematics - difficulties and questions

Mathematics educationalists, who are generally sympathetic to or adopt alternative socio-cultural perspectives, have critiqued both its ability to account for all aspects of learning and the unmodified application of Lave and Wenger's theory to school mathematics classrooms.

In discussing the applicability of the theory I believe it is helpful to distinguish between two aspects of the theory. Firstly, *learning as participation in communities of practice* is a theory of learning and identity, that represent a distinct **philosophy**, or as Lave and Wenger put it an "analytical perspective" (1991, page 37). As such it is an epistemological and ontological account of the nature of knowing and being in the world. Metaphorically, it is about the fabric our worlds are made of. Secondly, it is a sociological **description** of the *forms of participation* and the nature of the groupings, *the communities of practice*, that emerge through the reproduction and evolution of social practices. It is about what patterns may emerge on the cloth.

A generalised theory of learning?

Lave and Wenger claim that the theory is a universal one about learning:

> We should emphasise, therefore, that legitimate peripheral participation is not itself an educational form, much less a pedagogical strategy or a teaching technique. It is an analytical viewpoint on learning, a way of understanding learning. We hope to make clear as we proceed that learning through legitimate peripheral participation takes place no matter which educational form provides a context for learning, or whether there is any intentional educational form at all (Lave and Wenger 1991, page 40).

Criticisms of Lave and Wengers' theory as a philosophy of learning include:

- The lack of account of the role of emotion in the learning process (Walkerdine 1997; Linehan and McCarthy 2001).

- The lack of historical and social location of the subject (Hodges 1998; Lerman 2000; Walkerdine 1997).

- The intrinsic power relationships involved in learning (Fox 2000; Hodges 1998; Walkerdine 1997).

- The multiple forms of participation and identification possible in communities of practice do not always follow the trajectory of legitimate peripheral participation (Lemke 1997; Linehan and McCarthy 2000, 2001) including the possibility of non-participation (Hodges 1998).

- The extent to which individuals not only participate and change in the social practices of the communities that they participate in but also create or reconstruct contexts in particular moments in the flow of events in the community of practice that may be contradictory or in opposition to those practices (Linehan and McCarthy 2000, 2001).

- The need to give an account for the learning mechanism, that is, how learning takes place within communities of practice (Lerman 1998).

- The possibility of dis-identification from the community of practice (Hodges 1998).

The research material presented in this thesis tends to support many of these criticisms. In addition, in using the lifeworld as an analytical tool, I show that participation in the same social practice does not necessarily have the same meaning in the lifeworlds of each participant.

Are school mathematics classrooms communities of practice?

In addition to the above difficulties with the theory as an analytical perspective, there are particular issues connected to its application to school classrooms and the extent to which legitimate peripheral participation describes the nature of participation in mathematics classrooms and the extent to which they are like the communities of practice described by Lave and Wenger.

Wenger (1998) makes the claim that communities of practice are **the** sites in which learning takes place and certainly refers to schools as places that have communities of practice in them. What is not clear is whether this is intended to refer to individual classrooms, though it appears to be the case: for example he

gives the examples of taking a spelling test and shooting spitballs as examples of the shared repertoire of a community of practice (Wenger 1998, page 83). Jean Lave (1996) also extends the claim that school learning is best understood as taking place in communities of practice:

> Wherever people engage for substantial periods of time, day by day, in doing things in which their ongoing activities are interdependent, learning is part of their changing participation in changing practices. This characterization fits schools as well as tailor shops. There are not distinguishable "modes" of learning, from this perspective, because however educational enterprises differ, learning is a facet of the communities of practice of which they are composed (Lave 1996, page 150).

However, they recognise that institutional settings are different from the apprenticeship situations that they analyse and that there may be particular issues when their analytical perspective is applied to them (Lave and Wenger 1991). However, I believe that the nature of school mathematics classrooms means that to claim they are communities of practice stretches the meaning of the concept to the point where it loses analytical value. I set out some of the reasons below.

In schools issues of power relationships are intensified. Participation, by students, in schooling practices is often coerced (Lerman 1998). Students acquiesce to the social practices of the school mathematics classroom rather than helping to create and constitute them (Winbourne and Watson 1998). The particular forms of social practices found in schools have ideological purposes related to social reproduction. Stephen Lerman draws on Bernstein's (1996) concept of pedagogic discourse to point out the way in which the school mathematics is an ideological recontextualisation of other mathematical practices and the way in which this acts against the creation of communities of practice (Lerman 1998). Valerie Walkerdine argues that schooling generally and school mathematics in particular are implicated in the production and regulation of particular types of "subject", by this she means for example the "slow child" or "mathematically able child" (Walkerdine 1997).

Carol Linehan and John McCarthy discuss the "control relations" in mathematics and other lessons in a primary school classroom that they characterise as a community of practice. They describe the way in which during localised and short-term interactions, participants position each other in complex ways in which

there are shifting relations of control, responsibility, authority and power (Linehan and McCarthy 2000, 2001).

Various writers have pointed to the way in which the triadic learning relationship of old-timer, established community member, and newcomer does not easily fit the school classroom situation where the social roles are divided into teacher and student (Adler 1998; Lemke 1997; Lerman 1998). Clearly the notion of trajectory associated with the concept of legitimate peripheral participation does not apply to school classrooms; most students are not going to become teachers.

In the context of mathematics in schools, learning mathematics does involve a change in the identity of the learner:

> Students do not just learn methods and processes in mathematics classrooms, they learn to *be* mathematical learners and their learning of content knowledge cannot be separated from their interactional engagement in the classroom, as the two mutually constitute one another at the time of their learning (Boaler 2000, page 380).

Thus the theory of learning taking place within communities of practice helps to explain issues of mathematical identity (Boaler 2000; Boaler and Greeno 2002; Leman 1998). However, because identity is plural, and learners can exercise agency, this process is by no means automatic. Different trajectories of identity are possible within the usual school mathematics classroom with many students being unable or unwilling to make the required realignment or will only do so grudgingly and temporarily leading to alienation and dis-identification. (Bartholomew 2002; Boaler 2000; Boaler and Greeno 2002; Boaler, Wiliam and Zevenbergen 2000; Mendick 2002)[10].

Local communities of practice

As one means to address these concerns Peter Winbourne and Anne Watson identify, what they refer to as, local communities of mathematical practice:

> Such communities may be local in terms of time as well as space: they are local in terms of people's lives; in terms of the normal practices of the school and classrooms; in terms of the membership of the practice; they might 'appear' in a classroom only for a lesson and much time

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[10] Such identity conflicts are not unique to usual school mathematics classrooms. Some learners find it difficult to 'be' the type of learner classrooms based on alternative pedagogies require (see Boaler and Greeno 2000). I return to this in Chapter Seven where I discuss the experience of particular learners of different questioning practices and the issues this raises for the possibility of democratic classroom practice.

might elapse before they are reconstituted (although it may be possible to detect the subtle effects of the echo that remains after their passing in the trace of learners' trajectories or the development of other practices) (Winbourne and Watson 1998, page 94/95).

They give examples of such local communities of practice and summarise the features that they believe are necessary to constitute a local community of practice:

1. pupils see themselves as functioning mathematically and, for these pupils, it makes sense for them to see their 'being mathematical' as an essential part of who they are within the lesson;
2. through the activities and roles assumed there is a public recognition of developing competence within the lesson;
3. learners see themselves as working purposefully together towards the achievement of a common understanding;
4. there are shared ways of behaving, language, habits, values, and tool use;
5. the lesson is essentially constituted by the active participation of the students and teacher;
6. learners and teachers could, for a while, see themselves as engaged in the same activity. (Winbourne and Watson 1998, page 103)

Their description of the nature of a local mathematical community of practice prefigures Wenger's later detailed description of mutual engagement, joint enterprise and shared repertoire that he proposes define a community of practice.

Learning communities

In addition, these features are a good summary of the social practices of the various alternatives to usual school mathematics described earlier. Considering communities of practice in school mathematics classrooms in this way echoes Merrilyn Goos who does not see the theory of community of practices as being generally applicable to school mathematics classrooms but rather a particular form of pedagogy to be established (Goos, Galbraith and Renshaw 1999).

Moreover, educationalists have pointed to the creation of particular forms of community of practice in which learning is placed at the centre of the communities project and purpose and posited the notion of a community of learners (Rogoff, Matusov and White 1996). A community of learners is one in which participation is favoured over transmission or acquisition and responsibility

for learning is shared. Wenger himself suggests a similar particular sort of community of practice, a learning community, which puts learning consciously at the centre of its enterprise and purpose (Wenger 1998). The ideal is, I believe, found in the learning communities established through co-operative inquiry and other participative research methodologies (see Chapter Two for discussion and references). In posing a 'hypothetical' ideal to guide choices made in the research, I posited the idea of co-operative, co-reflective learning communities (see Preface, page 35)

But what about usual school mathematics?

As Peter Winbourne and Anne Watson point out, learning does take place in school classrooms where local communities of practice or learning communities do not appear to exist. This learning is both mathematical and social. This leads them to conclude that it would be absurd to not describe everyday classrooms as communities of practice (Winbourne and Watson 1998). However, this conclusion rests on the premise that communities of practice as described by Lave and Wenger are the only form of social grouping within which situated learning takes place[11]. If a more general description of meaning making arising from processes, relationships and interaction is sought, the insight that learning may be seen as participation in practice can be retained, without accepting that school classrooms are always communities of practice. In Chapter Five, I put forward the idea of ecologies of practice as a general description of formations in which learning takes place.

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[11] I leave to one side the question of whether or not all learning takes place through participation in practice except to say that I believe the nature of learning changes. A single theory of learning is not appropriate and different theories of learning tend to refer to different sorts of learning.

CHAPTER ONE, FIFTH PIECE: THE LIFEWORLD AND SCHOOL MATHEMATICS

The lifeworld in educational research: a missing concept

A concern for the experience of the learner calls for some way of describing the meaning learners create from their experiences and the way these meanings also help to create the experiences. The concept of the lifeworld is one way of doing this. Considering people to have different lifeworlds asserts and emphasises the ways in which the worlds, as already existing realities, of the participants in interaction, are productive of the meaning of particular events and interactions.

The lifeworld as an analytical tool has not often been employed in classroom educational research. Tony Brown adopts a hermeneutical approach that draws on the concept of the lifeworld to understand the way mathematical concepts are developed by learners (Brown 1997). In terms of understanding the social practices of the classroom it has been applied fruitfully as a means to interpret a micro-ethnographical study of a science classroom (Roth et al 1999, Roth and McRobbie 1999). Wolf-Michael Roth, Sylvie Boutonné Campbell McRobbie, and Keith Lucas found that many different lifeworlds[12] could be identified within one classroom (Roth et al 1999). The use of the term lifeworld for these researchers stresses respect for and acceptance of the existence of participants' worlds regardless of what might appear to be incoherence from the researchers' perspective:

> ... when our participants made seemingly contradictory statements, we did not take this as evidence that they were irrational or had split personalities; we took this as evidence of their attempts to construct coherently intelligible and plausible accounts of some phenomenon (Roth et al 1999, page 64).

A key outcome of their lifeworld analysis was a recognition of the extent to which different participants existed in distinct, if overlapping worlds; the authors posit the existence of "One class, Many worlds" (Roth et al 1999, page 59). These many worlds did not simply include different emotional responses to the same phenomena or different meanings attached to social practices but extended to some students seeing and experiencing different physical worlds from the teacher

during science experiments. Different students described the same situations in very different ways.

The notion of learners living in and through different worlds also emerges in the work of Jo Boaler and Jim Greeno (Boaler 2000; Boaler and Greeno 2000). The theoretical perspective of these writers is rooted in social practice theory rather than phenomenology. They employ the notion of "figured worlds" (Holland et al 1998) to explicate the way in which learners are alienated from the world of school mathematics. The notion of figured worlds "rest[s] upon people's abilities to form and be formed in collectively realized 'as if' realms" (Holland et al 1998). A figured world is an imaginary world, such as the world created by children during play, within which people act 'as if' it were real. Jo Boaler finds it intelligible and necessary to consider the way in which school mathematics, for many learners:

> was *of another world* and to fully engage in that world, students needed to suspend their knowledge of the real world, suppress their desire to interact with others, and strive to reproduce standard procedures that held little meaning for them (Boaler 2000, page 391).

She indicates ways in which entering into the school mathematics world creates conflicts for the identity of many learners.

However, from a phenomenological perspective the different worlds that we live in, through and are part of, are not 'as if' realms but rather are 'what is' realms. The lifeworld is the objectively existing reality for the subject, the material and non-material fabric of the world. Lifeworlds are not about opinions or transient experiences. They are what we live in to have opinions and transient experiences.

Various researchers, have then, pointed to the way in which considering participants as existing in multiple worlds may help us to understand more about classroom social practices. However, the use of the lifeworld by classroom researchers as yet is under theorised, with little discussion of its origin in phenomenology and the insights offered by the philosophical and psychological tradition from which it originates.

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[12] Roth et al use the term life-world as opposed to lifeworld, for ease of discussion and consistency I use lifeworld throughout the thesis.

The lifeworld in phenomenology

> ...phenomenology wishes to "see" what our place, our life, our lived-experience (of the world) *is*. We are to faithfully document the interweaving meaning of our experience-of-the-world just as it gives itself to be, without (as the thesis of the natural attitude would require) asking of that experience whether it is or is not indicative of some univocal world which has its being "out there". (Jardine 2002, page 101, original emphasis)

The notion of the lifeworld has its origins in phenomenology. The concept of the lifeworld was developed by Edmund Husserl in his later work (Husserl 1970/1). Husserl's project was to find an alternative to Cartesian dualism; his method of reduction aimed to reveal 'things in themselves'. His concern was to elucidate philosophically the structures of the world that are universal rather than individual subjectivities. He makes a distinction between the individual or particular life world and the lifeworld as "the shared world of lived experience" (Pike 1986, page 101). This inter-subjective lifeworld can be revealed, according to Husserl, by the phenomenological methods of epoché and philosophical reduction.

Some consider Husserl's conception of the lifeworld to be "univocal" (Jardine 2002) and flawed in the supposed independence of the lifeworld from history and culture. The extent to which Husserl's notion of the lifeworld is ahistorical is contested, particularly as the later work of Husserl is published (Ashworth 2003). It is arguable that critics of Husserl's ahistoricity misread his stress on the existence and importance of the lifeworld as independent from the "mathematization of nature" through modern science (Husserl 1970). Regardless of this, later theorists using the concept of the lifeworld have distanced themselves from Husserl's project to establish phenomenology as scientific philosophy and challenge the notion of pre-suppositionlessness as employed by Husserl. The sociological phenomenology of Schutz and Luckman implicitly includes the idea of historical and social location of the lifeworld:

> The everyday life world is to be understood as that province of reality which the wide-awake and normal adult simply takes for granted in the attitude of common sense. By this taken-for-grantedness we designate everything which we experience as unquestionable (Schutz and Luckman 1974 page 3/4)

From this perspective what may be "common sense" in one culture or for one individual may not be common sense for another.

Heidegger's existential phenomenology also denies the existence of an ideal detached observer (Ashworth 2002). The nature of being-in-the-world precludes the possibility of bracketing pre-suppositions, indeed such pre-suppositions, or in Heidegger's terms "fore-knowledge" (Heidegger 2000/1926) or in Gadamer's "prejudices" (Gadamer 1975), are necessary for interpretation or knowledge to exist at all.

One way of summarising an important difference between Husserl and Heidegger, with regards to the research process, is that Husserl believes that intra-subjective knowledge can be put aside (bracketed) to reveal inter-subjective knowledge of the lifeworld whereas Heidegger points to the way in which intra-subjective and inter-subjective knowings are part of a whole and are inseparable.

However, even this distinction between intra-subjective and inter-subjective knowledge is misleading. The self cannot be isolated ontologically as an entity that is separate from the lifeworld of which it a part. The notion of the lifeworld expresses a radical anti-dualism in which an embodied self is embedded within the world or as Heidegger puts it being-in-the-world[13]. Thinking in terms of 'the self' and 'other aspects of the lifeworld' are analytical tools rather than epistemologically or ontologically separate categories. Paradoxically, it appears that it is part of the structure of the lifeworld, the self appears to be a separate part of the 'rest of the world' and itself is an object of consciousness. I consider the reflexive aspect of the self in Chapter Five.

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[13] The terms 'embodied' and 'embedded' are appropriated from Phillip Agre and Ian Horswill (1997). However, their use of these concepts in connection with the lifeworld is dualistic in that they assert a dichotomy between agent and environment.

> ...phenomenology is akin to ecology which will also leave alone this irresolvable paradox that this pine tree is part of us and apart from us. It is not blessed by human dominion, yet it is intimately part of me, or my breath and bone.
>
> In this way? in living with this tension of experience/experienced? phenomenology does not provide us with a new standpoint, new methods, a new framework, a different model, an alternate theory, another perspective, a better picture, a clearer view. Things are *exactly* what they were before *except for this one blessed difference*? the intra-mundane desire to redeem the world through the wielding of the weapons of clarity, objectivity, truth, univocity, has been "let go"...It leaves us right where we always were, with the actual play and interplays of life, with all its difficulty and ambiguity, unredeemed, or, better, not in need of redemption. (Jardine 2002, page 103, original emphasis and punctuation)

In this thesis I make a number of claims about the lifeworld in respect of school mathematics. The central claim is that it is worthwhile and important to consider the existence of individuals as having a school mathematics' lifeworld (or more properly both having and being a lifeworld). Recognising the existence of the lifeworld both helps us to understand the variety of experience of school mathematics and complements theories of learning as social practice. Social practice theory has tended to stress the commonality of experience and meaning that arises from shared practice, for example in the notion of a community of practice (Lave and Wenger 1991). However, shared practice does not always generate common experience or meaning, as I illustrate in various places in this thesis, and the lifeworld offers one way to understand why this is not so[14].

In Chapter Four, I give an example in detail of both the nature and structure of one lifeworld of school mathematics. In my analysis I draw on Heidegger's ontology of the lifeworld (or in Heidegger simply the world). Here I consider the entities of the lifeworld as consisting of the self, entities in the world and others. By considering one lifeworld of school mathematics in detail I argue that Heidegger's ontology must be adapted to make sense of this particular lifeworld.

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[14] I leave aside the question of whether a practice is truly a 'shared practice' if it does not have the same meaning for the participants until Chapter Five.

CHAPTER TWO

METHODOLOGICAL YARNS

yarn [*yaarn*] *n* continuous thread of synthetic fibrous material or of twisted
fibres of wool, cotton *etc*; *(coll)* anecdote, *esp* long rambling tale; **spin a y.**
tell a story ~ **yarn** *v/i* (*coll*) tell stories; have a long comfortable chat.
(The Penguin Concise English Dictionary, page 838)

> when you tell me there are too many crossings out
> that the work is too messy
> my child is crushed, shamed
> but my adolescent self
> screams
> Fuck you!
> How can I know where I
> am going to go before I get there
> and my adult self
> says maybe my PhD examiners
> had better be careful what they say
> About my methodology

(Poem written at PME 2001 in a Working session on Expanding
Researcher's Abilities to study Student Experiences)

FIRST PIECE: ABOUT THE CHAPTER

In this chapter I set out the methodological traditions that inform the research and my
use and adaptation of them. The metaphor of a 'methodological yarn' suggests both the
meaning of a material that can be woven with, that texture and text can be created from,
spinning yarns to weave with, and that of spinning a yarn, telling a tale that may not be
altogether believable or 'true' but may still have purpose and value.

In the Second, Third and, Fourth pieces of the chapter, I position myself in relation to
three principle methodological standpoints, post-modernist research, critical research,
and hermeneutical inquiry. The methodology as a whole is best summarised as an
engaged (post-critical), ecological hermeneutic inquiry influenced by existential
phenomenology and post-modernist thought. I am compelled to echo Hilary Povey in
her caution about her description of her (somewhat different) PhD methodology: "I
cannot take myself seriously in writing such a sentence: I caution the reader to think
(seriously) before doing so" (Povey 1995, page 9).

As discussed in the preface I began this research as a schoolteacher with relatively little knowledge of research theory or methodology. I indicated there some of the ways in which the research process and journey influenced my methodological perspectives and thinking. Here I consider some of these issues more fully and formally in relation to methodological traditions. Although, the methodology developed during the course of the research, I believe my early research activity is largely compatible with the views put forward in this chapter, even if this activity was not fully informed by all of the perspectives I develop here.

In the Preface I used the metaphors of cloth and tents to discuss the text and the research as alternatives to more traditional metaphors of buildings. Employing this metaphor the methodology and philosophical concepts employed in the research are perhaps akin to the paradigmatic poles and guy ropes and the earth to which these are fixed, even if the anchoring is temporary. These enable the fabric to find its functional form and to hold its shape.

The research is premised on the belief that legitimate claims to knowledge can still be made if one has stepped outside of any single research paradigm. I do not have space to justify this in the chapter but consider and justify this in Appendix IV. My primary aim in this chapter is to explain why the stories I offer are not arbitrary and that they have been woven in such a way that they are similar to ones usually created or told in academic research contexts.

In the Fifth piece, "Weaving the Yarns Together", I firstly describe the way in which these philosophical and methodological frames have together shaped the methods of the research. I then go on to briefly consider the implications of my discussion for the status of knowledge presented in the thesis.

CHAPTER TWO, SECOND PIECE: THE INFLUENCE OF POST-MODERNISM[1]

Educational research and the post-modern tradition

Given the anti-paradigmatic concerns of post-modernist thinkers and the diverse, eclectic, contradictory nature of work that identifies itself or is identified as post-modern (Griffiths 1995), it is inappropriate to talk about a post modern paradigm or a post modern methodology. It is more useful to think in terms of a post-modern research tradition[2]. This tradition has a number of different strands and concerns (McLaren 1998).

In educational research, perhaps because of its concern with the immediacy of the educational situation, this tradition is less well developed than in other areas of social research. This is particularly true of mathematics educational research. However, within educational research we can find a multiplicity of concerns that are derived from the projects of post-modernist theoreticians: deconstruction of objective generalised truth and the localisation of knowledge, attention to discourse, uncovering of relations of power, and the ways in which identity and self are constructed both within found discourses and research discourse (see for example Ball 1990; Brown 1997; Brown and Jones 2001; Ernest 1998; Evans 2000; Griffiths 1995b; Hardy 2000; Hardy and Cotton 1999; Lather 1990, 1991; Stronach and Maclure 1997; Walkerdine 1988, 1996, 1997).

These concerns are ones that I share and have influenced my thinking and actions. Although reference to post modernist thinking is not central to my methodology, it does in various ways enable and frame the research and thesis. I discussed in Chapter One the text and textuality of the thesis and in Appendix IV I argue that post-modernist thinking supports the use of multiple research paradigms. Here, I identify those aspects

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[1] A caution: I am suspicious of post-modernism as a label. My suspicion has two roots. First it is a term that has multiple meanings. The post-structuralist, deconstructionist, and post-modernist lineage is a heterogeneous one in which there is much familial feuding (Stronach and Maclure 1997, McLaren and Kincheloe 1998). Second, important features of a post-modern perspective can be located in modernity. For example, Alex Callinicos argues that self referentiality, montage, paradox and ambiguity and the demise of the integrated individual subject are already existent and perhaps defining features of modernity (Callinicos 1989). However, regardless of whether Callinicos is right that society remains essentially Modern, my concern here is with the way some of the ideas of post-modernism have influenced my methodology. There is one, if difficult to define, body of thought that is known as post-modernism and it is to this that I refer: "The post-modern has been described and redescribed with so many different points of departure that the whole discussion is by now its most exemplary definition" (Bordo 1992, page 159, quoted in Griffiths 1995b, page 224).

[2] I enjoy the irony in using the word 'tradition' about post-modernist thought.

of post-modernist thinking that have influenced my interpretation and appropriation of research methods and methodologies.

Firstly, I emphasise the local and subjective nature of knowledge. However, my approach is to assert the value of many truths rather than this leading to the conclusion that there is no truth.

Secondly, I embrace the complexity of a multiplicity of selves (this is important in Chapter Four particularly). One consequence of this is that I share the post-modernist perspective that there is not a generalised human subject on whose behalf an identifiable and unchanging project of political emancipation can be articulated[3]. My discussion in the next piece on 'Critical and Engaged Research' of the actor for change is influenced by post-modernism.

I share an interest in the way in which demeaning, restrictive, and inappropriate social relations are created and are embedded in our daily social relationships and believe that these are crucial sites for work for social change[4].

The concept of power is an important focus in post-modernist discussion about the nature of everyday social relationships and its relationship to knowledge. Schools and schooling are undoubtedly sites in which relations of power are important (see for example Ball 1990). However, in this thesis to an extent I sidestep an in depth consideration of theories of power due to limits of space. This is not least because, in the context of current academic thinking, using the concept in a manner fully located in current thinking would require a significant and lengthy discussion to position my perspectives in relation to others. In various places, and in particular in Chapter Six, I discuss power relations in the classroom. At such points I ask that you consider my discussion as a contribution to an understanding of the nature of power in social relationships and formations (and development of my own thinking about such matters) rather than flowing from a formulated or theoretically certain position. However, you will see that I adopt and illustrate Foucault's notion that power is productive and needs freeing from simplistic negative connotations (Foucault 1980).

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[3] The use of the term 'political' here is important. Later in the chapter in discussion of engaged research practice it is clear that I do believe in a trajectory of personal and spiritual development and growth both individually and collectively that at the very least can be chosen.

There is an important difference between what might be expected of a post-modern research text and this thesis and that is in its relation to discourse. A focus on discourse is perhaps the defining feature of post-modernist social theory. However, analysis of discourse is not a central tool that I employ. I do consider the type of language that I along with other participants use in relation to discourses of others. For example, the way in which the children I interview use the discourse of teachers and schooling to describe themselves and others is taken as giving insight both into the lifeworld and the ecologies of practice they live in and through.

However, I do not treat the school classroom as a text. Post-modernism, at least in the post-structural variety of Foucault and Derrida, has been concerned to undermine the legacy of Cartesian rationalism. One way they do this is by insisting on "the importance of language as constitutive of reality and subjectivity" (Griffiths 1995b, page 226). In my view, the essence of Cartesian rationalism does not consist solely in the centrality of the rational unitary experiencing I, the cogito, but the co-emergent ideal of thought as language, and knowing as thinking with words alone.

> ...it remains very hard to ascribe its behaviour to ignorance.
>
> After all, it is not blind. It has eyes, recognizable eyes. They are enough like our eyes that it must see somewhat as we do. It has a mouth, four legs, can move bipedally, has grasping hands, etc; for all its gigantism and strange looks, it seems less fundamentally different from us, physically than a fish. And yet, fish school and dance and, in their own stupid way, communicate!
> ...
>
> ...I noticed early that from time to time it would move its curious horizontal mouth in a series of fairly delicate, repetitive gestures, a little like someone eating. At first I thought it was jeering at me; then I wondered if it was trying to urge me to eat the indigestible fodder; then I wondered if it could be communicating *labially*. It seems a limited and unhandy language for one so well provided with hands, feet, limbs, flexible spine and all; but that would be like the creature's perversity, I thought. I studied its lip-motions and tried hard to imitate them. It did not respond. It stared at me briefly and then went away.
>
> (Le Guin 1987, page 64)

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[4] Such views are not unique to post-modernist thought but are shared or are similar to the views of social constructivism and other interpretivist paradigms (see Gergen 1999).

In seeing the world as text, post-modernist thought reflects the hegemonic construction of what it is to know and to think. Part of my identity is as a dancer and a climber, each time I dance or climb I directly experience knowing without words. My dance or climb could be seen as language but it will be a language that is very different from a text.

We can and do communicate meaning without the mediation of words. Others ways of knowing the world other than through rational or irrational language are possible, we can have a different sort of connection with the world (see Reason 1993). A focus on text and language can lead us to forget about our embodied relationship with the world. I support David Jardine's call for "post-critical naiveté" which acknowledges that the webs of relationship we are in are not only discursive (Jardine 1994).

The lexiocentrism of post-modernism is not neutral and value free. I will share an anecdote to illustrate that. I have a friend who I went to school with. Schooling was a painful process for him. He left school unable to read and write very well. In his early twenties he attempted to improve his reading and writing ability. He became aware of the term dyslexia and believed that it might apply to him. My friend is a very skilled mechanic, he has a small business and employs other people and organises both his business and his work colleagues efficiently. In a recent conversation I was struck by the extent to which he still feels shame about his difficulties with reading and writing. I thought of the fact that I find activities which involve tools and machinery much more difficult than him. He has a label 'dyslexic' but there is no equivalent for my 'disability'. In a less language-orientated society perhaps I would be seen as 'suffering' from 'dysfrabilia'[5], an abnormal inability to become competent with tools and objects made with them.

Ironically, the deconstructive tools of post-structural theory can end up supporting and strengthening a disembodied rationalism in which the subject is identified only with the mental and where our relationship with the world we are born, live and die in, is ignored:

> We get caught too easily in worlds of our own making. I will admit as well that, in experiencing the Earth – not just talking about it and understanding it, but walking it and breathing it – we do impose our expectations and constructions and conceptions upon it. But a clarification and developmental sequencing of these impositions does not describe a sustainable ecological starting point for our curricular reflections as much it

[5] I have little knowledge of Latin. Interestingly, I found no translation for 'practical' and the key translation of tool was connected to weapons, f fabrilis -e [relating to an artificer]; n. pl. as subst. , [tools].

describes a profound *problem* we face in respecting what comes to meet us in our experience as having *its own* life and integrity. Saying that this leaf or the life of this animal (or the cadences between my heavy breath and the pitch of the hill I am climbing) has no pattern/order of its own and that all we can understand of the Earth are the patterns/constructions we impose on it – this might make some sort of epistemological or philosophical sense but it points to a way of life that is becoming no longer sustainable. (Jardine 1994, page 111, original emphasis)

My response to post-modernism is also influenced by my respect for those belief systems that modernity and at least some strands of post-modernist thinking might dismiss as naïve and superstitious. In my practice as a dancer for whom dance is both a means of self-realisation and a spiritual path I seek an integration of the mind with both heart and body as equally important centres of knowing, feeling and experience[6]. From this perspective, some post-modernist discourse represents a 'hyper-mentalism' in which the mind or thinking tangles itself in ever more complicated and abstract knots. It is not particularly helpful in seeking, for example, greater emotional fluidity or expression, or in understanding the body's needs. Wisdom traditions teach that integration of all aspects of one's being is emergent with full connection with others, with society and with the rest of existence. I am suspicious of any discourse that cannot find room for, or be comfortable about, speaking of compassion and love. This is not to say that at least some post-modernist thought is not concerned with value and ethics. However, in critiquing, in its terms, master discourses and regimes of power, it often fails to make explicit its axiological commitments.

In the next two sections I explore the way in which an ecological perspective, influenced by post modernism, allows for a reinterpretation of critical research as engaged and transformative research and of hermeneutics.

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[6] The distinction between mind, heart and body here leans on Gabrielle Roth's work (Roth 1990, 1999) and should be read as a map that guides practice rather than a theory of the way people are.

CHAPTER TWO, THIRD PIECE: CRITICAL AND ENGAGED RESEARCH

Critical, criticalist and engaged research

In the Preface I declared my lack of neutrality with regard to the subject matter of the thesis. My inquiry is about ways in which mathematics classrooms might be different and more worthwhile, what serves to inhibit movement towards such change, what theoretical understanding might support change, and what teachers might do who wish to support such change. To carry out such an inquiry assumes that there is something wrong with schooling in general and mathematics learning and teaching in particular. Further, what happens in any particular classroom is ecologically connected to wider social and political relationships. I am to contribute to a critique of existing relationships and practice and seek transformation and change. The research is allied to and draws on the critical research tradition.

Like many labels used in discussion of research methodologies the term 'critical' is used in many different ways. One of its modern usages is to indicate research that is based on the critical theory of the Frankfurt School and of Habermas (Giroux 1981; Kincheloe and McLaren 1998; Lather 1991; McLaren and Kincheloe 1998). In educational research, the more pedagogical approach of Friere is also important (see, for example, Frankenstein 1990; Giroux 1992; hooks 1994). Here critical research is linked to a critical pedagogy. Regardless of the theoretical basis, the goal of critical educational research is firstly an ideological critique that attempts to uncover or reveal the roots of powerlessness and oppression and secondly an emancipatory project to be realised by action based on such critique. However, as I have indicated, the possibility of such an emancipatory project being based on universal non contextualised values has been undermined by the post-modern critique (Brown and Jones 2001; Lather 1991; Usher 1996).

This has led to the development of critical postmodernist research (see for example Lather 1991; McLaren & Kincheloe 1998). Patti Lather, for example, accepts the post-structuralist critique that discourse is power-laden and there is no final knowledge. She does not see this as necessarily leading to nihilism, pessimism and inaction. Rather, it turns us back to what she sees should be at the centre of the critical approach; research

as praxis that creates the conditions where: "legitimacy is plural, local and context specific" (Lather 1991, page 117).

Peter McLaren and Joe Kincheloe extend the notion of critical research to loosen its ties to critical theory by positing the notion of criticalist research consisting of four different schools of inquiry with various theoretical perspectives. Those perspectives being: critical theory, Foucault's genealogy, deconstructionism and poststructuralism. They define a criticalist:

> as a researcher or theorist who attempts to use her work as a form of social or cultural criticism and who accepts certain basic assumptions: that all thought is fundamentally mediated by power relations that are social and historically constituted; that facts can never be isolated from the domain of values or removed from some form of ideological inscription; that the relationship between concept and object and between signifier and signified is never stable or fixed and is often mediated by the social relations of capitalist production and consumption; that language is central to the formation of subjectivity (conscious and unconscious awareness); that certain groups in any society are privileged over others and, although the reasons for this privileging may vary widely, the oppression that characterizes contemporary societies is most forcefully reproduced when subordinates accept their social status as natural, necessary, or inevitable; that oppression has many faces and that focusing on only one at the expense of others (e.g., class oppression versus racism) often elides the interconnections among them; and finally that mainstream research practices are generally, although most often unwittingly, implicated in the reproduction of systems of class, race, and gender oppression. (Kincheloe and McLaren 1998, page 263)

In this sense I would identify myself as a criticalist. However, I believe that there are key issues about the nature of the research relationship and the current human crisis that are not addressed in the above description.

Firstly, as described above, the question of the nature of relationships between research participants is under theorised. An important aspect of much criticalist research is a concern for creating and supporting relationships between researchers and others that are congruent with the criticalist project. One way of conceptualising this concern is to explore whether the research is 'on' or 'with' other participants (Setati 2000). This question does not delineate research that is criticalist. Research that contributes to movement for positive social change can use methodologies and methods that mean the research is carried out 'on' the other participants (Angier, Boylan and Povey 2000; Wiliam 2000). However, such research generally contributes to a critique of existing situations. Where an attempt is made to explore the possibilities for social change

99

through research then, I believe, it is better conducted with at least the intention of being 'with' the participants.

Secondly, whilst the above description stresses the alienated and oppressive nature of social relations it pays scant attention to the way in which these social relations are co-emergent with an alienated and disharmonious relation with the universe we exist in and, in particular, with the earth. The current social crisis we face is born out of a profound disconnection from the earth, each other and even our own emotional and spiritual needs.

Thirdly, and connectedly, the espoused values on which the criticalist response is based do not foreground the experientially spiritual nature of human existence. Here spiritual can be read in its broadest sense of purposeful and meaningful existence in relation to the universe we find ourselves in and need not be associated with religion. I contend that within the four strands of criticalist thinking that McLaren and Kincheloe identify there is woven a sense of what human life is for and should be. Where human life is meaningful it has a spiritual content. Such a concern needs to be placed in the foreground of research for transformative action.

I am not arguing that any particular spirituality should be attached to the criticalist project rather that part of its critique of existing social relationships must explicitly be that they do not foster but prevent the expression and development of spirituality. This is inextricably linked to the prospect of social change. I do not wish to decry the importance of political engagement at the level of social movements that contest economic and state power. Indeed, I am an active participant in such movements. However, the social relationships that create these are sustained and recreated in our own personal circles of relationship and responsibility and existential relation to our own and the universes existence. In the context of this thesis, the social practice of school mathematics as implicated and saturated as it is in capitalist ideology arises not only in an abstract world of 'capitalism', 'ideology', 'discourse', 'grand narratives', 'agency' or 'power', but in the lived relationships of people in classrooms and schools. These lived relationships change and can change through the expression of the participants' desires, fears, purposes, dreams and other aspects and expression of self/selves.

This suggests the need to redefine the purpose of inquiry so that it:

100

is not simply of even primarily to contribute to the fund of knowledge in a field, to deconstruct taken-for granted realities, or even to develop emancipatory theory, but rather to forge a direct link between intellectual knowledge and moment-to moment personal and social action, so that inquiry contributes directly to the flourishing of human persons, their communities, and the ecosystems of which they are part. (Reason & Torbert 2001, page 3-4)

Such an approach places ethics and value at the heart of the research process and calls for the question to be addressed "What ethics and what values?" I do not propose to attempt to fully elucidate the values that informed the choices I made in this particular inquiry; to some extent they may be read from the text as whole. What I feel is more important is to recognise that the legitimacy of actions as being more or less appropriate and more or less worthwhile, is determined not by individual conscience but is produced within and through the communities and relationships that the researcher is part of (Wiliam 2000). In this sense the appropriateness and worthwhileness of actions are open to challenge in the same ways that claims to knowledge are. Indeed, the appropriateness and worthwhileness of actions and the inquiry itself is intimately bound up with the status of the knowledge that arises[7].

One means to embrace these concerns is through the developing research traditions of co-operative inquiry and participatory action research [8] (see for example Heron 1992; Reason 1988, 1994a, 1994b, 1998; Reason & Heron 2001).

Co-operative inquiry assumes that every person:

> is a fundamental spiritual entity, a distinct presence in the world, who has the potential to be the cause of his or her own actions. To actualise this capacity and become fully a person is an achievement of education and self-development. It involves learning to integrate indivdiualising characteristic with a deeper communion with others and the world (Reason 1994b, page 41).

Co-operative inquiry aims to support this process for all participants and so conceptualises all involved as co-researchers, responsible for and involved in all aspects of the research process. Particular protocols and methods involving cycles of reflection and action have developed to support this aim (see Reason 1994b).

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[7] Patti Lather (1991) conceives of "catalytic validity" as one way of approaching this idea.
[8] This research tradition has many strands and forms of practice, not all of which would embrace fully the questions of value that I am interested in. For example, action research need not necessarily be critical or aimed at human liberation at all as it can and has been appropriated by powerful interest groups (Gaventa and Cornwall 2001).

Although locations and research foci vary widely, it appears from reports of co-operative inquiries (see Reason 1988, 1994a) that this research method is successful when involving a relatively small number of co-researchers and ones amongst whom rank is fairly evenly distributed.

Participatory action research is a method of collaborative research which has its roots in the tradition of liberationist movements (Reason 1994b, Fals Borda 2001, 2002). Its focus is on working with communities or groups to generate knowledge and practices that are of immediate relevance. People advocating and using participatory action research describe themselves as practitioners rather than researchers. Participatory action research shares with co-operative inquiry a concern for the self-determination of participants. However, the relationship between the experienced practitioners and community members is clearly a complex one. The concept of dialogue is an important one in this tradition.

Later, I describe the way in which co-operative inquiry and participatory action research influenced my research actions particularly in the second year of the research. Before this and to introduce this discussion I discuss the way in which different strands of the critical tradition envisage or conceptualise the researcher as an actor for change.

Agents for change

An extension or opening up of the critical project calls for some account to be given of the nature of the actor who seeks change.

Different strands of the critical tradition give various accounts of both the project of change and the agents of change. The critical theory of Habermas seeks emancipation and the organisation of enlightenment through dialogical knowledge arrived at by a process of critical discussion. On this view a critical researcher is engaged in praxis that allows at the very least for critical dialogue and discussion to take place (Usher 1996). In the classic Marxist tradition Gramsci proposes the concept of the organic intellectual that emerges (or is developed) from and within the oppressed group (classically the working class), who can act not only as an agent of praxis for themselves but crucially a leader of others (Gramsci 1988/, Gramsci 1982). In Paolo Friere's radical pedagogy the actor for change is described as a 'conscientizer' of the oppressed (Freire 1972) and this perspective is clearly influential in participatory action research (Reason 1994b). These are valuable and important conceptualisations of what it might, and can, be to

work for social change. However, they speak from a notion of a universalising project of emancipation and knowledge.

An alternative to the notion of the organic intellectual is suggested by the, as yet underdeveloped, notion of the specific intellectual (Knijnick 2000, Foucault 1980). The specific intellectual is modelled on the idea of an expert in some particular field. Others have referred to research as being transformative and researchers and critical pedagogues adopting the mantle of 'transformative intellectuals' (Giroux 1992). One interpretation of this concept is that transformative action must be contextualised and 'local theory' created to guide action for transformation. Alternatively, Tony Brown and Liz Jones offer the concept of a "transgressive agent" (Brown and Jones 2001). Working in an educational context, they recognise that spaces for action are limited but that it may be possible to transgress, to step over rules and boundaries and thereby to create new situations and possibilities.

However, once the notion of a universal emancipatory project is stepped away from, it is not always apparent what ought to be transgressed. In the context of education and educational research there are many opportunities and possibilities for action against the accepted norms and ideologies. However, not all such actions will necessarily lead to worthwhile outcomes. Teachers find themselves in situations that (depending on worldview) can be seen as engaged in social and ideological reproduction and/or creation of the subject and regimes of truth. Yet at the same time teachers are also engaged in caring and supporting young humans in navigating the potential reefs of their early life cycles. There may well be tensions between transgressive actions and the teacher's responsibility to care for and support their students. For example, even if a teacher chooses to ignore the potential personal costs in choosing not to teach the mathematics curriculum as currently prescribed, it still will remain an important gate-keeper for the students' subsequent life choices.

Moreover, the different conceptualisations of the agent for change as an 'intellectual' are one sided in their emphasis on a theoretical and mentalistic route to social change. I do not wish to decry the importance of theory, after all I am engaged in its production. However, I do not believe we are so much deficient in theory, universal or local, that can guide social change but rather that our theories are often disconnected from our hearts and bodies. This disconnection is an obstacle to dialogue with others that is a means of furthering social change.

During the course of the research, I began to use the concept of 'engagement' to describe and guide my research practice. In the next section I describe how this concept came to be defined through my attempt to enact research based on the principles of co-operative inquiry and participatory action research, and how it draws on the notion of participation in these traditions.

Engaged research practice

"The longest zoom lens is your legs"

(*anonymous[9]*)

The idea of engaged research practice developed during the second year of the research. In the preface I described the way in which the inquiry changed and developed as a result of the experience of the research practice. In this section I give an account of the same period in terms of changes in methodology.

In the initial stages of the inquiry in the first year, my research practice was much more 'on' than 'with'. Nonetheless, in my dealings with all the participants I was influenced by the concerns of deep respect for others drawn from principles of co-operative inquiry even though encounters with other participants were generally short term. An exception to this was the work with Peter, Jill and Paul. Here, I attempted to work with them as co-researchers. However, in retrospect fuller reflection on the nature of the research relationship particularly about issues of rank might have alerted me to some of the difficulties encountered in the second year of the research.

The research activities in the second year were intended to "open dialogue about the experience of school mathematics". The intention was to facilitate dialogue between the teacher and students about their experience of classroom social practices. Renuka Vithal's concept of "hypothetical", "actual," and "arranged" situations was important to my thinking (Vithal 1999, 2000, see Chapter One). The hypothetical situation, or guiding aim or value, was the possibility of creating co-reflecting learning communities in the classroom (see Preface). The actual situation was one in which I expected the social practices of school mathematics to dominate. The arranged situation was one in which myself and the teacher as co-researchers would create opportunities for students to reflect on and discuss their experiences of the social practices.

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[9] I acknowledge Christian DeSouza, a photographer, for this unattributed aphorism.

From beginning to work with Jill, I attempted to develop a process of co-operative inquiry with us working together as co-researchers. However, I envisaged a different pattern of participation by the students in the research. My knowledge as a teacher and a researcher of the practice of school mathematics and reflection on methodology meant that I did not believe it would be possible to involve the students in her classes as co-researchers in any meaningful sense. Issues of power, rank, different interests and life-worlds and the structures and practices of schooling appeared to preclude this[10]. In relation to the students I believed that the principles of participatory action research could be applied, with the students becoming involved over time and through dialogue in changing and developing their classroom community. Indeed, my hope was that discussion about the social practices could support change to these practices.

In summary, the intention had been for a two-fold inquiry in which I and Jill would be co-operative inquirers about her classroom practice generally and teacher questioning practices in particular and where together we might involve the students in a community inquiry modelled on participatory action research.

In the preface I outlined the way in which events in school and differences between Jill's lifeworlds and mine, our differences of experience and rank, and crucially our different purposes, led to the methodology of the research changing[11]. Although the initial research focus was negotiated, Jill then wanted me to "take the lead". She recognised we were not equal in terms of experience and also identified that I had the privilege to spend time on reflection in a way she did not. Secondly, she wished the first steps towards 'opening dialogue' with our focus class to be delayed as she believed it would be "unsettling" in a situation where the class was already difficult to teach.

The concept of 'engagement' emerged as I attempted to enact the values underlying a participative perspective in a situation in which full participation in the research process was not possible. In a more general sense, the concept of engagement attempts to address the issue of how to act when starting from a participative outlook, when people

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[10] This does not mean that I do not believe that fruitful co-operative inquiries are necessarily impossible in school classrooms with students as co-researchers. Indeed, the models of communities of practice as 'learning communities' (see Chapter One and Seven) point to the creation of communities in which such research practice may be possible. However, I had chosen the research site, in part, precisely because such a learning community did not pre-exist. In any event involving students as researchers is a difficult one given the nature of schooling.

[11] As already mentioned in retrospect, the possibility of a successful co-operative inquiry between a novice teacher and a novice researcher was unrealistic. However, that does not mean that I regret attempting the inquiry and one outcome was that we did become co-collaborators towards the end of the research.

we wish to participate[12] with do not wish to or are unable to. The dilemma posed during the research encapsulates and reflects one found in other areas of life, not least for teachers who seek to be actors for social change, particularly if it is believed that the locations and circles of relationship we find ourselves in are precisely those ones that we have the greatest responsibility to act in.

To be engaged suggests the idea of being connected to the situation one finds oneself in. It suggests the type of 'coupling' in systems theory (Varela, Thompson and Rosch 1991) that leads to change and, in human terms, the development of knowledge.

The situation that one engages in has a number of aspects that will be more or less important in different contexts and as events unfold. Firstly, and as a starting point there must be engagement with the self, physically, emotionally and cognitively. For me part of this engagement with self is necessarily also an engagement with that part of self which is aware of its connection and ultimately its indivisibility from the mystery of creation. To be engaged requires a commitment to be present as fully as possible even if this is always as a work in progress. The meaning of being present is perhaps more easily understood and recognised by its negation. There are many ways to not to be present to the situation one is in, these include: rehearsing or planning some future event, going over what has already occured, being lost in loops of repetitive thoughts or patterns, or escaping into daydreams and fantasy. Being present can be summarise in the phrase 'showing up' rather than absenting ourselves from ourselves (and others) in some way.

Secondly, there engagement involves relationship; to be engaged with whomever one finds oneself in relation with at any particular time. Engagement here requires a willingness to recieve the other person with integrity and to attempt to avoid acting out from projection or transference.

Thirdly, we are engaged with the communities and groups that we are in a circle of relationship with. Engaged creative action demands integrity and deep respect for those

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[12] 'Participate' here is used in a strong sense of involved and active participation rather than simply involvement in social practice, see Chapter Five for a discussion of the nature and meaning of participation.

we are in relation with. Fourthly, our engagement with self and others is always part of the wider world-ecology that we collectively have a shared responsibility for[13].

My engaged research practice involved putting into practice the idea of researcher as bricoleur "creating solutions to our problems with makeshift equipment, spare parts, and assemblage" (Denzin and Lincoln 1998, page 425). In practical terms it requires an eclectic use of research methods. Important in the context of this research project were the principles and practices of ethnography, particularly in its critical variety (see for example Atkinson and Hammersley 1998; Creswell 1998; Denzin 1997; Fetterman 1989; Hammersley 1983, 1990; Thomas 1993).

Part of our choice of research methods is constrained by the audiences we write for. One of my audiences is the mathematics education research community and mathematics educators and I want my research to be treated as credible. Some in these communities may be more well disposed to points in the text in which research methods and forms of analysis that are favoured in the post-positivist paradigm. For example, interview material in Chapter Three was analysed using an approach that was drawn from Grounded Theory (Glaser and Strauss 1967; Strauss and Corbin 1990) to generate themes.

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[13] The notion of engagement I put forward is similar to Peter Reason's concept of a participatory world view, where 'participation' is understood as a way of being in the world rather than linked only to particular research methodologies (for example see Reason 1998). It was only after I had space from the frenetic pace of the second year of the research experience that I was able to return to literature on the participative research tradition to appreciate this broader definition. I prefer to retain the term 'engaged' as it is possible to participate in what is happening without truly partaking of it (following Bohm 1996). A central purpose of engagement is to foster the conditions in which participation may take place and thus is supportive of participation as a world view (Fals Borda 2002; Reason 1994a)

I went to a piece of performance theatre by the Charlotte Vincent Dance Company. Two dancers, a man and woman, moved in an out of the performance space, dancing in intense relationship. The performance took place in a space within an installation that included a glass house. This allowed the watcher-participants to be able to see the same scenes from different views (we were encouraged to move around the space during the performance). At one point the dance of tangled relationship seemed to become tense. I felt that there was the threat of violence. I was scared.

I moved my position slightly and the same scene now appeared as playful and light. Even my experience of the mood of the music changed as a result. If I had not moved then I would have had one understanding of the scene. If I had been in the second position I would have had another. So the same event can be seen differently from different standpoints. This is not so surprising but the performance gave me a visceral embodied experience of the way in which our different 'sitting places' dramatically alter our understanding.

My first interpretation of the experience was to believe that by moving my position I could come to see the event from the perspective of another, to be able to adopt multiple viewpoints.

However, this is not really the case. When I move and see the scene anew, I do so from the point of view of someone who had seen it differently not as someone seeing it for the first time. I have an expanded horizon but it is still a singular perspective. Taking multiple viewpoints does not mean seeing from another's viewpoint.

In relation to the piece as a whole, there was 'truth' both in playfulness and lightness of the particular moment and also in the shadow of tension and possible violence, and thus also in the duality of both aspects of the moment. Yet if I had started in the second position and moved to the first the experience would have been different. We cannot avoid the singularity of embodied experience. We can choose whether to celebrate or grieve about this.

(From Research Diary March 2000)

Hermeneutics as a way of being

Hermeneutics, and interpretivist approaches to research more generally, form a complex and varied tradition (see Schwandt 1998 and Bernstein 1983 for discussion). The

concept of the hermeneutic circle is key to hermeneutics as a research method[14]. The hermeneutic circle points to the importance of considering each part in relation to the whole and the whole in relation to each part. The use of hermeneutics as a method in this sense is discussed more fully in Chapter Four[15]. In passing I note that this aspect of the hermeneutics is important to an ecological perspective.

Brent Davis highlights the pre-modern meaning of method as "shared–way" (from meta-odos):

> That is a method was an approach to knowledge that foregrounded the place of common action and accord rather than the questing to erect an autonomous truth – the process rather than the goal. (Davis 1996, page 26/27)

In the seventeenth century, method came to mean a standard, unchanging procedure that produces truth. Essential to modernist methods is an idea of the separation of subject and object. The emphasis is on outcome.

Davis argues that hermeneutics is best understood as a method in a pre-modern sense. This idea of focus on process rather than outcome describes important aspects of hermeneutics; in particular that knowledge and its creation is relational and in a continual process of change. Knowing always involves 'coming to know' (Davis 1996). By focussing on the process and a shared way, the exact manner in which the research is conducted is not against a fixed measure but arises pragmatically from considering fitness for purpose.

In this piece of the thesis I am concerned with giving a philosophical account of the hermeneutic aspects of my approach to the research inquiry. I take as a starting point Hans-Georg Gadamer's hermeneutics. For Gadamer:

> the hermeneutical condition is a fact of human existence, and philosophical hermeneutics is concerned with a phenomenological (i.e., existential) explication of *Dasein* (condition of existence or being-in-the-world). (Schwandt 1998, page 227-228)

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[14] Given the manner in which the endpoint of the hermeneutic circle is the starting point for a new cycle of interpretation I prefer the term 'hermeneutic spiral'.

[15] Although hermeneutics generally privileges the principle of the circle of interpretation over particular methods (Shwandt 1998)

Prejudice and horizons of understanding

> It is not so much our judgements as it is our prejudices that constitute our being. (Gadamer 1976, page 9)

Gadamer stresses the importance of the initial standpoint for any interpretive act. Our views are not something to be put aside in order to seek 'objectivity', indeed for Gadamer this is impossible. He follows Heidegger in insisting that projection, fore-understanding are preconditions for understanding. Gadamer chooses an even stronger word, 'prejudice' which should be understood as a positive or at least neutral term. Prejudices are biases of our openness to the world.

Prejudices are not necessarily unjustified and erroneous, so that they inevitably distort the truth. In fact, the historicity of our existence entails that prejudices, in the literal sense of the word, constitute the initial directedness of our whole ability to experience. The hermeneutical cycle consists in being open; open to what and whom we seek to understand and open to our own prejudices and projections, and from here interpreting (see Gadamer 1975, pages 235-240). In terms of this research inquiry and particular interpretive acts within it, as a teacher and educationalist I come to any situation with ways of framing what I experience and how I interpret these experiences[16].

The existence of such prejudices means that we are always bounded in horizons of understanding. This term suggests:

> the ever-present but never quite fully transparent presuppositions, contexts and referential networks that we must always take for granted when we are in the world. The horizon is ever present, and it recedes into infinity; at any point in time, it is only some part of it, on which we focus our attention, and this then becomes present to us and reveals itself to us. (Benhabib 1996, page 112)

Privileging dialogue

Gadamer tells us that it is only through the dialogical encounter with what is at once alien to us, makes a claim upon us and has an affinity with what we are, that we can open ourselves to risking and testing our prejudices (Bernstein 1983, page 129).

Gadamer is centrally concerned with the interpretation of texts but he extends this to include 'real' conversations.

> A conversation is a process of two people understanding each other. Thus it is characteristic of every conversation that each opens himself to the other person, truly accepts his point of view as worthy of consideration and gets inside the other to such an extent that he understands not a particular individual but what he says (Gadamer 1975, page 347).

Gadamer is explicitly saying that in a conversation we do not get inside another but that we attend to what they present to us. The characteristic of a conversation is openness from a particular perspective. The fact that we have an existing standpoint means that we "do not relate the other's opinion to him but to one's own views"(Gadamer 1975, page 347). Thus it is dialogical.

Such interpretation does not occur in some linear or determined manner, Gadamer uses the idea of play to illustrate the way interpretation like play leads the participants on with its own dynamics (Gadamer 1975 page 92; Bernstein 1983, page 121). Conversation also has this characteristic.

> We say that we 'conduct' a conversation, but the more fundamental a conversation is, the less its conduct lies within the will of either partner. Thus a fundamental conversation is never one that we want to conduct. Rather it is generally more correct to say that we fall in to conversation, or even that we become involved in it. The way one word follows another. With the conversation taking its own turns and reaching its own conclusion, may well be conducted in some way, but the people conversing are far less the leaders of it than the led, no one knows what will 'come out' in a conversation (Gadamer 1975, page 345)

Gadamer here summarises my experience of the research inquiry as a whole and particular dialogical encounters during it.

Whilst the outcome of a conversation may be that we come to understand another's point of view and gain an insight into their horizon this does not mean that we can, in rigorous terms, claim that we share another's view point or horizon. I opened this section with a story about witnessing/participating in a piece of performance art, The House by Carol Vincent, within which a physical movement to another perspective allowed for a reinterpretation. However, the new interpretation that I have is not the

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[16] I highlight here my identity and prejudices as a teacher and educationalist. However, these are only the most easily named, the prejudices or fore-understandings are a vast array of complexly interwoven structures of cultural and social beliefs that extend even into fundamental notions of time and space.

111

one as if I had seen the piece from the other side in the first place. If I come to understand something of your perspective, my horizon changes, is broadened, but it is now my understanding of the world in relation to my understanding of your understanding.[17]

The concept of the hermeneutic circle moves from a circle of interpretation between the parts and the whole, to a cycle of interpretation based on dialogical encounter. Entering into 'conversation' with what or whoever is being interpreted, leads to a partial revealing of aspects of the interpreter's prejudices or foreunderstandings. Horizons of understanding are broadened. This allows for further dialogue and further interpretation. This concept of the hermeneutic circle is important in the research in seeking to understand others' lifeworlds and the challenge this created for my own.

Potentially hermeneutics is deeply democratic (Mindell 1984,1995) and appreciative of the unique lifeworld of each human or other part of the ecology of being:

> To let be – that is to let beings be as the beings which they are – means to engage oneself with the open region and its openness, into which every being comes to stand, bringing that openness as it were along with itself. To engage oneself with the disclosedness of beings is not to lose oneself in them; rather such engagement withdraws in the face of beings in order that they might reveal themselves with respect to what and how they are in order that presentative correspondence might take its standard from them. (Heidegger 1978 page 128)

Gadamer's analysis of conversation stresses the importance of the 'solidarity' and respect between those involved (Bernstein 1983).

Hermeneutics of suspicion

Gadamer's hermeneutics has been criticised as subjective, relativistic and blind to the ideological nature of "prejudice" and tradition and the importance of interest, most famously by Habermas (Bilimoria 1998). Although I accept that interpretation based on Gadamer's hermeneutics is subjective, Habermas' challenge has particular weight in the context of my inquiry.

One research aim was to understand more about the experience of the social practices of school mathematics. The principle research method used to do this, group and individual interviews. In a situation of more or less equal relationships and outside the

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[17] I acknowledge a friend, Lisa Meaney, for this insight

ideological suffused context of schooling then a dialogue and conversation of the sort that Gadamer uses as a model for dialogue might be possible. However, part of my fore-understanding as researcher was a belief that such conversations are not a usual feature of usual school mathematics classrooms. Indeed, the research explored if it was possible to open dialogue and aimed to find ways to do this.

Thus issues of power in the interviews, and research participants' concerns with presentation of self, creation and maintenance of identity, and location in multiple ecologies of practice means that we must at the very least doubt the extent to which statements or actions represent aspects of the participants' lifeworlds in some relationship of direct correspondence (participants here includes myself).

Paul Ricoeur's hermeneutics of suspicion addresses some of these issues (Ricoeur 1970). Ricoeur's hermeneutics is derived from analysis of the methods of Freud, Marx, and Nietzche in their analysis of religion (Robinson 1995). Each of whom questions, in different ways, the nature of religion through a process of deconstruction and recontextulisation of its historical and cultural reality. Put simply a hermeneutics of suspicion advises us not to take matters at face value but to inquire more deeply.

Ricoeur, like Gadamer, locates ideas in the context of textual criticism; my interpretation here generalises from this context to interpretation of speech and action. Central to a hermeneutics of suspicion is the importance of the interpreter inquiring as to the historical and cultural context in which text, speech or action occurs. This requires distancing oneself from both one's own prejudices and the tradition or context and also adopting a critical attitude (Bilmoria 1998). In terms of an ecological paradigm, Ricoeur points to the way in which text, speech or action are not bounded by the interpretive act separate from the wider ecology.

Ricoeur shares with Gadamer the belief that the hermeneutic circle inevitably leads to greater self understanding and an opening of horizons. However, he goes beyond Gadamer in believing that the interpretive circle must be able to lead to a more radical challenge to one's own horizons of understanding. For example, during the course of the research, students and other research participants revealed the extent to which the concept of 'teacher' was bound up with 'one who asks questions'. Reflection on this caused me to see the extent to which I shared this concept and thus allowed me to broaden my understanding.

113

Ricoeur's hermeneutics calls for a critical and suspicious response to others' speech and action. However, this does not mean that this ought to restrict or abjure a commitment to receptivity to research participants, especially not to children. This is not merely due to an ethical issue of respect, but because, methodologically, what is most immediately apparent or obvious, is as just as much part of the whole as what is obscured.

A post-modern hermeneutics?

Riceour's hermeneutics stresses an awareness of location and self-reflexively our position in that location. In this section I go further to argue for reflexivity about the hermeneutical process which points, perhaps, to a 'post-modern hermeneutics'.

A post-modern hermeneutics focuses on process, on the method as a shared way, but the process itself is subject to the hermeneutic process. To draw out this distinction I will return to the essential metaphor for the hermeneutic method, the conversation and use as a foil to my discussion Brent Davis' consideration of the nature of conversation (Davis 1996).

For Davis an essential feature of having a conversation is that we are not aware we are having one. He contrasts conversations with discussions. A discussion is a coordinated action between participants whose concerns "are for the articulation, explication, and defence of their own views" (Davis 1996, page 39). For Davis, the aim of discussion, particularly in its more adversarial forms, is not to understand others' views but to interrogate them. The aim is not to find consensus but to explore difference. He notes that to discuss originally meant to shake apart: "to *converse* much in contrast, had a meaning more toward "to live with" or "to keep company with"" (Davis 1996, page 39, original emphasis).

Because of this quality of being immersed in the conversation and its unpredictability, Davis makes the claim that:

> the idea that one can be aware that one can be in a conversation is in some ways self-contradictory, it presumes an awareness of one's self and one's subjectivity. It is precisely this detached, observer-like awareness that must be set aside to allow a conversation in the first place.
>
> In other words, we can never be aware that a conversation *is taking place*. We can however, be aware that one *has taken place*. When understandings

have changed, when a new commonsense as been established – when self and other have been altered – it has happened. (Davis 1996, page 28, original emphasis)

I believe that we can, and do, conduct conversations in a hermeneutical sense and can retain our awareness of the process we are involved in. In asserting the hermeneutical character of such conversation I assert that such awareness does not mean that the outcome of the conversation is constrained or that the subject matter loses its productive quality.

If I have a unitary notion of self then the impossibility of awareness of being in the conversation is clear, I am either in it or outside it. However, a recognition of multiplicity of selves allows an understanding of how I can be in process and aware of process as well. Indeed, there is the potential to develop, as John Mason puts it, "an inner-witness who watches but does not participate, does not get in the way" [18] (Mason 1999, page 200). However, although the witness does not participate, we can choose to act upon what we perceive; bringing awareness to how a conversation or interaction is taking place will itself shape the conversation in particular ways. I believe that in interaction, we do generally act on our awareness of the nature of interaction for example adjusting our tone or words if we perceive that the other is uncomfortable.

An example of just such a process occurred during the case study reported in Chapter Three. Fuller details of the context are given there. I intervened in a 'discussion' about a mathematical topic to bring awareness to the possible nature of underlying social practices. Opening dialogue about the social practices of the classroom acted as an interruption to the usual classroom procedures. The description of the initial incident that sparked the case study does not convey a sense of the change in atmosphere that resulted in the classroom when the conversation switched from talking about finding the 'nth term' of a sequence to talking about the way in which the students were responding. As we moved to this meta-practice of talking about the practices of the classroom, energy and excitement were generated and, what I interpreted as, a sense of relief occurred; a conversation began. It was a single, small, and isolated event but gave me an insight to the potential power of dialogue about the practices in the classroom *as they are occurring*. Interestingly, one of the students turned to me and asked me if I was a psychologist.

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[18] I differ slightly here from Mason in that I believe that what we develop is more an awareness and an ability to access the inner-witness that already exists as a given aspect of human existence.

This is very different from 'deconstructing' the classroom discourse. Rather, the aim is to reconstruct the classroom discourse by breaking the contract that we do not say what we see or what we feel. This hermeneutical approach to creating dialogue moves from conversation as metaphor for the hermeneutical process of interpreting text to seeing hermeneutics more fully as a way of being with others in the world; having a conversation with the world. Such a hermeneutics calls for a post-critical awareness of our position and practices in relation to the dialogue.

CHAPTER TWO, FIFTH PIECE: BRINGING THE YARNS TOGETHER – BRAIDING OR SPINNING?

> As in spinning a thread, we twist fibre on fibre. And the strength of the thread does not reside I the fact that some one fibre runs through its whole length, but in the overlapping of many fibres. (Wittgenstein 1968, page 32)

I asserted at the start of this chapter, and argue in Appendix IV, that it is appropriate and possible to move between different paradigms. This is to warrant the use in my research of two research traditions with very different methodologies and apparently in opposition to each other.

In this short piece, I indicate how these two research traditions informed different aspects and phases of the research process and the analysis of research material. The metaphor of braiding is helpful here: the different methodological yarns being wrapped around one another.

However, in the interplay of the different traditions during the research there is a sense in which the different traditions have started to be 'spun' together to form a single methodological approach in which the fibres are enmeshed. Therefore I go on to consider the ways in which the methodological strands may come together through the concept of dialogue.

Braiding

The inquiry as whole is both engaged and hermeneutic. It is an engaged inquiry in the choice of research topic(s): I am to effect change in myself, others and the world, it is an exercise in praxis. It is hermeneutic in the sense that the research process is akin to a conversation with the world. Starting from a concern with the learner's experience of mathematics, the research process revealed my fore-understandings or prejudices about the nature of classroom practice. This led to a reconceptualisation of the nature of both experience (through the concept of life world) and of social practice (towards understanding classrooms as ecologies of practice). Both the hermeneutic and engaged processes were distilled in the context of post-modern thinking.

The case study presented in Chapter Three on teacher questioning is principally a criticalist piece of research that adds to a specific understanding of the way in which one aspect of school mathematics social practices impacted on a particular group of

learners. It is typical of other research activity of this type in the first year. The research here is criticalist, in its concern for the student' experience, in seeking to develop a dialogue about this, and in the co-operative nature of my work with Peter, the teacher in question. In terms of analysis of research material I employ an analysis of themes drawing on grounded theory.

The case study presented in Chapter Four, Louise's lifeworld, is hermeneutic both in the nature of the interview and in the form of analysis. The decision to present Louise's lifeworld as a monologue, and thereby to dramatise it, arose from both a phenomenological perspective and the influence of post-modernist thinking about the textual forms through which academic research is communicated. This case study is representative of other in-depth interviews conducted. The analysis of material is through a hermeneutic process that has a number of phases. Firstly, presenting the monologue as research outcome, stresses a respect for the lifeworld of the other. In creating the monologue interrogation of my own foreunderstanding was vital. Secondly, whilst continuing with the same Gadamerian hermeneutics (Gadamer 1975), I then go on to include in the hermeneutic process, Heidegger's ontology of the lifeworld (Heidegger 2000/1926). Thus a new hermeneutic circle of interpretation is used to critique and develop Heidegger's ontology in relation to Louise's lifeworld. Finally, in considering the Louise's mathematical lifeworld as alienated, I begin to widen the analysis more in the spirit of Ricoeur's hermeneutics (Ricoeur 1970). Chapter Five is a theoretical discussion of the nature of participation and social formation in school mathematics.

The material presented in Chapters Six and Seven was gathered during the research activities of the second year. This arose out of an inquiry that began on the principles of co-operative inquiry and participatory action research. The actions I took were informed by these traditions and the more general notion of engaged research. However, in choosing what to record, how I observed and how I conducted interviews, I was hermeneutical. The analysis of the material in Chapter Six evokes Ricoeur's hermeneutics more fully in seeking to understand the nature of participation and engagement in one particular ecology of practice beyond what is immediately apparent.

The debates between Gadamer and Habermas highlight the extent to which Gadamerian hermeneutics is not easily incorporated into a criticalist project, leading to Habermas proposing an alternative hermeneutics (Bernstein 1983). However, an important point of intersection between the hermeneutic and criticalist traditions is the stress placed on dialogue. Bringing together engaged, critically aware, transformative philosophy with hermeneutics in the context of a post-modern understanding of dialogue is an example I believe of what Thomas Schwandt sees as a "turn toward the moral-practical (*phronesis*) and away from *theoria*" (Schwandt 1998, page 250) in hermeneutics.

In both co-operative inquiry and participatory action research, dialogue is central to the process of inquiry and the creation of knowledge (Reason 1994b). Both knowledge and common action develop through a process of negotiation and agreement. Similarly, in hermeneutics the notion of dialogue is the principle metaphor for interpretation and in a possible post-modern hermeneutics dialogue is more than a metaphor.

Without ignoring the deep ontological and epistemological differences between the conception of dialogue within the two traditions, my own experience as a researcher is that they speak of and distil a common approach to being in community or, where community does not exist, to the attempt to create it.

Knowing through dialogue

The participatory research tradition and hermeneutics give stress to two aspects of dialogical knowledge. Through participatory action understood as praxis - "the self creative activity through which we make the world" (Lather 1991, page 11) – we generate "a practical knowing" (Reason and Torbert 2001) that can guide action. Hermeneutics stresses understanding of the nature of others and necessarily my own being in the world. As such it accesses, explores and expresses the "experiential grounding" (Reason and Torbert 2001) on and through which action occurs. I propose that though this thesis is concerned in places with abstract and theoretical means of conceptualising the world it should be judged by the extent to which the text articulates practical knowing and elucidates the experiential grounding of the participants and areas of inquiry.

CHAPTER THREE

TEACHER QUESTIONING AND STUDENTS' PARTICIPATION

How to be a 'pupil'

...As a pupil you have to

- listen to the teacher, often for long periods of time
- when the teacher stops talking, bid properly for the right to speak yourself, sometimes when competition for the next turn means balancing the risks of not being noticed against the risks of being ignored as too enthusiastic;
- answer questions to which the answer will be judged more or less relevant, useful and correct by a teacher who is seeking not to know something but to know if you know something;
- put up with having anyone's answer treated as evidence of a common understanding or misunderstanding, so that the teacher will often explain something again when you understand it first time or rush on when you are still struggling with what was said before;
- look for clues as to what a right answer might be from the way a teacher leads into a question, and evaluates responses – that last source of clues being often so prolific that even a wild guess may lead the teacher to answer the question for you;
- ask questions about the administration of the lesson but not usually about its content (and certainly never suggest that the teacher may be wrong);
- accept that what you know already about the topic of the lesson is unlikely to be asked for, or to be accepted as relevant, unless and until it fits into the teacher's frame of reference
- (Edwards 1992, page235/236)

CHAPTER THREE, FIRST PIECE: ABOUT THE CHAPTER

In Chapter Two I described the dominant social practices of school mathematics and reviewed literature on students' experiences of these practices. In this chapter I focus on one particular aspect of usual school mathematics: the questioning of students by the teacher. Teacher questioning is an important but under researched aspect of classroom practice. In particular little is known about how students experience teacher questioning in school mathematics. Through discussion of a particular case study, I explore important themes about students' experience. Based on these emergent themes, I interrogate the notion of school mathematics classrooms as being communities of practice.

In the second piece of the chapter I discuss 'knowing' about teacher questioning strategies and pupil participation. There is an incongruity between the importance and prevalence of teacher questioning in classrooms and the relative lack of research and literature about it. I suggest some possible reasons for this.

The third piece of the chapter is a review and discussion of literature about teacher questioning of the whole class, the form of interactions that may follow in different types of classroom situations, and importantly the students' experiences of them. I begin by examining questioning in the context of schooling generally before considering school mathematics.

In the fourth piece, I summarise a case study based on students' accounts of how their willingness to participate in whole class interaction indicates a desire for greater participation and discussion, although this desire is not uniform and is mediated by their existing experience. This case study supports and is supported by existing research literature and implies that students experience traditional classroom practice in negative ways and that this has implications for issues of equity and gender.

In the fifth piece, I discuss the nature of communities of practice in school mathematics with respect to teacher questioning. I argue that the nature of teacher questioning in school mathematics shows that communities of practice as described by Lave and Wenger do not generally exist in usual school mathematics classrooms.

As an early piece of exploratory work by a novice researcher the methodology of the study had significant weaknesses. However, I include this piece of research for a

number of reasons over and above those given above. Firstly, although some of this material has been reported on before (see Boylan and Lawton 2000; Boylan, Lawton and Povey 2001), I now include further material here and discuss this more fully in relation to previous research. Given the paucity of research in mathematics education that treats learners as credible informants about their experience, almost any additional material is worth making public. Secondly, both the experience of collecting the research material and of analysing it were important events in my development as a researcher and in the development of my intervention in the second year of the research. Thirdly, whilst the particular case is limited, the themes that emerge are ones that pervade the whole of the corpus of research material collected over the last three years and my experience as a researcher.

In the section of the chapter that forms a report from the case study, I refer exclusively to material from the particular class surveyed and interviewed. Elsewhere in the chapter I do make reference to and quote from other research participants and the field-data of other researchers that helps to illustrate the points I make. The theoretical claims about the lack of communities of practice in usual school mathematics are based on the whole corpus of research material gathered during the research project as a whole.

CHAPTER THREE, SECOND PIECE: KNOWING ABOUT TEACHER QUESTIONING STRATEGIES AND PUPIL PARTICIPATION

> John, George, and Dave are ranking statements about possible situations that might occur during teacher questioning. The first dimension they have been asked to consider is how often the different events occur during their lessons and to put those that happen most often at the top and those that happen the least at the bottom.
>
> John: [Reads] 'The teacher does not ask questions', that would be in Australia, way down
>
> George: Maida Vale
>
> Dave: Pluto
>
> John: Canada
>
> (Group discussion in North School, Seven Blue, January 2001)

This is an extract from a transcript of a group of boys discussing the frequency of different social practices related to questioning in mathematics lessons. The extract reveals in a humorous way the extent to which 'asking questions' is an intrinsic part of what teachers do in these boys' lifeworlds.

Culturally, many of our archetypal images of teaching and teachers involve the teacher asking questions of students. The classical model of teaching through Socratic dialogue rests on the teacher leading the student to new knowledge through incisive questioning. Certainly, observation of classrooms shows teacher questioning of students is a frequent, pervasive, and persistent aspect of practice in school classrooms (Roth 1996). It has been estimated that a teacher will pose one and a half million questions during a typical professional career (Kerry 1987; Wood 1992) and teachers end nearly half of all their speaking turns in class with a question (Wood and Wood 1988). Susskind (1969) reports that teachers ask on average two questions per minute, whilst all the students in a class combined only ask two questions per hour (Woods 1992; Brown and Wragg 1993). James Dillon's review of both primary and secondary studies suggests that each student asks only one question per month of the teacher (I take this to mean a substantive question about the subject matter rather than a question seeking clarification

or instruction). Dillon argues that there is no need to refer to 'teacher questions' in the classroom, rather than simply questions, because invariably questions are teacher questions (Dillon 1990).

Given the prevalence of teacher questioning and the key role this has in constituting what takes place in classrooms there is surprisingly little research specifically about teacher questioning strategies or about pupil strategies when responding to questions or their experience of these exchanges. Explanations for this relative lack of research are likely to be varied, multiple, complex and opaque. Here, I will suggest a number of factors that I believe are part of such an explanation.

Firstly, the fact that questioning is such a universal phenomena and that one form of interaction predominates in classrooms (see below for discussion of Initiation-Response-Evaluation, IRE, type dialogues) means that teacher questioning practices have a quality of being 'taken for granted'. From a phenomenological perspective questioning is so embedded in the lifeworld of teachers, what they do and are, that it is hard to conceive of what it might be like if they did not question, or questioned in very different ways; this would require going to 'Maida Vale' or 'Pluto'.

Secondly, precisely because it is so deeply embedded in the life world of being a teacher or having been a student, we know, in a certain sense, a great deal about teachers' usual questioning of students and about students' experience of teacher questions. This knowledge, however, is the tacit knowledge that comes from participating in the social world of the classroom, a knowing in practice. We have all experienced hours of this in one role or another. For the teacher it forms an important aspect of their craft knowledge. For example, we 'know' as teachers and as participants in the social world that some of our students are embarrassed when directly asked a question by name. If we care about our students' comfort, we may try to avoid putting them in a situation where they might get a question wrong. We may adopt various strategies to avoid this.

A third factor is the complexity of questioning practices. Paradoxically, although we do have a great deal of tacit knowledge, as with much of our knowing in practice, it is very difficult knowledge to formulate given that the classroom is "a complex of multiple contexts" (Dillon 1990 page 9). Dillon suggests that one way of analysing the context of questions is to consider up to seventeen different activity or instructional formats (such as lecture or discussion) and a similar number of dimensions could be identified

in terms of purpose or subject matter or many other classifications (Dillon 1990). To pre-empt a later discussion, it is precisely this complexity that calls for thinking in terms of more organic and holistic concepts such as communities of practice.

Lastly, I believe that thinking about teacher questioning can be discomforting because it is close to the centre of what we are doing in classrooms and why we are doing it. Arguably, what we are doing when we question students often does not support their learning or even their active participation in the lesson, as questions are less helpful than other strategies for encouraging involvement and discussion (Dillon 1985; Dillon 1988; Dillon 1990; Van Zee et al 2001; Woods 1992). To reflect on teacher questioning practices is to reflect on the core of the meaning and underlying purposes of interactions in the classroom.

> The next time that you find yourself in some social situation, pick a point in the conversation and ask a question, then ask another question at your every turn to talk. See how long your friends or fellow teacher will let you get away with that. Note the particular device they use to stop you. Wonder about asking questions during your classroom discussions. (Dillon 1988, page175)

CHAPTER THREE, THIRD PIECE: TEACHER QUESTIONING, SCHOOL MATHEMATICS, AND THE PUPIL EXPERIENCE

> A five-year-old girl returned from her first day at school and announced that her teacher was no good because she didn't know anything. When asked why she thought that, she replied that the teacher just kept on asking us things...
> (Brown and Wragg 1993, page 3)

Part One: Teacher Questions and Schooling

Post-positivist research

Whatever the reasons, research specifically on teacher questioning is relatively limited and has tended to be generic rather than specific to mathematics. Such research has often focused on the product, or outcome, of questioning rather than the process and been conducted in an individual-psychological paradigm and based on quantitative methodologies. Quasi-experiments have been used to explore the relationship between the type of question (for example open/closed or higher/lower order) and learning outcomes. Meta-analysis of such research is inconclusive with some studies reporting a correlation between learning outcomes and cognitive level, but with others indicating no significant difference (see Redfield and Rousseau 1981; Samson et al 1987; Winne 1979). Given the complexity of interrelated factors that are involved in a context for questioning indicated above perhaps this variation is not surprising. More conclusively, a positive relationship has been between of wait time and the following factors: the frequency of student responses, the correctness of responses and the level of cognitive engagement (see Tobin 1987 for a meta-analysis). James Dillon's analysis of questioning and other discursive practices outside the classroom support this. In other questioning situations or discussion, pauses are frequent and lengthy, indicating that breaks in speech are a necessary part of the process of talking. Evidence from situations such as therapeutic interviews indicates that waiting and silence are not only important cognitively for the responder but emotionally as well (Dillon 1990).

Socio-cultural research

Research conducted in alternative paradigms, in particular with a socio-linguistic orientation, has tended to focus on questioning as part of classroom talk rather than

particularly focussing on questioning strategies or the students' experience. The different ways that teachers question students have been described. Teachers question using the direct grammatical form or by other forms such as cued elicitation (Edwards and Mercer 1987). Thus questioning strategies have often been analysed in terms of teacher initiation, rather than simply questioning. The dialogues that result frequently follow a structure of Initiation, Response and Evaluation or IRE (Mehan 1979) or Initiation, Response and Feedback, or IRF (Edwards and Mercer 1987; Mercer 1995). This has been referred to as the triadic dialogue (Lemke 1990).

Other types of dialogue, triadic or otherwise occur. Nevertheless, the IRE form is the most prevalent in school classrooms. We can see why this is the case if we consider the context and the content of questions as well as the form of questioning and response and reaction to questions (Carlsen 1991; Roth 1996) and the way these different aspects are co-emergent.

The type of questioning most prevalent in schooling at all years in over 1000 US schools was found to be

> ...direct, factual question whose answers can be produced from rote memorization. And the depth of the teacher's evaluation of students' answers is that the answers are 'right' or 'wrong'. (Gregg 1995, page 442)

This situation appears to be remarkably stable over time, with a similar finding being recorded by Stevens (1912), Haynes (1935), and Gall (1970) (cited in Brown and Wragg 1993).

No comparable research exists for secondary schools in the UK, however a survey of primary practice reported that

> Teaching in today's primary schools at Key Stage 2 is very much a matter of teachers talking and children listening...When questions are asked of children, these questions require them either to recall facts or to solve a problem for which their teacher expects a correct answer. (Galton et al 1999, page 33)

The findings of observation in the 1999 study are very similar to research reported in 1980 (Galton, Simon and Croll 1980). This continuity might seem surprising given that one reason for the introduction of National Numeracy Strategy into Primary schools was the supposed prevalence of 'child centred' methods (Boylan 2000), what has been referred to as the Plowden ideology (Edwards and Mercer 1987). It is beyond the scope

of this thesis as to how a discourse was constructed that demonised child centred, progressive and 'trendy' teaching methods that supposedly were dominant in primary schools when research of actual practice indicates the extent to which classroom practice has remained fairly consistent (Galton et al 1999). However, I note that such a discourse has not been so prevalent about secondary schools as the Numeracy Strategy has been extended[1]. I contend that one reason for this is that 'traditional' teaching methods, and related questioning practices, have remained more entrenched in much secondary schooling.

The IRE form of questioning is co-emergent with the type of content of the questions; asking factual questions with memorisable answers allows for IRE dialogues and the prevalence of IRE as the dominant, 'taken for granted' social practice tends to require asking factual closed questions with memorisable answers. The IRE form co-emerges with the context of schooling in which a transmissive orientation to the nature of knowledge predominates, IRE helping to reinforce such an orientation and being produced by it.

> Teacher: 'How many millimetres in a centimetre?'
>
> Pupil: 'If you don't know you should be in a different job!'

The purposes of questioning

Generally, the social practices of schools are very different from those that might appear to have similar purposes outside schooling, often because the social practices have different ends. This is particularly true of questioning:

> In everyday life outside of schools, most questions are of a genuine information-seeking type designed to elicit missing information. Several assumptions need to be fulfilled before a question can be categorized as genuinely information seeking. Among these are: the person asking the question (a) does not know the requested information, (b) believes that his or her counterpart can provide the information, (c) is genuinely interested in the requested information and (d) believes the answerer will provide the answer. (Roth 1996, page 711)

Teacher questions that predominate in schools are rarely 'genuine' questions in this sense, rather:

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[1] Generally, there has been less public discourse from politicians about the need for the Numeracy Strategy in secondary schools. The discourse has focused on 'standards' and 'under-achievement' rather than teaching methods as such.

They are part of the discursive weaponry available to teachers for controlling topics of discussion, directing pupil's thought and action, and establishing the extent of shared attention, joint activity, and common knowledge. (Edwards and Mercer 1987, page 46)

The use of the noun 'weaponry' is apposite here as teacher questions are intimately connected to teacher's power and authority. Interestingly, the sense of questioning as an arena of conflict is echoed by students' descriptions of short closed questions that often form the 'Mental and Oral Starter' in Numeracy lessons as having questions *fired* at you (Anderson and Boylan 2000). The Strategy documentation itself refers to 'targeting' questions at students (Boylan 2000).

Power

The relationship between questioning, control, and power is also indicated by the frequency with which the primary purpose of a question relates to the management of the class. In addition to seeking factual responses from students the other significant purpose of questioning is class management with one study of primary schools indicating that as many as 57% of questions were primarily managerial in purpose (Wood and Wood 1988; Wood 1992).

Questioning is a powerful means of 'surveillance' for the teacher. The teacher invariably asks questions standing at the front of the class, surveying the students, gauging responses, and selecting who will speak. The students are seated and their physical position allows for the teacher's gaze to fix on them at any time. The teacher occupies a position not dissimilar to the watcher in Bentham's hypothetical Panoptican (Foucault 1977).

Authority in many situations is often marked by who has the right to speak and to interrupt and to choose who speaks. By questioning teachers establish that they have this authority and maintain it. They can choose to whom they will give their attention and the right to speak, and reward the behaviour that they desire. As Tony Edwards puts it, in the extract that opened this chapter, a pupil has to: "bid properly for the right to speak yourself, sometimes when competition for the next turn means balancing the risks of not being noticed against the risks of being ignored as too enthusiastic" (Edwards 1992, page235/236). The 'game' that is played here is one students are aware of:

George: but sometimes what Miss does a lot when you really know the answer and you put your hand up and you're right in front of her she doesn't and she

[Interrupts] John: yeah and she'd go and look over there

George: and she'd deliberately not looking at you

Dave: and look the other way

George: and when you shout out by accident…

John: all teachers do that

Mark (interviewer): all teachers do that?

John: if you're like that and you really, really want to answer it they'll look at you and they start looking at everyone else

Dave: you're like that and you're standing up and she'll tell you to sit down

George: even in some other things

John: yeah yeah like if you're going, huh, huh, huh [breathes heavily, excited panting, like a student who urgently wants to speak, mimics a teacher] "I'm not asking him because he's breathing too loud" or something like that

Dave: I won't ask him because he's standing up

(From interview in North School, Seven Blue, Boys B, January 2001)

Ways to answer

There are two ways that students may legitimately speak in whole class situations in traditional schooling practices. Firstly, they may remain relatively still and be selected by the teacher either by name or pointing. Secondly, they may indicate that they wish to speak by raising their hand and waiting to be selected. John, George, and Dave are aware of the complexity of interactions that can follow the latter situation; too much eagerness can lead to not being selected. Their account is familiar though not every classroom may be like this. Indeed the observed practice of the teacher they mention is not like this, rather it is their perception of what happens. It indicates what the teacher and questioning is in their lifeworlds. The teacher may choose those who sit quietly and wait with hands raised, or those that are eager, or indeed students who are not volunteering to speak. What is essential to being a teacher in these life-worlds is the power to decide.

However, it is important to recognise that questioning practices not only serve the social function of control but other more positive social functions as well (Watson 2003). Such functions as developing a sense of mutuality and involvement of students in lessons. More generally the teacher in the classroom may use their power positively if they wish (or even 'give it away').

Part Two: Teacher Questioning in School Mathematics

Tim arrives and immediately rubs some work off the board and says: 'OK, quadratic functions, we began last lesson, very quickly, with x^2-3x-4'. While he writes this on the board the class watch and listen in silence. 'And we said yesterday, how did we write this? Sara, you were the star yesterday.' Sara looks at him blankly. Tim says: Anyone? They all look at him blankly. He moves on quickly saying: 'No-one knows? Well it was (x+1)(x-4).' He writes this and continues. 'From the book yesterday, we were practicing C1 yeah?, and C3?' Sara says: 'Sir we got stuck on [question] (e)' Tim picks this up saying: 'Stuck on (e)? Well what number goes with x?' [the expression in question (e) is x(x-5)]. Eventually someone says 'nothing'. Tim says: 'Yes, so the curve is (x+0)(x-5), so nothing is nought, OK C5, C6, so ...C5a, what numbers will we get? Karina [silence], Tafaz? What did you get?' Tafaz says: I didn't get nothing cause I didn't do it.' Tim continues: 'Well what is the number?' Tafaz says: I dunno I can't do this chapter.' Tim moves on. 'Sara, what is the number?' Sara says: '4 and 3' Tim comes back with: 'so what do they give you?' Sara says '12' and Tim starts to draw a curve on the board. All of the students are watching and listening in silence. So far all of this lesson has been delivered at breakneck speed and I am not sure whether many of the students are understanding the concepts Tim is discussing. They can answer his small question each time, such as 'What do 4 and 3 make' but I don't know how much more of this they are understanding.

(Boaler 1997, page 29)

Usual school mathematics

Although there is some evidence that the frequency of purposes that teachers give as reasons for questions varies from subject to subject (Brown and Edmondson 1984; Brown and Wragg 1993), questioning practices in usual school mathematics are typical of those already described.

Paradoxically, questioning practices may be reinforced by a desire on the part of teachers to appear not to be 'traditional' in their practice. 'Traditional' teaching is most closely associated with 'telling' students[2]. As an alternative to 'telling', teacher may use a form of recitation where closed questions and cued elicitations are used so that

children supply the missing elements of the teacher's explanation or information (Dillon 1990; van Zee 2001). Dillon compares this to the use of written 'cloze' passages where answers or text is given with gaps to be filled in, often with a choice of words given (Dillon 1990). In mathematics education literature 'recitation' has been referred to as 'funnelling' (Wood 1994).

Teachers' practices appear to vary according to the level of the set (Boaler, Wiliam and Brown 2000) though we do not know in detail how these practices vary. For example, relatively simple factors such as the amount of questions asked or the length of recitations in different sets has not been ascertained. From my experience, the level of wait time in mathematics classrooms is frequently low in all sets, although the reasons may be different. In 'top sets' teachers are concerned to maintain 'pace', in lower sets, teachers may not wait long for pupil response from a concern to maintain control.

However, given the general uniformity of usual school mathematics, in all classes such recitations will frequently be the basis of the teacher 'presentation' that forms the first part (or in some situations the whole) of a typical mathematics lesson. The questioning practices in these presentations are governed by the second part of the lesson, in which students practice procedures by completing exercises in one form or another. This reinforces a tendency to ask factual closed questions about procedural mathematics.

As part of my teaching of student teachers, I set the observation task of recording the frequency of open questions during teacher presentations. Such questions are invariably non-existent or consist of the semi-open 'how did you do that'[3] or almost rhetorical questions such as 'Okay?' or similar through which the teacher seeks reassurance that that class is following.

Studies have recorded the unequal patterns of interaction of boys and girls with the teacher in mathematics classrooms (Leder 1990; Zevenbengen 1999) and asking closed factual questions in IRE dialogues may be implicated in this. Girls often feel an unfulfilled desire for understanding in classrooms where the mathematics is 'closed'

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[2] Thanks to John Gutteridge for suggesting this.

[3] I term such questions 'semi-open' because although the answer is unknown to the teacher and there is more than one acceptable answer, the question is closed to the students. Compare the 'openness' of the 'How did you do that?' with 'In what different ways could you do that'. The 'How do you do that?' question is becoming more common due to the influence of the National Numeracy Strategy. Questions like these do not necessarily mark a change from an evaluative and transmission stance.

and disconnected (Boaler 1997a, 2000; Boaler and Greeno 2000; Boaler, Wiliam and Brown 2000). Certainly IRE dialogues leave little space for discussion that might develop such understanding.

National Numeracy Strategy

However, it is important to note that currently in England questioning practices are changing. The National Numeracy Strategy (NNS) recommends a three-part lesson, consisting of a Mental and Oral Starter, a Main Activity, and a Plenary. The Mental and Oral Starter is frequently interpreted (and exemplified in Strategy training materials) as a time to question children. Frequently, these questions form a rapid series of IRE triads, with questions asked to individuals. However, the introduction of the NNS is also leading to a greater varieties of forms of student response, in particular various forms of unison response (Watson 2003) either orally or by using 'show me' equipment such as individual whiteboards or number fans. Potentially, the plenary, , allows for less evaluative questions being asked by the teacher, as this is recommended as a time for discussion of the activities the students have engaged in and any learning that has occurred. However, descriptions of how different aspects of the NNS are being implemented in the classroom are at an early stage and the strategy as such legitimises and supports a wide range of contradictory practices (Boylan 2000).

Learners' Experience of Questions and Whole-Class Interactions

The idea that learners' often experience questions in a negative way is to some extent taken for granted, and has often been commented on (see for example Holt 1963; Buxton 1981). Introspectively, it is part of the tacit knowledge of being a teacher. As teachers we are aware that some students enjoy times in lessons when questions are asked of the class and are enthusiastic to participate yet there are other students who clearly feel uncomfortable. However, knowledge of how far questioning of the class is related to dislike of mathematics, anxiety or other negative emotions is largely tacit, or anecdotal.

Julie Anderson's ethnographic study of pupil anxiety and generic teacher questioning in primary classrooms indicates that questioning is not only a cause of anxiety, but also

affects self-esteem (Anderson 2000). This appears particularly the case where teacher questions are perceived as testing[4] (Anderson and Boylan 2000).

Jo Boaler's descriptions of learners experience in open and closed learning situations indicate that in secondary schools, the unsatisfactory nature of the experience of learning mathematics in the closed situation is related to the nature of teacher expositions, and related questioning strategies, that are embedded in such pedagogy. For example, a key aspect of the student experience in some classrooms was being expected to "think quickly" (Boaler 1997a page 29); participation in recitations requires this.

Elena Nardi and Susan Steward report that many students say that they appreciate having a teacher who "invites questions but does not pick on them" (Nardi and Seward 2003, page 364).

Although research evidence on how questioning is experienced is scant, given that questioning reduces participation in discussion and interaction (Dillon 1985; Dillon 1988; Dillon 1990; Woods 1992), it is reasonable to conclude that questioning is frequently received in a negative way.

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[4] This does not mean that a Mental and Oral Starter need be like this, a more open problem might be given to the students, or a visualisation or a request to discuss a puzzle, or a problem.

CHAPTER THREE, FOURTH PIECE: STUDENTS' PERSPECTIVES ON PARTICIPATION IN 'DISCUSSION' - A CASE STUDY

Part One: The Context of the Research

The research findings presented here arose from a piece of collaborative work I undertook with a student teacher (Peter) in the first year of the research. We were working together to support Peter in developing reflective aspects to his practice and in deepening my understanding of classroom practice. We focused on issues to do with mistake making and teacher questioning in whole class situations. A particular interest was in exploring and developing alternatives to 'hands up' as a form of answering[5].

Peter's final teaching practice was in an 11-18 school in a semi-rural area on the edge of a large Northern conurbation. The school, East High School[6], has a comprehensive intake with respect to gender and class but is almost exclusively white. Results in external examinations are near national averages. This research reports on the views of a class of Year Eights (twelve/thirteen year-olds), a 'Set A', this being formed from the highest quartile of pupils by attainment based on Year Seven examinations. The class consisted of 12 girls and 17 boys. The school set for mathematics in two half-year groups.

The decision to ask the class about their experience of whole class interaction arose from an initial discussion that occurred during one of Peter's lessons when I was present:

> Peter introduces the day's topic – revision of formulas for the nth term of a series. He asks the class to spend a moment individually thinking about the topic to see what they can remember and invites those that "have some thoughts" to put there hands up. About four or five hands are raised. He then asks the students to discuss in pairs. Nearly all students seem to be involved in this and the discussion seems to be centred on the topic.
>
> He now asks again for people to put their hands up if "they have any ideas". There are now perhaps 6 or 7 hands up. Peter comments that lots more should have something to say, he indicates two girls as an example "you were saying some really interesting things". He looks a little perplexed as to why there were not more hands up. I intervene and refer to the implicit

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[5] See the Preface for further details of the context.
[6] A pseudonym

question, that "who has some thoughts" also implies "who wants to say something". A buzz of conversation goes around the room.

Peter picks this up and asks again for hands up but this time saying he won't ask anybody to share; nearly all put their hands up. He asks the class why the difference. One boy responds: his comments include "people don't want to make a mistake, they might look stupid" (Field notes, May 26th 2000).

This striking incident indicates the extent to which there can be a great difference between public participation and private engagement in mathematics lessons. It is also indicates that whilst Peter was attempting to create spaces for greater student discussion by using an alternative to typical closed question/IRE sequences this did not in itself lead to greater participation. In the incident above, Peter is revising a topic and begins with a statement and then asks for the students to contribute. However, attempting to move the students from the practice they were used to was not easy (they had had nearly two terms with the regular class teacher before Peter took over). An interesting discussion followed between members of the class, Peter and myself that raised a number of issues and we decided to continue the dialogue with the class about some of them at a later date.

The fact that Peter had finished his teaching practice creates a need for caution in respect of interpretation of some of the research material gathered from students reported below. In particular, when the students refer to their experience of their teacher's practice, especially during interviews, there are indications that occasionally they refer to Peter's practice, but more usually to their normal class teacher and at other times interviewees refer to their experience of mathematics teaching more generally, for example by comparing to other years. Peter's practice is not the subject of the study reported here, however, it can be characterised as an attempt, certainly with respect to questioning practices, to move away from that typical in usual school mathematics. However, his exploration of alternative practices was in the context of a short teaching practice. Thus the mathematical experience for the students during the year was overwhelmingly that of usual school mathematics with any novel practices acting as reference points for comparison. So for example, when they asked about their preferred means of answering, the alternatives are not completely hypothetical.

Part Two: Data Collection and Interpretation

A number of sources provided data for analysis. The incident above occurred near the end of Peter's time at the school. We arranged to both go back together and work with

136

the whole class for a lesson. The story from the earlier lesson was re-told to the students and responses were invited. Peter devised a short questionnaire, completed individually, that focused on the students' willingness to answer questions in class. The students, working in groups, completed an exercise devised by me. This involved them in ranking statements about possible strategies a teacher might use after asking the class a question against three criteria: the frequency in which the situations occurred in mathematics lessons; how nervous they felt in the different situations; and how helpful the different means of responding were to their learning. The statements were:

A: The teacher asks a question and then gives time to think about an answer before people can put their hands up

B: We don't put our hands up and then the teacher asks someone by name for the answer

C: Call out the answer

D: The teacher asks people to discuss the answer with someone else and then ask for hands up

E: The teacher asks people to discuss the answer with someone else and then ask a pair to give an answer by name

F: Everyone answers the question together, for example by writing down the answer and then showing it

G: Everyone takes it in turn to answer

H: The teacher asks a question and people put their hand up straight away

I: The pupils ask the questions

J: The teacher does not ask questions

The reasons for the group activity were twofold. First, students' behaviour in whole class interactions is socially focused and the intention was to reflect this. Second, I was interested in beginning to explore the potentially transformative effect of such discussion about the social practices of the classroom.

The students' responses to the survey and group exercise were collated. The answers to the open question in the questionnaire were analysed initially by an open-coding of meaning units and these generated some more general themes. Based on these themes, a summary in the form of a class letter entitled "We would be more likely to

contribute/discuss in class if ..." was prepared (see below). The results of the sorting exercise were summarised and compared.

Later we returned to the school and interviewed seventeen of the students (9 boys, 8 girls) in single gender groups about the class' responses. Interviewing in groups can help to prompt discussion about issues that might not be revealed in individual interviews (Wilson 1997).

The data collection as a whole attempted to develop a partial cycle of interpretation in which the pupils' initial responses were interpreted and then this interpretation was the subject of further discussion and validation by the students. In presenting material from this process I choose to give priority to giving space to the students' responses rather than analysis of them. My desire is to privilege the student voice and stems from a belief that:

> ...young people are observant, are often capable of analytic and constructive comment, and usually respond well to the responsibility, seriously entrusted to them, of helping to identify aspects of schooling that get in the way of their learning. (Ruddock et al 1996, page 8)

Privileging the student voice in this way also is in accord with a concern to give insight into the students' lifeworlds.

Part Three: Analysis and Discussion

Reasons for a reluctance to answer questions/participate in 'discussion'

The reasons students gave, both in the survey and in the interviews, for why they might not answer questions in class were, unsurprisingly, varied.

In the survey the students were asked to complete the sentence, "I would be more comfortable speaking/contributing to a discussion in maths class if..."

The students' responses were summarised in the form of a short passage or 'a letter to our teacher'. This was discussed during the interviews and was broadly agreed on by the students. This is the summary:

> As a class we would feel more comfortable speaking/contributing to a discussion in a maths class if...

138

('We' here may mean all of you or it may mean some of you)

> If we felt more secure about our understanding of the subject so we were more certain of being correct. Some of us don't want to be wrong. Having better explanations and being able to go more slowly might help. There was not the pressure of the expectations we feel because we are in Set A. Also some of us feel nervous about answering in case we get it wrong. We are worried about what other people might think. There are many of us who don't like to be put on the spot and be the centre of attention. It doesn't help that some people in the class shout out, as it is important that we get a chance to think about our answers. We think that we should have the chance to discuss our answers with someone else before answering. This means we get more time to think and we don't feel on our own as much.

In the interviews a number of these themes re-emerged and were emphasised by the students and additional insights into the students' experience gained. These factors are discussed below . One feature that it is difficult to convey in the transcribed text is the intensity of emotion some of the students felt about these factors.

Being in Set A

One of the most remarkable aspects of this issue is that it was not initially part of the researchers' agenda. In the survey a quarter of students referred to being in Set A or the expectations on them; in addition others referred to the pace of lessons. Some identified particular aspects of teacher behaviour as contributing to this

> I feel in all subjects in A sets are always expected to get answers right and if you don't then they say that they expect you to get the answers right, and they expect more from an A set

> We are expected to know everything being in an A set

> (From questionnaires)

In spite of this theme emerging in the questionnaires our focus as researchers on means by which students' answer meant that we had not prioritised this for discussion in the interviews, however, in the interviews it became clear that it was important for some students:

> Cause some of the questions are really hard you get them wrong and then you're worried about, you might be moved down into B set

> ...well some people say, like, if you're in Set A you should be able to get that

139

(Boys, Interview with Peter)

...there is a lot of pressure

you're expected to behave, like, really good

(Girls, Interview with Peter)

Because we're in A set, we get hard explanations and we have to find out what it means by ourselves

(Girl, Interview with Mark)

And you're up in A group and your struggling

(Boy, Interview with Peter)

The students' views are reminiscent of those of other 'top set' students. Previous reports of students' unhappiness with the top set experience have tended to indicate the alienation felt due to the pace and procedural nature of the curriculum and that this is particularly true of girls (Boaler 1997a, 1997b, 2000; Boaler, Wiliam and Brown 2000). Although this aspect of Set A's experience is only glimpsed here, in this particular class boys as well as girls are unhappy about the experience. In addition the students interviewed here are younger than in previous studies and indicate that this alienation with setting practices can start at a young age (Year Eight/Grade seven).

We also get a glimpse here of the way in which the students' ability to "find out what it means by ourselves" when explanations are not understood may mask the inefficacy of the teaching approach customarily found in Set A classes.

Overall, the students indicate that, for some of them, being in Set A reduces their willingness to participate in whole class interaction. One at least explicitly relates this to the danger of being moved down a set and indicates the way in which setting serves to further deepen the high-risk nature of usual school mathematics.

The danger of 'getting it wrong': public and private shame

More generally unwillingness to contribute was linked to anxiety about being wrong. The vulnerability the students felt had two aspects: the risk of public and of private shame. The possibility of public shame was articulated most frequently:

140

Cause they're, like, kind of embarrassed. If they're - some people are kind of embarrassed if they get it wrong

If you get it wrong in front of the whole group and you're - when you don't get the right answer then people think that you're totally rubbish at maths

If you get it wrong, everyone thinks you're not very good

(Boys, Interview with Peter)

You could talk to the person sitting next to you, and you and your partner could agree on an answer and then at least if you're getting it wrong someone else is getting it wrong as well, so no one can take mick out of just you

(Boy, Interview with Mark)

...you'll feel scared that like if you answer a question wrong they're just gonna laugh at you

(Girls, Interview with Mark)

The existence of fear of public shame is something that is recognisable and understood about classroom situations. However, what we may be less conscious of is that fear of being wrong arises not only from the possibility of public ridicule but the private shame of being wrong:

But not everyone takes the mick out of you, some people just feel embarrassed, you might just be feeling bad or something

You feel sick and tired

There's no one taking the mick out of them, they're just feeling bad about it.

(Boys, Interview with Mark)

Kids think of it in a different way because they don't like being wrong. Like most of them think, most of them like being right, but if they put their hand up and get something wrong then they don't like it. Not, like, they don't like other people seeing them get it wrong, but they don't like it themselves, because it makes them feel as though they don't know anything

(Girl, Interviewed with Peter)

The practice of evaluation of student responses serves to create the conditions in which shame, whether public or private, will be felt. Regardless of the way in which Peter had

tried to change the practice of teacher questioning, the evaluative practices and the students' experience of them were deeply embedded.

In the analysis of the whole class' questionnaire the students' responses often had an underlying theme of a lack of security and the vulnerability the students felt in whole class interactions (Boylan and Lawton 2000).

Indeed, it may be that the ability to create a secure and comfortable learning environment in which 'getting it wrong' either means something very different from its meaning in the usual classroom and/or does not engender shame, is essential to successful teaching. It may be that the key to understanding effective teaching may not lie only in teachers' beliefs about mathematics (see for example Askew et al 1997) but more fundamentally in teachers' beliefs about children, and how children and how adults should interact with children.

A desire for discussion before contributing: mutuality

In the interviews when asked both about the general nature of classroom practice that the students desired and particular aspects of practice related to teacher questioning, all students stressed a desire for greater discussion. It was clear that this was not simply in response to the interviewers' agenda: in one of Peter's interviews, the girls being interviewed kept raising the idea of wanting more discussion even when Peter tried to move on to other subjects.

The desire for discussion was related to the benefits of hearing other perspectives in class discussions:

> I think that you should be able to discuss it more...but if there were examples and discussion and all that then people with other ideas might look at it in different ways
>
> (Boy, Interview with Peter)
>
> Because you get other people's points of view. So you have a couple of different ideas about one thing. Then you can work out whatever more easily
>
> (Boy, Interview with Mark)

The girls in addition supported the idea of discussing in pairs before answering in whole class interactions, again for cognitive reasons:

It gives you more ideas so you understand it more fully before you answer (Girl, Interview with Mark)

If you understand it then your friend, like who you're sat with, knows how you learn and they can, like, explain it in a way that you'd understand straight away

(Girl, Interview with Mark)

In the interviews only one person explicitly referred to the affective dimension of the mutuality that comes from agreeing on an answer together:

Yeah, 'cause if you discuss it with someone then you know that someone else is thinking along the same lines as you after your discussion

You're more confident then

You're more confident

You've got it right, because more people are thinking it

(Boys, Interview with Peter)

Nevertheless, having students agree on an answer before answering is one simple way of increasing students' security and decreasing their feelings of vulnerability. Interestingly this procedure also has the effect of slowing down the questioning interaction and naturally creates 'wait time'. In the ranking exercise of different ways students could respond, both giving time before answering and discussing with someone else before responding were ranked as most helpful for learning (alongside 'the students asking the questions').

Dissatisfaction with the wider pedagogy

During the interviews student dissatisfaction with the wider pedagogy, beyond teacher interactions with the whole class, became apparent. This was articulated in terms of the nature of the mathematics curriculum in relation to other subjects and the balance of different activities within the mathematics curriculum (see Boylan, Lawton and Povey 2001).

The majority of students, when asked in the questionnaire, "What were the parts of the lesson in which they felt most involved?" chose discussions or puzzles. Both boys and girls were positive about the effect of 'puzzles' on the curriculum. The students tended

to identify 'puzzles' in their previous experience as added extras but expressed a desire for this approach to be incorporated into the topics they were studying. Both boys and girls made a spontaneous connection between the value of 'puzzles' and the fact that they permitted and indeed provoked discussion.

> I think [the puzzles] they've got to – they've got to have some sort of maths in them, and they've got – you want to try and get them related to - if you're doing like a topic, then try and get them related to the topic – so you can put a little bit of that in so it'll help them learn...
>
> Yeah. 'cause, that's a bit more exciting and you get to have a bit of an investigation
>
> You want a variety –you want a variety of sort of things – so you don't want straight maths all the time – you want puzzle maths – bit of a discussion in there, so – it makes it easy to lean and more helpful to learn
>
> (Boys, Interview with Peter)
>
> *Did you put puzzles [in the questionnaire]?*
>
> I think it's mainly because, like they can have a go at things and if they don't understand it they can, like, confer with other people and ask the teacher
>
> I think they enjoy it more as well
>
> It depends which type because, like, if you're doing one subject that you can't really have puzzles on them – so it's like, better to do questions. But on others – like with sequences – I think it's better to do puzzles on them
>
> (Girls, Interview with Peter)

The students clearly differentiated between the sort of thinking generated by 'puzzles' and what they saw as the demands of 'questions' in mathematics lessons. At the same time they found it hard to conceive of an approach to learning in which 'puzzling' was the norm and where they were actively engaged in the construction of their knowledge.

> *Would it be better to help you to be able to see questions a bit more like puzzles and for you to puzzle it out for yourself?*
>
> I don't understand
>
> I don't know
>
> Try and puzzle out things? You mean work things out?

144

(Boys, Interview with Mark)

More generally, much of the discussion with the students reflected the fact that the meaning of 'questions' for these children was deeply connected to the notion that a question must have a single correct answer already known to the teacher. This interpretation of what it means to be asked a question in mathematics infuses the interviews with the students so strongly that it is difficult for them to imagine of conceiving of interactions with the teacher differently. This conception of the nature of mathematics was linked back to fear of being wrong:

> Because if you take RE, there's not like no definite answers for RE questions, like – but in maths there's – most of them are definite answers, so they might be as confident if they know that, if they get it wrong, then they're definitely wrong,

(Boy, Interview with Peter)

It would be misleading to give the impression that all students interviewed did not enjoy their mathematics lessons. One group of boys were keen to express their enjoyment of both mathematics and their teaching. However, the factors that they spoke about were about the manner in which their usual class teacher leavened the mathematical diet with jokes or "fun lessons", which they contrasted with the normal mathematical routines.

However, overall the students' overall conception of, and dissatisfaction with, mathematics echoes the experiences of students in other usual school mathematics classrooms discussed in Chapter One. In particular Elena Nardi and Susan Steward report that students in their study also asked for 'puzzling ' curriculum and for a deeper understanding rather than "rule and cue following" (Nardi and Steward 2003, page 362). The desire on the part of the students for more opportunities for discussion and for a more 'puzzling' curriculum is, I believe, a mandate from this particular class for alternative questioning practices embedded in a different pedagogy.

Gender

During this study gender emerged strongly as an issue. These issues related both to the actions or practices of the students and to their experience of interactions. It is important to note that the class composition was unequal with more boys than girls in the class. However, I believe that this situation served to bring to the fore issues that are present in other classes.

In the questionnaires the boys, as a group, were more willing than girls to answer questions in class, and were more prepared to take risks if they were not sure of being correct. When asked if they would ever guess an answer, a quarter of boys would never guess an answer whereas nearly half of the girls would not. The students' accounts of their willingness to participate confirmed Peter's observations of the levels of participation of boys and girls.

In the interviews, both groups of girls reported the boys' behaviour as one reason for their reluctance to contribute.

> *Why is that a problem, being wrong?*
>
> You get embarrassed and everyone laughs at you. With there being more boys in our class they tend to laugh more than what we do
>
> [everyone begins to talk at once, excitedly]
>
> There's a boys' side and a girls' side
>
> When you answer when boys are there they laugh at you
>
> (Girls, Interview with Mark)

However, for at least some of the girls the issue is not primarily to do with the disproportionate number of boys. The group Mark interviewed said that the situation had been similar the previous year when classes were more evenly balanced and in other classes outside mathematics: "They still shout out and try to take over and things".

The girls experience in this class is similar to the pattern of interactions reported by Zevenbergen (2000) where boys dominate the interactions and have a strong influence on the tone, language, and structure of whole class interactions between teacher and students. She contends this is disempowering and marginalizing for girls. The girls in East High School give an account of the way in which they do find the behaviour (of some) of the boys disempowering. The girls suggest some practices that would enable greater participation by them: discussion in pairs or small groups before contributing to the whole class. Interestingly, these are very similar to strategies that have been found to help promote more equitable patterns of participation in terms of gender in the classroom (Roth 1996; Barnes 2000).

However, the issue of unequal participation is gendered rather than a strict division by gender. By using the term 'gendered' I am indicating that the social practices of the boys and of the girls are shaped by gender discourse but that it is important to think in terms of masculinities and femininities as pluralities. For example, within the boys there are a majority of confident articulate boys, ones who 'shout out', and others who are 'quieter' From questionnaires and interviews it was clear that some of these quieter boys are also marginalised and felt uncomfortable due to those who dominate classroom interactions.

The girls themselves identified the issue about not being all boys:

> There's some boys that just tend to get on with what they're doing and ignore the other. If you say something wrong they'll not laugh. But such as John and everyone, they'll just burst out laughing

(Girl, Interview with Mark)

The willingness by different gendered groups to participate in the class was clearly connected to the students' different relationships to the possibility of shame. There is some evidence from the interviews to suggest there is a difference in girls' and (some) boys' experience of shame, with girls appearing to have greater concern about public shame. For some of the boys taking risks was an intrinsic part of school life and that confident masculinity could ride out the debilitating effects of being wrong:

> You've got to be confident, that's what I think. You've got to be confident then it doesn't matter if you get the wrong answer. Well it does matter, but you learn from your mistakes, but it's not like life and death if you get it wrong. Because it's...as long as you're confident you should be all right.

(Boy, Interview with Peter)

The type of behaviour of the group of boys who 'burst out laughing', that the girls described, is a reminiscent, of that discussed by Mary Barnes of the 'mates' (Barnes 2000). Barnes reports how the domineering behaviour of the 'mates' was lessened, though not eliminated, by a collaborative approach to learning and reducing whole class interactions. I contend that the social practices of usual school mathematics help to support and foster such masculinities in their stress on speed, the correct right answer (univocality), and competition, not least for the teacher's attention. These issues will be explored further in Chapter Six.

CHAPTER THREE, FIFTH PIECE: COMMUNITIES OF PRACTICE AND TEACHER QUESTIONING

In Chapter One, I reviewed community of practice theory. I indicated that I shared the view of others that usual school mathematics classrooms are not generally communities of practice. Here I argue that the form of teacher questioning practices, interactions by the teacher with the whole class and the students' experience of them, are strong evidence that usual school mathematics classrooms are not communities of practice of the form described by Lave and Wenger (Lave and Wenger 1991; Wenger 1998).

Given the conflictual relationships between different groups in Set A described above and the pervading sense of competitiveness, it might appear that there is clearly a lack of 'community'. However, community in the sense used by Lave and Wenger does not necessarily feel very communal. In their first full account they stress that relationships can involve conflict. Therefore, a more detailed analysis is necessary.

To recap on Chapter One: communities of practice are constituted through legitimate peripheral participation (Lave and Wenger 1991; Wenger 1998). Essential features of communities of practice are the existence of a joint enterprise, a shared repertoire, and mutual engagement (Wenger 1998).

There is one obvious sense in which participants in questioning practices in usual school mathematics classrooms do not have a joint enterprise in the same way as in communities of practice. As Stephen Lerman argues, in an apprenticeship situation, the purpose of the old-timer or master is not centrally to foster the learning of the newcomers or apprentices. Learning takes places as a by-product of the enterprise around and for which the community of practice exists; for example the purpose of tailors is to make clothes. However, a teacher's purposes in formal learning situations, whilst very varied, are connected to the role of being a teacher (Adler 1998; Lerman 1998). In a usual school mathematics lesson, during questioning interactions, the enterprise of the teacher is to 'teach'. Though, as discussed earlier, 'teaching' in this context may by much more about maintaining control, asserting power and testing students than engaging students in the social practices of mathematics. In usual school mathematics the teacher is the one "who asks the questions". Lave and Wenger do not discuss questioning as particular part of community discourse. However, reading the vignettes Wenger offers as illustrations of the community of practice of claims

processors (Wenger 1998) shows, as might be expected, that in an apprenticeship learning situation it is the newcomers who ask questions of the old-timers. In these contexts questioning has the everyday qualities described by Roth (1996) in the discussion above.

In any event the enterprise of the teacher and the students is different. What may be less obvious is the extent to which the enterprise of the students, considered as a group, is not a joint one. The responses of the students in Set A highlights the extent to which the students' forms and degrees of participation in questioning practices are due to other 'enterprises' than learning mathematics[7].

The patterns of participation in questioning practices and enterprises of the students are clearly complex in this class and to an extent have to be inferred from their responses rather than being directly described. Nonetheless, two distinct patterns stand out. Firstly, there are students for whom personal security is very important, they do not want to be wrong and risk public or private shame, and/or they do not want to 'stand out'. This I believe is central to their enterprise and purposes in questioning situations. A second group of students (and on the basis of the incomplete research material presented here) all apparently male have the enterprise of wanting to be the first to answer, to dominate, to assert position and to have the teacher's attention.

Of course, these two enterprises and patterns of participation are not the only ones possible. Another is found in the description by Hazel Denvir's, Mike Askew, Margaret Brown and Valerie Rhodes of one student's strategy in 'interactive whole class teaching'. They provide an illuminating account of the way in which one girl "Meg" who had developed various sophisticated strategies for engaging in the practice of answering questions in class and providing explanations of answers. However, observations by the researchers showed that these strategies were aimed not at mathematical learning or even providing the correct answer, but rather maintaining her status by appearing to be an able, hardworking, and reliable student (Denvir, Askew, Brown and Rhodes 2001).

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[7] In contrasting the enterprise of the students in mathematics classroom with those of participants in the communities of practice described by Lave and Wenger (Lave and Wenger 1991; Wenger 1998), I acknowledge that, for example, the claims processors described by Wenger also have other enterprises than the one constituted by the community of practice. However, the question here is what is at the centre of the participants' enterprises.

More generally, Paolo Valero describes the "myth of the active learner" (Valero 2002, page 543). The assumption in much mathematics education research is that any and all students' primary purpose is to learn mathematics. Valero calls for "a re-humanised view of students" (Valero 2000, page 550), that recognises that students are not bounded by the classroom, they have a life beyond it and that there are various reasons for learning (and not learning). Given the lack of joint enterprise shared by the teacher and students, and the differences in power relationships that are qualitatively different to those in apprenticeship situations, it follows that they are not mutually engaged in the same project. However, the situation within the students is more complex. On Wenger's account the (largely hidden) conflicts between groups within Set A, does not negate the possibility of mutual engagement: "peaceful coexistence, mutual support, or interpersonal allegiance are not assumed" (Wenger 1998, page 77).

Thus the gendered experience of some students and the possibility of "mickey taking" or "being laughed at" underline the fractured nature of social relationships but would not for Wenger mean that mutual engagement does not necessarily exist. However, if we consider the extent to which these factors determine the patterns of participation in the social practices of questioning for some students, then I believe the idea of mutuality is stretched beyond usefulness, if we are to believe that the students are mutually engaged at these times in terms of participating in school mathematics. In so far as the students are mutually engaged during questioning practices they are engaged in the social practice of ranking each other and being ranked[8].

However, clearly the students are engaged together in learning school mathematics, even if an individualised form. Interestingly, there is a sense in the interview of a developing mutual identity being formed around being in Set A. All students interviewed about what they saw "unfair" testing practices felt a sense of injustice. I do not believe that it is any accident that it was around testing that mutual identity formation occurred.

The concept of mutual engagement is closely associated with the nature of relationships within a group. In mathematical classes in secondary schools this situation is complicated by setting arrangements. In early years of secondary schools students may be taught in mixed ability form groups, in such situations sustained relationships may

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[8] This claim is a little tenuous when made on the basis of only the material presented in this Chapter, however, as I consider other material I believe this claim can be justified.

develop over a period of time and a complex and dynamic class life emerge. However, in the context of setting the students may only come together in that particular constellation of individuals for their mathematics lessons and in usual school mathematics practices the interaction with other members of the class may be very limited. In one Year Nine group I surveyed and interviewed, it became apparent that the students did not even know the names of everyone in their class, this makes mutual engagement difficult to develop to say the least[9].

Although questioning practices, like other practices of the mathematics classrooms, are 'shared', they lack the quality of local negotiation and development characteristic of communities of practice. Questioning practices and 'discussions' are a key time where students interact with the teacher, and in usual school mathematics classrooms may be the only time that a student has the opportunity to interact with the rest of the group they are part of. It is through such interactions that both the social mathematical practices and wider social practices of the class are created and sustained. Thus the lack of the features of a community of practice during such times raises doubts that usual school mathematics classroom are generally communities of practice. In the next Chapter, I present and then explore one particular lifeworld of school mathematics that adds to this argument. In Chapter Five, I return to community of practice theory and drawing on the life-world analysis and my discussion of teacher questioning practices develop the argument further that usual school mathematics are not sites of communities of practice.

However, one reading of the comments of students in Set A about the sort of practices they would prefer to be engaged in suggests that there is a desire for more mutual relationships. This is particularly so with regard to the desire for time and space to discuss with each other and for more collaborative forms of working. Some of the students pointed to the benefits of peer explanation, (also reported by Nardi and Steward 2003). Interestingly, such peer explanation is found in the triadic learning relationships found in communities of practice. The students desire for more 'puzzles' is also congruent with a desire to be genuinely engaged in a joint enterprise in which the outcome is less predictable that the normal routine.

However, it is important to note that in creating a 'class perspective' in the form of the 'letter to the teacher' individual difference are glossed over. Given the very different

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[9] Of course this is complicated by the schools location, size and location, for example a large school serving a geographically diverse area will be different to a school that draws students overwhelmingly from smaller community.

histories, identities and positioning of these students we would not expect to find a universal desire for more 'community'. In Chapter Seven I return to this issue in considering the implications of different lifeworlds within a single class for democratic or engaged classroom practice. Nonetheless, the students' experience of questioning in this study supports the contention from research literature on students' experience of usual school mathematics and alternative practices in Chapter One, that students do want a different sort of more sociable experience.

CHAPTER FOUR

THE LIFEWORLD AND SCHOOL MATHEMATICS:

A CASE STUDY

> Without an appreciation of the radical mystery which confronts us in the face of every other person, our theorizing must inexorably become stuck, for then we are no longer available for that which comes to meet us from beyond ourselves, having determined in advance the conditions under which any new thing will be acceptable, and thereby foreclosing on the possibility of our own transformation. (Jardine 2002, page 203)

FIRST PIECE: ABOUT THE CHAPTER

In this chapter I extend the discussion of the concept of the lifeworld that I introduced in Chapter Two and give an interpretation of the mathematical lifeworld of one research participant. I go on to discuss the nature of the lifeworld more generally, using this case study to critique aspects of Heidegger's account of the nature of the lifeworld.

During the first year of the research, I conducted a series of interviews with learners of mathematics, both adults and children in a variety of contexts with a focus on the general experience of the participants in learning mathematics and in particular the experience of making mistakes during whole class interactions. Here I report on one of these interviews, with a woman whom I here refer to as 'Louise'. In the second piece of the chapter I describe the methodology of the case study and choices made in analysis and presentation of this material. In the third piece of the chapter I provide an interpretation of Louise's lifeworld in the form of an extended monologue.

In the fourth piece of the chapter, I extend the theoretical discussion of the lifeworld. I explore and critique Heidegger's conception of the lifeworld by using the monologue as a reference point. I adapt and critique Heidegger's categories of the nature of the lifeworld to propose an analytical map of the Self, Practices and Reifications, and Others. In discussing the self as part of the lifeworld, I consider the way in which the text 'Louise and mathematics' reveals multiple selves and consequently multiple lifeworlds. However, I suggest that, if the reflexive nature of the self is considered, this does not invalidate analysis of Louise's self within her lifeworld of mathematics. I argue that the lifeworld must also be understood as a situation that involves interrelation

of action, reification, affect, and cognitive areas as different types of knowing. This discussion generates a means to map Louise's mathematical lifeworld.

I use these two maps to structure an analysis of Louise's lifeworld of mathematics. This analysis reveals important relationships between different aspects of her particular lifeworld of mathematics and generates further theoretical development of Heidegger's phenomenology.

In the Preface I discussed the reasons why I choose to report on Louise's lifeworld, rather than that of other research participants and the influence of the interview on both the theoretical direction of the research and the research activity in the second year.

The impact this one interview had is due to both the typicality and the atypicality of Louise's lifeworld. Her mathematical lifeworld is typical in that there are features of her story and lifeworld that seem to speak about the way mathematics is experienced by and what it means for many people. It made sense of the insights into the experience of mathematics reported by writers in Chapter Two. More importantly it made sense of my own experience as a teacher of how students responded to my teaching. Whilst interviewing and subsequently attempting to understand Louise's experience was a novel and sometimes shocking experience, her story and her words, paradoxically, also felt very familiar. In her account of her mathematical lifeworld I hear echoes of many students I have taught in the past or of adults who have spoken to me about their experience of mathematics.

However, Louise is also atypical, not least in the way she is able to articulate her experience. Louise, in her own words, often desperately struggled with mathematics, an experienced shared by many others. However, her struggle has also involved an attempt to make sense of her experiences, to reflect on the nature of mathematics and her relationship to it and, on the evidence of this interview, has resulted in an ability to articulate her experience and the nature of her lifeworld of mathematics. I suggest that Louise's testimony can be read as that of a spokesperson for many. Certainly, people who have read her story have said that many parts resonate deeply with their own experience of learning mathematics.

CHAPTER FOUR, SECOND PIECE: RESEARCHING A SCHOOL MATHEMATICS LIFEWORLD

In this piece of the chapter, I give an account of the process of researching Louise's lifeworld of school mathematics[1], before offering an interpretation in the next piece of the chapter. I firstly discuss general issues about researching the lifeworld. Secondly, I introduce Louise and describe the nature of the interviews and the process of interpretation and the creation of the text that forms the next part of the chapter.

Researching through/with the lifeworld

The following principles describe the general approach I adopt to researching the lifeworld.

1) The lifeworld is taken as real:

> ...the researcher is debarred from *querying the validity of the lifeworld.* External validity is irrelevant. The researcher must adopt no position on the correctness or falsity of the claims which are implicitly made by the research participant in the views and judgements intrinsic to their lifeworld. Data gathering should be seen as a process of discovery, concentrating in the first instance on each individual as a separate case, a possibly unique world. Indeed, we cannot even assume that the meaning of the 'same' situation is similar from different people (Ashworth 1997, pagexxx, original emphasis).

2) Lived experienced is foregrounded and given pre-eminence over theoretical constructions (Ashworth 2002).

3) The lifeworld is real but cannot be described in itself separate from the subjectivity of the interpreter. This calls for a hermeneutical process (see Chapter Two).

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[1] The material presented here is more extensive than simply a report of Louise's school experience. She gives an account of her relationship to mathematics in her daily life. However, after reading her story, it should be clear that 'maths' for Louise is school mathematics; when she encounters mathematics in her daily life she frequently feels like she is back in school. Louise is a pseudonym and in order to preserve anonymity details about her biography are not given.

4) A hermeneutic interpretation stresses the importance of the interpreter's foreknowledge and prejudices. Some of these are necessary for the interview to have taken place at all, these include: the deep, generally unarticulated, shared 'knowings' about the existence of the physical world (the material-structural ecology); considering Louise to be 'another like me', capable of reporting on her lifeworld; a host of shared understandings about the nature of schooling; and many others. Other prejudices are undoubtedly more subjective on my part. Thus the monologue, 'Louise and Mathematics' is not *the* truth about Louise's lifeworld of mathematics but *a* truth.

I do not propose to analyse fully the way in which the monologue may reveal these prejudices and horizons of understanding, my primary interest here is in Louise's lifeworld not my own. However, points 5) to 7) below do represent some of the assumptions made in researching Louise's lifeworld.

5) When a person is asked to describe their experience of particular aspects of the world those features that come first to mind are significant in revealing important aspects of the lifeworld. Moreover, the level of emotional content and quality of engagement by the person in relating different experiences or stories is related to what is important in the lifeworld.

6) The lifeworld is historical, not simply in the sense that it has a history and trajectory in the past but that this history and trajectory is alive in the present. In this case, the way that mathematics is now for Louise is inseparably bound up with how mathematics was. Her experiences of engaging with mathematics at the time of the interview are connected with her experience at school. This is more than a causal relationship that might posit a chain of negative experience causing a particular disposition causing a negative experience. From her response, (or in my interpretation of it) we find that the experiences at school pervade her description of mathematics as it is now. When she engages in mathematics today it is often as if she were in school. More generally, the meaning of practices, others or artefacts in a lifeworld are bound to previous events involving those or similar practices, others or artefacts.

7) The interview process is necessarily pervaded by power and rank and the interpretation of the lifeworld cannot be freed from this. However, by privileging the

participant's voice and encouraging as much speech as possible uninterrupted by the interviewer the formatting of the interpretation by power and rank can be undermined.

The context of the case study

At the time of the interview, Louise was coming to the end of a training course preparing her to teach in secondary schools. I had previously interviewed Louise as part of a research project about student teachers' attitudes to the introduction of government numeracy tests for all teachers in initial teacher training and during this earlier interview Louise had expressed anger and anxiety about these tests. After that interview was complete Louise began to talk about her general relationship to mathematics, she spoke of how numbers 'floated away'. Her remarks were interesting, though I did not understand fully what she meant. She agreed to a subsequent interview that would have a wider focus about her experience of mathematics more generally.

The semi-structured taped interview with Louise lasted for over an hour. The interview was personally transcribed during the following week.

Often, Louise spoke at length about her experiences with only short responses from me, to indicate that I was listening and understanding or reflecting back some of her words to elicit further remarks. At times Louise clearly takes control of the subject of the interview by introducing new topics or by reintroducing earlier material. Sometimes, Louise's speech has a sense of being part of a stream of consciousness: for example, by entering into a dialogue with another person, such as an imaginary teacher. These features mean that it is reasonable to suppose that the interview tape and resulting transcript do give insight into aspects of Louise's lifeworld in relation to mathematics.

My interpretation of the interview is based not only on the transcript but on repeated listening of the interview tape, which records more of the emotional content of Louise's speech and importantly, the way in which her voice and register changed at various times.

The construction of the monologue

The next piece of the chapter 'Louise and mathematics' is an attempt to give a description of her lifeworld as a whole. It is given in the form of a monologue fashioned from the transcript material. However, it is not the transcript or even extracts

157

of it. It is my interpretation of the transcript. The selection of the text is not arbitrary. Firstly, either through repetition or tone or both, Louise gave an indication herself during the interview of what is more or less important to her. I have used this as a guide. Secondly, there is nothing left out that I consider to be significant with regards to mathematics.

The consequence of this is that the resulting text is unusually long, if thought of as a research 'data'. However, the length of the text arises from my concern to understand and present Louise's lifeworld as a whole.

The more usual form of thematic quotation tends to undermine the sense of the whole person. To do this "others" (Fine 1998) the research subject by 'parcelling them up' through a set of neat categories. It undermines, through the form of the text, the wholeness of their world as an objectively existing reality. I wish to try, as far as I am able, to give Louise the opportunity to speak for herself, at least in one part of this chapter. As an articulate, self-reflexive person she can do this better than I can. The monologue also gives the reader an opportunity, if they are willing, to try to stand in Louise's place. To see 'understanding' as akin to being an understudy, to be capable of standing for Louise. Of course, the persona presented in the monologue is not Louise. Neither is the person presented in the transcript. However, I believe the text I have created bears a closer relation to her than a selection of quotations interspersed with comments.

This form provides a powerful narrative that compels the reader to engage with the issues and practices that Louise describes. It inverts the conventional form of research report where 'qualitative data' is often marginalised in the text as the supporting cast to the voice of the lead actor, the researcher. It allows the research subject to step out of the chorus line and into the centre of the stage. It also invites readers to pre-empt my later discussion by re-interpreting Louise's story for themselves and so, if they choose, participate in the play.

Such a form of text requires different demands on the reader than other forms of academic text: it "asks readers to engage in reading *as work*" (Roth and McRobbie 1999, page 505). Specifically, one part of the work that I ask of you in reading Louise's story is to do so aloud, with emotion, imagining if you can what it might be like to be in Louise's world, to have had her experiences, to try to feel the way she does.

From twenty four pages of transcript, I have selected, as the material for the monologue, those parts of Louise's speech that fulfil any of the following criteria: strong emotional content, Louise introduces an event of issue herself, Louise returns to an issue or event, or she speaks about a topic for a long time without prompting.

In creating the fabric of the text I have attempted to stitch together Louise's own words with additions, [in square brackets] minimised and included only where it helps the flow of the text or to summarise text not included or to make her meaning clearer. I have omitted pauses and words repeated as part of speech that I interpret as detracting from meaning rather than adding to it. Sentences or phrases repeated in the monologue are ones that were repeated in the transcript. Italics indicate strong emotional emphasis.

Describing the lifeworld

The monologue is intended to present Louise's lifeworld in a descriptive manner. In the Fifth piece of the chapter a further interpretation is given in relation to Heidegger's ontology of the lifeworld. Here the hermeneutic circle involves not only Louise's discourse about mathematics but also Heidegger's phenomenology. I attempted to map Louise's lifeworld using Heidegger's categories and found that whilst this elucidated aspects of the lifeworld, the categories themselves required interpreting in the light of the interpretation of Louise's world. The interpretivist model here continues to be drawn from Gadamer, but is now extended to include Heidegger's ontology as a subject of interpretation. In the Sixth Piece of the Chapter I move in the direction of Ricoeur's hermeneutics akin to "hermeneutics of suspicion" that seeks to create an interpretation that goes beyond what is immediately apparent or presented (Ashworth 2002; Ricoeur 1970).

CHAPTER FOUR, FOURTH PIECE: LOUISE AND MATHEMATICS

(Directions: A young woman is alone in the centre of the stage. The stage is empty except for an old-fashioned, single school desk and at the side a blackboard. Behind the woman, projected on to the backdrop, are large numbers and other mathematical symbols. Sometimes these are stationary, sometimes they move slowly, floating diagonally across the screen, sometimes they spin in an anti-clockwise direction.

The actor adopts various voices during the monologue. These voices reflect herself as an adult remembering, a nine year old girl experiencing in the present, a fourteen year old questioning, internal dialogue between various of Louise's characters and various 'teacher's voices'. She starts standing but may sit down at the desk when she feels it is appropriate or write on the board.)

I was a good all rounder at subjects at Junior school. However, I was very aware that I was not part of what my teacher, and I *hated* this term, called 'the maths pundits'. They would have extra work to do and I would just do mine. I cannot really remember [very much], but I do remember Friday afternoons.

We used to have like a football league for the times tables. Your name was on a little strip and you used to get relegated to another division and you used to get put up. I was usually somewhere in the first division but [only] because I really, really [tried]. I was usually hanging around at the bottom of division one. I never learnt long division, for instance, because it wasn't worth teaching me that. My junior school teacher said that I'd never get it: "There's no point teaching her it". I don't think I was alone in that. I think it was only these maths pundits who got taught this long division.

[Anyway] it would be whoever's turn it was on the Friday afternoon. The two top from the first division, and then the [next] two, and it would go down, down this table of all the kids in the class. And you know you would be put up against somebody and you would both have to stand up. Everybody else is sitting down quiet listening to you, and you would both have to stand up and the teacher would ask you one of your times tables. And you had to be the first one in with the answer.

I *hated* it.

I remember that I used to stand up and my stomach would be going and I'd be going "oh no I can't lose... can't do this". You stood up, the two of you, in front of *everybody*, you stood up and fought it out.

I didn't like it at all. You couldn't get out of it and I used to *dread* it. I didn't worry about it all week but by the time it got to Friday morning and I knew it was coming Friday afternoon, yeah, I'd be dreading it.

I'll be looking "who have I got to beat, who have I got to beat?" [or] "They're going to beat me, don't worry about it, they're gonna beat me" or "I've got a chance with this person".

You're *weighing up* other people's weaknesses. It's cruel really [I would be thinking] "mmm he's a bit thick, I'll beat him [or] he's really clever, so I won't, I won't be able to beat him". And it's terrible to be making those sorts of value judgements about other people at nine. [But] you do know it. That was the culture of the school then: you told the kids at the top that they were at the top and you told the kids at the bottom that they were at the bottom.

I knew who it was ok to be beaten by at maths. It was ok to be beaten by [John Smith] who went on to Cambridge. It was ok, that was all right. I shouldn't be saying these names, [but] I can still remember them all. I can see them up there in green pen on these damn [league] tables. But to be beaten at maths, [to be beaten] at times tables by [Simon Jones] who I could beat hands down in any other subject. [Well it] was *embarrassing*.

To just not [get the answer] first or to just stand there - "er, er, er, er, er, er, er er, er," – stuttering. When the question got asked and the other person's got in there and you sit down. *When you're little* like that you don't want to stand up in front of all your mates, do you? You don't *want* to stand up in a classroom full of kids because you're not as confident.

I just hated it, it was *horrible*. Especially when you got relegated to the second division or something. And I'm sure, the kids who liked maths enjoyed it. I don't know how the kids who weren't any good at maths at all felt about it, but I felt pretty *terrible*. It was embarrassing, yeah it was *shaming*.

That's when I really, really started to think: "No, I'm no good at this". It is pressure and it's scary. And it's embarrassing when you get it wrong or you get into trouble at home, you know this is when it became this whole pressurised thing. It was the pressure.

161

I was getting the same pressure at home about learning my tables. I would have to go home and tell me mum who had beat me. I remember [one] time in the bathroom, getting yelled and yelled and yelled at, for not knowing my three times table and sitting up there crying learning my three times table (laughs). It sounds awful, doesn't it? I'm sure my mum didn't mean to upset me like that at all, I'm sure for her she just went "urghhh learn it" and she went down stairs and for her that was the end of it. But I got really upset about it. And [it made me] angry, very angry.

[I'm] not so much [telling you] my experience of maths as my experience of life and how maths fits within that. And that's really, really complicated. There are all the little bits and pieces of other things that must have happened whilst I was learning maths and whilst maths was [the main thing, there were] all these other things going on.

I don't remember the actual teaching of the maths; I do remember this 'being put on the spot'.

I did not have a good time with maths at senior school either. When I was about fourteen, I remember that I was taught maths by this [man]. We called him Speedy [Brown]. I don't think he had any concept of how to teach maths to children at all. He was very, very, quick. Apparently, he was this brilliant mathematician. He was a very scary, a very scary man. If you met him outside the classroom, he was lovely. But *inside* the classroom - he had the boys in tears as well.

(Intonation indicates copying the other persons style of speaking):

He would write on the board "TO CALCULATE" and [then] he'd underline it. And we would write what we had to calculate and it would be "CALCULATION". I only ever got it right by chance.

[Sometimes we would have to copy]. It would just be a complete scribble. I wouldn't have a clue what he was writing. And it would be (raises her voice in an aggressive tone and booming voice):

"NOW CLASS IS THAT CLEAR AS CRYSTAL OR AS CLEAR AS MUD?"

And we'd all have to say "crystal", *(quietens)* and it wasn't, it wasn't at all and I'd be just lost and it's - sit at home for hours with these damn things and I couldn't do them at all. It made absolutely no sense to me. Sometimes his calculations would be a page and a half long. I couldn't ask him at all.

162

[In all my lessons] it'd be "we're going to do this" and "we are going to do that". Put it on the board; go through it for five minutes. And say, "right off you go, there's twenty to do on your own", and I'd still be "whaaat?"

I was usually bored rigid.

[We worked on our own.] You sat in your two, two, two, twos and got on with it on your own. I might have turned round or said to somebody "do you know how do you do this?" I knew, I knew that copying wasn't the answer, especially seeing as the maths teacher would have known that's what I'd done. So I never sat and copied just [sometimes asked] "what did you get?"

"I didn't get that... try again" *(talking to oneself or thinking aloud)*. [Or sometimes my friends explained it to me]. And it usually helped me more if my friends could explain it to me.

I was usually bored. Either I was bored or I was desperately struggling, usually it was both bored and desperately struggling *(laughs)*

I used to quite often be in tears over my maths homework.

I think the maths people enjoyed it. You see here we go again 'the maths people'. You know they are defined by their ability to do maths. And some of those kids were all the way through senior school. The thing they were known for wasn't for well you know "because the women like him" or because "she's good at music", but it would have been - "they're really good at maths". They'd all be together and be sort of defined by it. That makes it a big thing, doesn't it?

I did it. I did my GCSE [and got a grade C]. I did the Intermediate paper[2] because I sat and revised it all from books and whatever and as far as I can remember a lot of it was really simple *(querying, confused)*.

But I still don't know my times tables. I still don't know them as I found out last night when I was trying to add up lots of long strings of single figure numbers. I was having some real trouble with that, you know I was having to count them up and doing it on my fingers.

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[2] In UK GCSE mathematics examinations, taken at the end of compulsory secondary school, students are entered for one of three levels of examination, Intermediate being the middle level.

I can do my elevens; I can do my elevens and my tens. I still have trouble with my fives *(quieter and sadder)*.

Yesterday I was adding sort of eight and four and six and I'd be like "eight and four, eight and four, eight and four, eight and four" *(thinking aloud)* and I just think, "I won't know". *"Twelve" (with surprise)* "twelve, eight and four - twelve and then add a six to the twelve" and then I'm thinking "well it's a six and a twelve - six and two, two and six - eight and oh no I've lost that ten that's gone" *(pace slows)*.

[The] numbers just float away, they just float away.

[Even when I] use a calculator I'll check three times, I *just* don't *trust* them, numbers, I *don't* trust them. They've got a mind of their own and they're just all over the place and I can't make any sense of them. At school I'd have all these numbers and I'd think I was doing a certain thing with them. And you would get an answer at the end and it'd be wrong and it'd be like "well god, I've just spent half an hour with you lot, how can it be wrong?" They just didn't work for me.

It was a case of just randomly hoping for the best. Maths is like fog. It's waiting to trip me up. It's almost like walking through a fog and everybody else knows the way and you don't. You're just running around willy-nilly hoping you are going to get out the other side *(laughs)* and you just don't know.

Like when you've got percentages, you've got such and such over such and such times something or other. I don't know which numbers go on the top, which numbers go on the bottom, which ones you're dividing or multiplying by, which numbers? They're all just numbers. I can't apply a formula because they're all the same. I know that it might be eight and seven and six and five but to me there're all the same, they're just numbers. I need definite things that my mind can hold on to.

I've been fobbed off. [When I asked "why", they said] - "just because it is."

(In the next part the teacher voice begins impatiently, the learner is calm as the dialogue continues the learner's voice becomes more impatient.)

"But why?"

"Don't ask questions like why, it just is, Pythagoras's theorem just says it."

"Well why?"

"Just because it does, that is what it adds up to."

"Why?"

"Because it does."

"Why?"

A lot of maths is 'because it is'.

"Well why is pi three point what ever it is?"

"Because it is."

"But why isn't it fifty six?"

"Because it isn't."

"Why?"

What I mean is, it comes back to *"why?"*

I have trouble with the fact that that they can be right and wrong [when] a man made numbers.

[A] person decided that pi is this, that and the other. How can he know really? Because he made it up didn't he? Made all the laws as well and I know that they all fit together and I find it hard to get my head round how somebody can discover a new mathematical law.

And its just because it is

And it's us that decided we needed numbers in the first place. Well we do. I need numbers too. I need numbers to think how much did I get paid for this week's work. You know I'm not saying I don't need numbers, I do. But if it's a man made concept then why can't we say "well because of this?"

I hate to say it – it's this sort of maths male world thing. Yes, maths - its all been male dominated. I don't think I've ever had a female maths teacher. [Even my female teacher at junior school] spent all her time teaching maths to the boys. I think there was only one of my friends who was a girl who was very, very good at maths, all the rest were boys. I don't know, it's very much, such a straightforward, cold, impersonal

kind of thing. That's the thing that bothers me with maths, it's not more appropriate, less appropriate, different – it's right and wrong, black and white.

That's another reason I had trouble relating to it. [Maths] is straight lines and I think in circles.

I'm very good at creative stuff. In English and that sort thing, [there are] feelings, emotions, trains of thought, frames of reference. It's all circles, there isn't necessarily one that has to be done before the other. It can be done non-chronologically, as it comes to mind. You know, you're piecing something together from all these little things and it doesn't really matter sometimes, which one comes first. Whereas maths, I think you've got a first bit and then a second bit you have to do and it's a straight line. [You need] a tidy mind (*Moves her hands forward in straight line, palms facing outwards, pushing away from the body*).

I suppose this is it, if I've got a collection of numbers, I can't get them in a straight line, they just go round in circles (*laughs*).

I am right at the bottom [when it comes to maths] (*laughs*). And it is not as important to who I am [now]. The fact that I can't do maths is something everybody else has learnt to live with about me.

[But] I've had jobs before where there is no till and you have to add up in your head. [And I have been able to do that] probably because I haven't worried about it because if you get it wrong it doesn't really matter (*laughs*).

You know I think I've blamed the numbers and blamed the maths and in fact I couldn't do it and that's stayed with me. When in fact it's not the numbers at all. [That's] the way people behave towards their computers isn't it, "oh it's just crashed for no reason and I've pressed this and it's done that" but you've done something. So you can only react in a way to what you've done Because you're the bad workman. And I feel that all along I've blamed the tools and it such a part of it now, but I realise now on an intellectual level if you like, it's the bad workman, it was always the bad workman. [And] that was me. You know and possibly the people who tried to teach me but I'm well aware that it's not the maths that's that the problem. But as a kid it would have been those horrible numbers, but it's not, I know it's not that.

Totally nine again, [that is what] I am when it comes to anything to do with maths. That's how old I am again. Worried about it, yeah, it feels like you are like some big kid who still can't do something.

166

CHAPTER FOUR, FIFTH PIECE: LOUISE'S MATHEMATICAL LIFEWORLD

Part One: Heidegger and the Lifeworld – A Map

Heidegger's map of the nature of the world

Heidegger's existential phenomenology offers us a map of the nature of the lifeworld. Heidegger does not use Husserl's term 'lebenswelt' but rather simply 'Welt'. However, 'Welt' for Heidegger does not mean the total world of things or nature (Cavalier 2002). Rather, what he refers to as 'worldhood', is part of the ontological or existential structure of being-in-the world:

Ontologically, 'world' is not a way of characterizing those entities which Dasein is essentially not; it is rather a characteristic of Dasein itself" (Heidegger 2000/1926, page 92)

That is Dasein is both the self and the lived in world that that self is part of.

Heidegger distinguishes four ways he uses the term 'the world' (all quotations from Heidegger 2000/1926, page 93):

1) "...the totality of entities which can be present-at-hand within the world."

2) An ontological term describing the Being of entities or "any realm which encompasses a multiplicity of entities"; thus it is possible to talk for example of "world of the mathematician."

3) The world in which a person lives, there are a number of possible referents here, the world: "may stand for the 'public' we-world, or one's own closest (domestic) environment."

4) "Finally, "world" designates the ontologico-existential concept of *worldhood*. Worldhood itself may have as its modes whatever structural wholes and special 'worlds' may have at the time; but it embraces in itself the *a priori* character of worldhood in general."

In this and the previous chapter, a central concern is to give an account or accounts of Louise's 'world of mathematics'. This has meaning both in the second and third senses

as Heidegger uses them. That is both Louise's lifeworld is a particular case of the lifeworld of school mathematics and Louise's lifeworld of mathematics is a particular part of her personal lifeworld[3]. In this interpretation of a single case these two aspects cannot be easily separated and in the later analysis are mainly considered together.

In mapping the lifeworld I draw on Heidegger to consider the following components of the lifeworld: the self, reifications and practices (from Heidegger's concept of entities that are not like ourselves) and others (entities like ourselves)

These are akin to the regions of the lifeworld that are to be mapped. However, the use of the terms 'regions' and 'mapped', are misleading in that they suggest separate, bounded spaces. Each of these parts of the lifeworld are mutually constitutive. A lifeworld, in its totality, is rhizomic in which all points are connected to any other point Earlier I discussed Giles Deleuze and Felix Guattari's notion of an infinite map needed to describe fully such a rhizome. Thus the description that follows is necessarily only an approximation.

Colouring the map and the method of analysis

The lifeworld consists of relationships. In Louise's discourse she either directly or indirectly makes statements about the nature of these relationships in the lifeworld. These statements describe not only the relationship but also the ontological form of the relationship, for example the nature of the self or others in the lifeworld.

In mapping Louise's lifeworld I pay attention to relationships indicated by: statements about her own, others, or entities' actions, statements about emotions or feelings; statements of knowledge and about Louise's relationship to knowledge; and statements of perception that is what is sensed or taken as immediately true.

Affect and emotion have become to be of greater concern within attempts to understand learning. There is a wealth of literature discussing different aspects of affect, emotions, moods and so on and their origins (see Parkinson 1995 for both an overview of research on emotions and an argument of emotion as social practice, see Evans 2000, and McLeod 1992 for discussion of emotion related to mathematics education). In this mapping of the lifeworld, all these different features are brought together under one

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[3] In Being and Time, Heidegger's investigation into the nature of Dasein is concerned with the third more abstract category only (see Heidegger 2000/1926, page 93).

168

heading of feelings; the question that I ask is how does Louise feel about herself, others and social practices and reifications within her lifeworld, and how do others feel. The feelings colour the lifeworld. As integral aspect of being in the world is that of 'throwness': we find ourselves 'thrown' into a world of entities that change that we must engage with (Heidegger 2000/1926). Part of our 'throwness' into the world is that we exist in/we are a river of changing motions. As these emotions flow through us/we flow through these emotions everything in our lifeworld is coloured by them; the same entities in our lifeworlds are different as our emotions change. I believe that the relationship between the full range of emotions and the lifeworld is under explored in Heidegger's phenomenology

These different categories are not used so much as analytical tools to dissect the lifeworld, but rather aspects that need attention paying to. The different categories are in Deleuze and Guatttari's terms, some of the "multiple entryways" into the map.

...if we inherit a strong reality of the individual self – a self that senses, thinks, feels and directs action – and we find this construction of the person flawed, can we set out to reconstruct reality in a different key? And toward what kind of alternative should we strive? In what way can we conceptualise persons such that the individualist ills are not duplicated, and the possibilities of more promising forms of societal life are opened? ... Even the concept of relationship itself, as we inherit it, presumes that relationships are built up form the more basic units of single individuals. It's as if we have become enormously sophisticated in characterizing individual pawns, rooks, and bishops, but have little way of talking about the game of chess. (Gergen 1999, page 122-123)

169

Part Two: The Self in Louise's Lifeworld of Mathematics

Heidegger and the self

It is not possible to give a full account here of Heidegger's philosophy of personhood and the self. At the centre of *Being and Time* is the notion of the person as Dasein, which asserts the idea of 'being there' (Inwood 1997). The essential aspect of what it is to be human for Heidegger is the awareness of our own and others' being. The self is not a substance or an essence that has an "inner sphere" from which it goes out to interact with the world:

> and further more, the perceiving of what is known is not a process of returning with one's booty to the 'cabinet' of consciousness after one has gone out and grasped it; even in perceiving, retaining and preserving, the Dasein which knows *remains outside*, and it does so *as Dasein*. If I 'merely' know about some way in which the Being of entities is interconnected, if I 'only' represent them, if I do no more than 'think' about them, I am no less alongside the entities outside in the world than when I originally grasp them. (Heidegger 1962, page 89-90, original emphasis)

Thus the self is always intimately connected existentially with the world of which it is part. It might be supposed from Heidegger's use of the term Dasein that the self is a singular, continuous and univocal, however this is not really the case (Ashworth 2003). Dasein is the state of being-in-the world. In considering the idea of conscience, Heidegger distinguishes this from other ways of talking of the self and of various 'selves' (see Heidegger 1962, pages 317-319).

Multiple selves – multiple life worlds

> Inside you are countless selves. Amongst whom there's the decent on, the indecent one, the honest virtuous one, the lying, thieving one, the loving, generous one, the hateful, mean one, the wise, peaceful one, the stupid, violent one, the secure one, the insecure one, the sexy, confident one, the frumpy, shy one, the sly, deceitful one, the open, honourable one, the feminine one, the masculine one, the old one, the young one, the bold one, the timid one, the crazy drunken one, the sane, sober one, the materially inclined one, the spiritually inclined one and so on (and on). (Russell 2001, page 26)

The notion of always being-in-the-world is conversant with the notion of multiplicity of selves, subjectivities or identities. The sense of the self as multiple, shifting, and discursive has arisen in many different disciplines and theoretical/philosophical perspectives.

The influence of post-structuralism and its approach of subjectivities fashioned by and expressed through multiple discourses are important here (see for example in mathematics education, Walkerdine 1988, 1997; Evans and Tsatsaroni 1994; Evans 2000, Tsatsaroni and Morgan 2003). Carol Linehan and John McCarthy utilise the analytical tool of the self that emerges through 'positioning' developed by Rom Harré and Luk van Langenhove (Linehan and McCarthy 2000; Harré and van Langenhove 1999).

A similar view of self, if founded on a different epistemology, is expressed by some working within social practice frameworks. Dorothy Holland, William Lachicotte, Debra Skinner and Carole Cain draw on Mikhail Bakhtin's work to posit the notion of selves positioned in different "figured worlds" (Holland et al 1998).

From an ecological perspective, the human organism as a socio-biological entity may be seen as an 'ecology' in itself – the ecology of the mind which is not separate and distinct from the world it is within (Bateson 1973). Those working in humanist psychoanalytical traditions think in terms of subpersonalities (Rowan 1990) or "a population of selves (Polster 1995) others echoing Vedantic traditions talk of many selves (Watts 1989; Wilber 1996).

Louise's selves

There is not one self in Louise's monologue but many. In the directions I indicated that the actor should speak in different voices, this reflects the way her actual speech changed during the interview in terms of register, tone and so on. There are many 'Louises' in the interview: the adult who is positioned/positions herself in the interview as an adult reporting on her past, the nine year old, the fourteen year old and other selves. The lifeworlds of these different selves are not homogeneous; they do not share the same quality. This is most striking where Louise, after graphically describing her relation to the fog of mathematics and numbers "that float away", also tells us that when she did a job that required mental arithmetic without the use of a till, she was able to do it. She says that this is "because if you get it wrong it doesn't really matter". In the situation where "it doesn't really matter", Louise does not find herself "totally nine again" and so her relationship to numbers and her ability to calculate them is different. Her earlier description of her difficulty with adding numbers was in the context of

working with some survey data gathered as part of her academic course; here she does find herself as a nine year old.

Louise's ability to carry out arithmetical operations depends on context. This is reminiscent and confirmed by a substantial body of material developed in an ethnomathematic or situated cognitive framework (see for example Lave 1988; Nunes, Shliemann and Carraher 1990). A lifeworld perspective shows more fully the fact that the numbers are different for Louise in the two different situations. They mean different things and act in different ways. In one she tells us that they "have a life of their own". In the other, she does not speak about them in this way, but we may presume that her ability to add with them means she is able to use them whether this is by cajoling them or controlling them is not clear.

It is notable and perhaps surprising that in the work situation, getting it wrong does not really matter. Normally, we might think that when dealing with money, in a situation where continued employment depends on getting it right would be a situation where it does really matter. But not for Louise, the situation that matters more is when the self and the lifeworld that emerges with it are a 'like at school, self' and 'like at school, lifeworld'.

The reflexive self

The monologue indicates the existence and flow through a changing ecology of selves. The monologue itself is made possible due to the reflexivity of the self.

Thinking in terms of multiple situated selves does not necessarily entail fragmentation either of the self or of a description of it within the lifeworld. Using a mycological metaphor, we might think of the different selves as akin to a fungal colony. The different selves that emerge/are created in discourse or actions are akin to the mushrooms that are the fruits of the colony. The form each mushroom takes is dependent on the micro-ecology that it emerges into and is part of. The mushroom may look like it is separate and distinct from each yet it is part of a whole. Unlike fungus the human self is able to give account of itself and the relationship between different parts of the whole. It has agency (though not a free choice) to choose which self acts in the world.

172

In the monologue 'Louise and mathematics' we find multiple voices. However, all of these voices emerge in a context in which Louise is asked, and is trying to, give an account of herself in the world of mathematics. Moreover, there is also a voice that seeks to synthesise and understand the experiences and aspects of the subtly different selves and lifeworlds that these are part of.

There are many ways that this part or aspect of the self has been conceptualised in many different philosophical traditions. In the existential and phenomenological tradition the self has a 'project' (Sartre 1969). For Hannah Arendt, the self that 'discloses' itself through speech and action, weaves a web of relationships and narratives, that though intangible "is no less real than the world of things we visibly have in common" (Arendt 1989/1958, page 183). For Søren Kierkegaard the essential nature of the self is its relationship to itself, a relation that relates to itself (Kierkegaard 1989/1849). Heidegger's notion of Dasein is based on such reflexivity, the nature of Dasein is awareness of its own being. Social practice theorists from a different starting point speak in parallel terms. At the heart of Heidegger's phenomenology is the description of the nature of being-in-the-world as relational, whether that being is in relation to entities that are found ready at hand or present at hand. This relationality includes relation to one self.

For Etienne Wenger, the self is constructed through "negotiating the self" through "a very complex interweaving of participative experience and reificative projections" (Wenger 1998, page 151). A more fully developed account of this can be found in the work of Holland, Lachicotte, Skinner and Cain who, drawing on the work of Bakhtin write of 'the authoring self' or the 'self-in-practice' (Holland et al 1998)

Given the limits of my particular project here, I gloss over the differences between these different positions. However, these different views share an assertion that this aspect of the self is important —we do not need to agree that this is a true or authentic self, but it is an intrinsic and important part of what it is to be human and from a perspective of deep democracy an essential one to understand and listen to.

I will make some assertions that are founded in reflection rather than primarily action in the world. The reflexive aspect of the self has both a receptive and active quality. The receptive quality is, metaphorically, a witness that makes sense of the shifts between different lifeworlds and is the basis for continuity between them and so the sense of

173

identity. The active quality is, metaphorically, that of the conductor of the orchestra or director of the play, that guides the shifts between the lifeworlds. What is common between these receptive and active qualities is self-reflexivity.

Kenneth Gergen argues, from a social constructionist perspective, that it is the 'polyvocality' that arises from the multiplicity of selves and identity that makes such self-reflexivity possible (Gergen 1999). Regardless of how convincing this is, self-reflexivity allows both a bringing together, and a description, of the different voices of the different selves. Thus we can ask what account does Louise give of her different selves in her lifeworld of school mathematics, how does she describe herself, how is she authoring herself, what is the web of stories she weaves about herself?

Louise's account of herself in the mathematical lifeworld

The interview with Louise focused on her experience of being engaged in mathematics practices and the social practices of school mathematics. She describes a range of different practices that she engages in (these are discussed in the next piece of the chapter). However, what is notable in her description of this engagement is the manner in which this engagement either comes about or is carried out.

There is an apparent lack of agency and 'authoring' in these practices; Louise is much more done to than doing. She is watched (having to stand up in front of everybody), subject to surveillance (the teacher "would have known what I had done" if she copied), compelled to take part, she feels herself to be excluded (not one of the "maths pundits") and ranked. Louise's own actions are characterised by "desperately struggling" at school and the same sense of frustration and struggle pervades her description of her engagement with mathematics since.

Louise is apparently powerless. She is powerless in relation to the requirements of the social practices and her teachers and powerless in relation to the mathematics and numbers themselves. Numbers have a "mind of their own" and "float away".

However, in spite of this apparent lack of agency and authoring, I suggest that there are two important actions that Louise takes. Firstly, she questions the nature of the mathematical practices that she engages in. Part of this questioning is of nature of mathematics itself. As well as desperately struggling with mathematics, she struggles to

174

make sense of the world she is thrown into and the events that happen within that world and the nature of the entities she encounters:

"Well why is pi three point what ever it is?"

"….I find it hard to get my head round how somebody can discover a new mathematical law"

"And it's just because it is."

The mathematical world belongs not to her but to her teachers and the "maths pundits". Her teachers provide no explanation that makes sense to her for the nature of mathematics or why mathematics is the way it is. Louise feels herself to have been "fobbed off" without being give satisfactory answers that would allow her to make sense of her experience.

Secondly, Louise is engaged in a struggle to 'author' herself. She is thrown into a situation in which, at junior school, she is forced to create her identity in relation to her success in the Friday afternoon tables competition. She "hates" the term "maths pundits". Thus she does not simply acquiesce to her positioning, she resents it and strives to overcome it. Later, in secondary school, she continues to strive to participate in the social practices and to conceal her lack of understanding.

Louise questions her positioning within the lifeworld, why she is in the situation that she is in. At the end of the monologue, in spite of her descriptions of teachers, one at least, who does not have "any idea of how to teach maths to children at all" and mathematics that is untrustworthy Louise ends by blaming herself for being the "bad workman". She cares deeply about being able to perform mathematically, to be mathematical. She blames herself.

Coupled with this sense of guilt is shame. In Chapter Four, students reported feelings of public and private shame connected to being wrong or potentially being wrong in teacher questioning situations. Louise shares this shame, but here we find it extends beyond those public situations to pervade the lifeworld of mathematics for Louise.

Being alone is a recurrent theme in the monologue. Louise must stand up on her own in front of all the other children. She is left alone to try to learn her times tables. She

struggles for hours at home with homework. She must and is not allowed to ask for help from her peers. Her unexpected success at GCSE is a result of revision alone. She is left wondering on her own about the nature of mathematics and her own relationship to it. She encapsulates this sense of being on her own, in a dramatic image:

"It's almost like walking through a fog and everybody else knows the way and you don't. You're just running round willy-nilly hoping you are going to get out the other side and you just don't know."

Here the sense of being alone is added to with an image of being lost, a term she uses to describe her attempts to engage with mathematics: "I'd be just lost".

Louise is silenced. In her description of standing in front of the class in the times tables competition she is left stuttering "er,er,er,er,er,er,er,". She cannot ask her secondary teacher for help. Moreover, when asked if she understands she is expected to say that it is as clear as crystal when "it wasn't, wasn't at all". Her attempts to understand why mathematics is the way it is are met with the wall of "because it is".

Louise's cognitive experience is of not knowing. This includes not knowing particular times tables, or how to apply a formula and so on:

" And [the teacher would] say "Right off you go, there's twenty to do on your own" and I'd still be "whaat?" ""

More importantly not knowing and confusion describes her general existential state.

Generally, the emotional experience of this lifeworld is negative for Louise. The emotions she relates to us range from boredom and ongoing sadness to anger, dread, fear, and hate.

The self in Louise's mathematical lifeworld is one that has emerged through negotiation and activity within an environment that is intended to be a learning situation. However, what Louise has learnt in this environment is very little about mathematical practices but a great deal about struggle, pressure, ranking, exclusion, compulsion, frustration, shame, anger, hate, sadness, boredom, fear, isolation, powerlessness, silence, and not knowing.

> This pine tree outside my window is deeply interlaced with me, with my breath, with my thoughts and words, with the moisture of my eyes, squinting as they must in the sunlight backlit yellowgreen standing out from the bluegreen spruces. But it is not experienced this way as an object that stands over and against me as separate and cut off. But then again, it is not *me*. (Jardine 2002, page 103)

Heidegger on equipment

One of the central features of being alive, for Heidegger, is "throwness", we find ourselves "thrown" into the world with which we engage or deal.

Heidegger uses the metaphor of "tool" or "equipment"[4] to analyse the nature of entities that we engage with. The notion of "equipmentality" points to the way in which the entities with which we deal are for something, they are "constituted by various ways of the 'in-order-to' " (page 97). Thus entities in the lifeworld are inexplicably bound with human action or potential for action. The ontological character of equipment is "readiness-to-hand" (Heidegger, 2000/1926, page 98). "Readiness-to-hand" denotes the way in which we know the nature of an entity through and in its use or potential use.

Heidegger, distinguishes between two types of entity that we engage with or deal with: entities that are part of nature that have a primordial quality of being present-at-hand and tools or equipment that are both present-at-hand and ready-to-hand (Heidegger 2000/1926, pages 100-101). However, when we begin to engage or deal with "nature", when we do something with natural objects, the entities take on the character of being "ready-to-hand".

This distinction may not seem immediately relevant when considering Louise's lifeworld of mathematics, which is a socially constructed lifeworld and so consists of a world of equipment, of socially created entities that are for something. However, I will revisit this distinction below when I consider the nature of the socially created entities that Louise engages with in her mathematical lifeworld.

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[4] The term Heidegger uses 'Zeug' has no direct English equivalent (see Heidegger 2000/1926, page 97, translators notes).

Equipment does not consist of individual discrete items but rather is always bound into and connected to a totality of other equipment or tools that it is in relationship to. For example a pen 'belongs' to other equipment such as paper, ink and table and even the equipment of the room, the doors, windows and so on (Heidegger 2000/1926, page 97)[5].

Heidegger's analysis of the nature of the entities we encounter in the world focuses on material objects and uses these as a primary metaphoric reference[6]. However, if we consider his initial description of the "world" as being capable of signifying also such worlds as the "private world of the mathematician" or the "domestic world" then the equipment in the lifeworld must be extended beyond material equipment to include the entities we deal with in our lifeworld that are abstract. Various philosophers of mathematics have argued that the objects of mathematics are best understood as socially constructed reifications of social practice (see for example Bloor 1994; Hersch 1994; Restivo 1999).

Such a perspective accords with Heidegger's characterisation of the entities that we engage with in the world as ontologically being for something and having a relationship to action. Applying the idea of readiness-at-hand and the notion of a totality of equipment is, I believe, a potentially fruitful one for understanding aspects of the nature of mathematical activity and learning. In any case, in analysing Louise's lifeworld, I will consider the extent to which the entities that she describes or refers to, other than herself and other people, have these qualities.

The 'entities' of Louise's mathematical lifeworld

The entities, the things she refers to or speaks about in Louise's mathematical life are of three different sorts, firstly social practices and associated reifications that are not explicitly mathematical for Louise, secondly mathematical reifications and practices, and thirdly mathematics itself taken as a whole.

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[5] Rephrasing Heidegger, we can think of an ecology of equipment rather than a totality.
[6] One of Heidegger's central concerns is countering Cartesian dualism thus the relationship between Dasein and objects found in the world is an early concern in Being and Time.

Many of the practices and artefacts she refers to, that are memorable are ones familiar from discussions in Chapter Two and Four about usual school mathematics.

Louise tells us that she remember "much about the teaching". What is memorable at junior school are "Friday afternoons". At secondary school her memories, in terms of classroom experience, focus on the start of lessons and teacher explanations[7]. This supports my contention in Chapter Three that these parts of lessons help to define the nature of the classroom practice and the student's experience of it.

In her lifeworld Louise, internalises the teacher practices of judging. Thus she "weighs up" others weaknesses, to judge the likely hood of winning and also whether it is acceptable, in terms of her identity, to lose to a particular person. She is acutely aware of her own position in relation to others. Most of her description of her mathematical lifeworld focuses on situations where establishment of rank occurs. This is perhaps not surprising as all the social practices she describes involve or allow the possibility for ranking students.

The practices at Louise's junior school might appear extreme. However, a similar sense of 'weighing others up' and comparing oneself to others during questioning practices was indicated in the previous chapter. However, what this lifeworld analysis adds is the way in which rather this is not simply a side effect of the social practice, but in Louise's lifeworld it is *what the practices are for*. Moreover, this becomes a repeated motif woven into the fabric of the lifeworld; part of Louise's struggle with mathematics at any time is a struggle to be able to obtain her right place in relation to others.

As stated in the last piece of the chapter, Louise's experience of the emotional content of the social practices is overwhelmingly negative. They are variously: cruel, pressurising, frightening, dreadful, embarrassing, shaming, and cause tears and despair. I suggest that within Louise's lifeworld of mathematics this is what these different practices are apparently for, they so overwhelmingly engender these negative emotions that any other purpose or effect is almost absent.

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[7] Louise gave other accounts of teacher explanations in the interview which are not included in the monologue.

The mathematical practices and reifications that Louise refers to are: long division, times tables, 'calculation', numbers, formulas, adding single digit numbers, percentages, Pythagoras theorem, and pi.

As discussed earlier, in Heidegger's phenomenology, entities we engage with are metaphorically akin to tools or equipment that are constituted by what they can be used for. Yet in Louise's mathematical lifeworld the mathematical entities with which she engages have a very different ontological character.

Some, like long division, are not 'ready at hand'. Long division is for others, for the "maths pundits". Whilst we might believe that the comments by her junior teacher that engenders this sense of exclusion, is inappropriate, the sense that some mathematics is only for others is a common one for mathematical learners. Observation of 'differentiated' teacher questioning in whole class situations has indicated ways in which the teacher gives verbal clues as to who is expected to answer different types of questions (Anderson and Boylan 2000) and an awareness of this on the part of at least some students (Boylan 2002).

Louise's relationship to the other mathematical entities that she engages with also stretches the metaphor of tools or equipment. For Louise numbers cannot be sequenced, they are "all the same", formulas cannot be applied, calculation is only got right by chance and times tables are unknown.

In places her discussion of some of these mathematical entities, such as pi, indicates that the status they occupy in her lifeworld is more akin to, in Heidegger's terms, entities that we come across in the natural world. They have the quality of strange and fantastical, almost mythological creatures, which Louise is thrown into the world with, or perhaps more accurately, are thrown into Louise's world. They are random and incomprehensible. A feature of entities that are ready at hand is that they are bound up in a totality of other equipment that they are in relationship with. However, pi seems unrelated, for Louise, to other mathematical entities or to social action: "Pi is three point what ever it is... because it is?" Yet, Louise also 'knows' that:

> A person decided that pi is this, that and the other. How can he know really? Because he made it up didn't he?

180

Therefore, Louise has to live with an inexplicable contradiction: a contradiction that exists on a fundamental ontological and existential level. She believes that numbers and mathematics were "made". They are equipment or tools, yet she has no access to any knowledge of how they are made or their relation to each other. She is told that it is just because it is.

The nature of her being-with mathematical entities is described at times as being more akin to being-with-others than with tools and equipment. Some of the mathematical entities she discusses have agency within her lifeworld or at least are actors. This appears in a number of places in the description of her lifeworld. Numbers "just go round in circles"; they will not go into straight lines. Numbers cannot be trusted. Most strikingly she tells us that:

> They've got a mind of their own and they're just all over the place and I can't make any sense of them. At school I'd have all these numbers and I'd think I was doing a certain thing with them. And you would get an answer at the end and it'd be wrong and it'd be like 'well god, I've just spent half an hour with you lot, how can it be wrong?' They just didn't *work* for me. (My emphasis)

Numbers in Louise's lifeworld are sometimes uncooperative, uncontrollable, untrustworthy, others who act to deceive or trick. The relationship that Louise describes here is not akin to a person using tools but rather someone attempting to direct or manage unruly workers.

Given Louise's relationship with mathematical entities the use of the word "my" when she refers to "my times tables" does not really denote any sense of ownership:

> I can do my elevens; I can do my elevens and my tens. I still have trouble with my fives.

In the culture of school mathematics in the UK, it is common for teachers to ask students to "learn *your* times tables" with students often talking in terms of knowing (or not knowing) "*my* times tables". Clearly, Louise has internalised this language, so that the times tables are seemingly hers. However, everything she tells us about her lifeworld points to the way in which mathematics is not hers.

In Louise's lifeworld mathematical entities have, at various times, any of the qualities of entities found in the world that are present-at-hand, tools that are ready at hand, and also the quality of being like others who are actors in the world.

181

This threefold nature of entities is also found in the nature of mathematics as a whole. One way that she describes mathematics is as a fog that mystifies, it is meaningless and incomprehensible: "It made absolutely no sense to me". The teacher's writing is a "complete scribble". Here, there is a sense of mathematics as something separate, outside, unknowable. Mathematics is an area that she cannot enter into without becoming lost and "running round willy nilly". I suggest that mathematics in these descriptions is like a strange and difficult land for Louise, that she encounters but does not engage with in a sense of 'in-order-to'.

In other places where she describes the times she is able to engage mathematically, she speaks of mathematics as being abstract, she ascribes her difficult relationship to it as being due to her "need[ing] definite things that my mind can hold on to". Unlike English or other subjects mathematics lacks frames of reference. It is "male", linear and chronological: "I think you've got a first bit and then a second bit". Here, mathematics is 'ready-at-hand'; she 'knows' how to operate mathematically but still finds it as something that is alien to her.

There is a third more active description of mathematics, which is possibly a reification of the experience of interacting with untrustworthy mathematical entities. This is encapsulated in the moment when she describes mathematics as waiting to trip her up. Here mathematics is an adversary, a trickster that seeks to fool her and get the better of her.

The mathematics, as the reification of a particular and specific set of social practice, that Louise is involved with in her mathematical lifeworld, are not only 'things' in the world that are acted on, but themselves act as if they are persons or actors in the world. Mathematics is waiting to trip her up; numbers have a mind of their own and float away. From a lifeworld perspective we must take Louise's statements seriously and literally as a description of (part of) the nature of mathematics in her lifeworld.

The emotional relationship to different types of entities

Above I described Louise's negative emotional relationship to the social practices of mathematics. Clearly, the affective quality of the mathematical practices and

182

mathematics itself is also negative. She feels frustration, resentment, and despair, when numbers "don't work" for her. However, mathematics, as a whole, is seen as unemotional.

However, what is striking is that these emotions are different both in intensity and apparently in importance to the way she talks about the social practices. When she describes the social practices she says, for example, that she dreads Friday afternoon and she hates standing up. She makes frequent references to her feelings about these events. However, when talking about mathematical practices the emotional content has to be inferred and the number of affective statements she makes are less.

What is it that Louise fears, dreads, becomes angry about, hates, or thinks is cruel? It is not mathematics or the mathematical practices themselves but the social practices in which they are embedded. I believe this interpretation calls for further research, because if the situation is similar for others, it implies that phrases such as 'Maths phobia' or 'Maths anxiety' are highly misleading. More accurate would be 'maths teaching phobia' or 'mathematical social practices anxiety'. For the adult Louise, in so far as mathematics continues to be a source of anxiety she tells us that it is because she feels herself to be "totally nine again"; still being ranked, still being shamed, still being "put on the spot".

Part Four: Being-With-Others in Louise's Mathematical Lifeworld

Heidegger and Arendt on being-with-others

In discussing the nature of being-with-others, Heidegger, prefigures and lays the basis for his later discussion of authenticity and the fallenness. He characterises the everyday nature of being-among-others as distantiality, averageness, levelling down, and publicness (Heidegger 2000/1926, pages 163-166). Heidegger's existentialism has been described as a secular version of the Judeo-Christian tradition (Benhabib 1996); a heroic struggle to regain an original authenticity that has been lost through a 'fall' into the everyday. Regardless of whether this is a credible reading, I believe Heidegger is one-sided in focussing on the difficulties being intimately in the world with others can bring. In *Being and Time*, joy indexed twice, love once and compassion not all in contrast to the space given to guilt, shame, anxiety and falleness.

183

For Heidegger, being-with-others is one of a number of essential features of which the most important is being-unto death (Benhabib 1996). Giving pre-eminence to being-unto-death is the basis for Heidegger's claims about authenticity and fallenness. Seyla Benahabib finds in Hannah Arendt's existentialism a revaluing of being-with-others in that she:

> ...resuscitates everyday-being-in-the-world with others as the basic condition of being human...Being-unto-death is displaced by natality; the isolated Dasein is replaced by a condition of plurality; and instead of instrumental action, a new category of human activity, action, understood as speech and doing emerges. Everyday being-in-the-world, rather than being a condition of inauthenticity into which Dasein is thrown, now becomes that "space of appearance" into which we are inserted as acting and speaking beings and within which we reveal who we are and what we are capable of. (Benahabib 1999, page 107)

Heidegger stresses the aspect of being-with that ontologically flows from our relationship to tools and equipment that are the outcomes of others actions; we live in a world of entities that others have created. Arendt stresses being-with-others in terms of our everyday interaction with others who are like us and with whom we create our lifeworlds in an immediate sense.

One means of bringing out this distinction is to think in terms of 'self', 'circle', and 'world-ecology'[8]. By 'circle', here I mean the immediate circle of relationships that we are in: family, friends, people we work with – people we know and share our lives with. 'World-ecology' here refers to the wider social ecology of which we are part. The boundary between these three categories is porous and shifting rather than that of hard, fixed edges.

Interpreting Arendt using this distinction, Arendt stresses the extent to which our being-with-others is most importantly our relationship with our circle whereas Heidegger's concern is with our relationship with the world-ecology through our interactions with equipmentality.

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[8] I could here use self, circle and world but in the context of this chapter, the term world, might cause confusion with lifeworld.

Arendt's insight is tremendously important, and in this chapter and thesis there is a stress on the immediate relations with others and the local production of practices and the lifeworld. It is an important correction to Heidegger's over-emphasis on our relationship to "equipment" as being the primary nature of being-with. Being-with is about being with embodied, sweating, smelling, changing, anxious, worrying, fearful, bored, alert, frowning, angry, raging, sad, tearful, melancholic, grieving, joyous, smiling, compassionate, loving, mirrors of our selves. The most important phenomenological insight of Heidegger is that when we are with others we are with 'another like me'. Another or others like me, with whom I engage through speech and action. The quality of this engagement is intimate and complicit.

When Heidegger talks of falleness and levelling down, I believe he moves from an ontological description to a psychological one or a description that gives insight into his own particular lifeworld. However, underlying Heidegger's pessimism is an insight that our being-with-others is necessarily relational, in the sense that being with oneself (and thus our identity) always emerges in relation to others. This may not necessarily involve a levelling down, or an averageness but it does involve a 'something'.

However, our relationship to the world ecology is also visceral and immediate through our engagement with artefacts and practices. In some cases and situations this relationship has a similar texture to that of our relationship to our circle(s), to those we engage with intimately and complicitly. Thus we relate to particular reifications, in specific lifeworlds/selves, in ways that are similar to our relationship with others who are "ones like us". If we reflect on our everyday lives we find that we engage with "equipment" as if they are persons or actors. We get angry with the computer when it crashes, we may find a building intimidating or energising, an object precious and affirming.

Louise's being-with-others

Louise's experience of the practices of the mathematics classroom is shaped by and shapes her relationship to others. These others in her mathematical lifeworld are her peers, the teacher, and her mother.

Her relationship to her peers, of this aspect of being-with-others is not one of falleness or levelling down, as Heidegger would have it, but of comparison, ranking and separation. The Friday league tables competition is a public form of this comparison. She has an acute sense of whom she ought to be able to beat and whom it is ok to be beaten by. She is positioned as an outsider (along with what is presumably most of her class) as not being a "maths pundit". Learning mathematics is an individual experience and even at secondary school where she tells us that her peers can help she feels unable or is prevented from seeking their help.

What is at the centre of the practice of Friday afternoons for Louise is her relationship to those she is in class with, to the teacher, and to her mother. Who is better, who is worse, who is a 'maths pundit', who is in division one, and who can get in with the answer first? Will she be relegated or promoted? Will she have to go home and tell her mother?

The experience of comparison and ranking is identity forming. She tells us that the junior school experience of not being a "maths pundit", of not being worth teaching long division to, of "hanging around the bottom of division one" of being placed in competition with others was when she started to think "I'm no good at this". In secondary school, her description of the practices is still pervaded by comparing herself to others who she checks her answers with.

At both junior and secondary school the teachers are powerful. They can compel her to stand up when she hates to do so or to say "crystal" when she does not understand and does not "have a clue". The secondary school teacher is the one who knows: "the brilliant mathematician" who is very fast and unapproachable. The knowing of the teacher extends to knowing if Louise were to copy or to get help from another student.

At the same time, the practice of the league tables competition and the secondary experience is embedded within a wider ecology. Perhaps Louise as a child does not know this (though she appears to have internalised an identity from this time as "a good all rounder"). But as an adult she does, she believes that the sort of ranking she experienced does not happen anymore. As already stated, she questions where numbers come from and how mathematics works, she has

"trouble with the fact that they can be right and wrong [when] a man made numbers" and that mathematical 'laws' all fit together. Thus in our relationships with reifications and practices we are aware of the wider ecology, that there is more in the social world than those we are intimate with.

Her experience of being-with-others is gendered. The "maths pundits" are generally boys, teachers are usually male and the nature of mathematics is experienced as masculine.

CHAPTER FOUR, SIXTH PIECE: SCHOOL MATHEMATICS AND ALIENATION

Louise's lifeworld of mathematics is pervaded by a sense of alienation from herself, others and mathematics. This alienation can be understood in a general Marxian sense in that she is subordinate to the products of human activity – the reifications of social practices and the social practices themselves. Her own engagement in these practices leads to both herself and others ranking and comparing her with others. Moreover, she feels herself to be subject to the deceits of untrustworthy and hostile mathematical entities that she must deal with.

Her alienation is also deeply existential: a continual state of anxiety and fear in relationship to mathematics and the associated social practices. She is separated from others and herself, through the internalisation of the measuring and ranking nature of the social practices she engages in. Mathematical reifications appear in her lifeworld as alien entities that are inexplicable.

I stated at the start of the chapter that Louise's mathematical lifeworld is not necessarily typical. However, other learners share many aspects of her relationship to mathematics. Jo Boaler argues that mathematics is of "another world" for many and the statements about mathematics and mathematical social practices made by students she interviews evoke a similar sense of alienation (Boaler 2000). This alienation is clearly related to the de-humanising social practices of ranking and comparison and the consequent anxiety these cause. But more than this there is a sense in Louise's discourse of a deep and on-going struggle to try to understand how mathematics can be as it is and to establish her identity in relationship to it. Louise has a clear sense of mathematics as a social construct and a human product, yet the social practices of school mathematics allow her no or little way to relate to mathematics in this way. How far other learners of mathematics share this philosophical concern is an open question. However, I believe many are left with unanswered questions about the nature of mathematics. As I approached the end of my research studentship a new friend asked me about my research work. After briefly referring to the experience of school mathematics she commented:

> One thing I've never understood, why is Pi what it is, where does it come from? (Quote from Joan: Research diary November 2003)

Joan asks the same question as Louise. Louise is clearly not alone in retaining a curiosity about the nature of mathematics in spite of her experience in school. Indeed, it is questions such as these that could provide the starting points for a very different set of school experiences.

CHAPTER FIVE

ECOLOGIES OF PRACTICE AND PARTICIPATION

> Shared participation is the stage on which the old and the new, the known and the unknown, the established and the hopeful, act out their differences and discover their commonalities, manifest their fear of one another, and come to terms with their need for one another. Each threatens the fulfilment of the other's destiny, just as it is essential to it. (Lave and Wenger 1991, page 116)

FIRST PIECE: ABOUT THIS CHAPTER

This chapter is something of a theoretical bridge between the previous two, reporting on research activities of the first year of the research, and the next two, which report on activities and material gathered in the second year. Reflecting on the material I have so far presented, I further interrogate the notion of communities of practice and the nature of participation in classrooms and argue that school mathematics classrooms are best understood as a regime of mathematical practices.

In Chapter One I reviewed objections raised by various commentators of the idea that school classrooms are generally communities of practice. In Chapter Three, I reinforced the argument that usual school mathematics classrooms are not communities of practice by considering teacher questioning. In the next piece of the Chapter, I propose and discuss a more general way of describing sites of learning through social practice as ecologies of practice

In the third piece of the chapter I consider the nature of participation in ecologies of practices, and put forward the notion of marginal participation as characteristic of students involvement in usual school mathematics classrooms and the term 'regimes of practices' to describe usual school mathematics practices. By considering Louise's lifeworld and other discussions of the social experience of school mathematics I argue that the general experience of school mathematic is one of alienation.

In the fourth piece, I go on to compare the nature of different types of ecologies of practice potentially found in school classrooms in comparison to community of practices.

Alessia Contu and Hugh Wilmott argue that situated learning theory should emphasise the idea of practice rather than community:

> Different sets of practices, located in different space-time contexts, are recognized to generate different and competing conceptions of the degree of consensus, diversity, or conflict amongst those who identify themselves, or are identified by others as "communities." Those who focus upon *communities* of practice (e.g. Wenger 1998), in contrast, are inclined to locate "practices" or "behaviour" primarily in the context of a unitary – and managerially more appealing – conception of "community" or indeed, "organization". This emphasis tends to inhibit consideration of the social location of "community" and "organization" members with a wider set of institutional relationships. (Contu and Wilmott 2003, page 287 original emphasis)

Contu and Wilmott are concerned with the need to recognise the importance of social difference and the buying and selling of labour in workplace contexts. Yet the same criticism applies even more forcefully in the ideological and compulsory education system.

Jay Lemke, in discussing Lave and Wenger's theory proposes one way to reconceptualise the process of learning and the social formations that arise from it and within which learning is embedded by thinking in terms of ecosocial systems (Lemke 1997):

> What is so special about ecosocial systems among all other possible ecosystems is not that they contain us and our things, but that our behaviour within the system, and so the overall dynamics of the system as a whole, depends not just on the principles that govern the flow of matter and energy in all ecosystems, but also on what those flows mean for us (Lemke 1997, page 40).

Understanding groups of people engaged in social practices as ecosocial systems allows insights of systems and activity network theory to be applied to understanding learning situations. In particular Lemke points to the way in which such insights suggest that whilst some learning situations will correspond to the simple community of practice model many, particularly those in schools, will not:

> To understand these more complex cases, we need a model of networks of linked or interdependent activities and CoPs [communities of practices] within a complex ecosocial system. The trajectories of individuals' participation in the community as a whole, in the ecosocial system, trace out

these networks, from activity to activity, from CoP to CoP, partly constrained by existing networks (opportunities, policing) and partly fashioning in their very biographies new connection and links that others may or may nor recapitulate. Individual identities are constructed across the whole trajectory of participations, but not necessarily equally in each activity oe CoP (Lemke 1997, page 43/44).

Stephen Fox also argues that systems theory, in particular Actor Network Theory, helps to address some of the possible deficiencies in the ideal community of practice model. In particular he points to the possibility of the development of a fuller account of the role of artefacts, and I would argue by extension the reifications of practices within a learning system (Fox 2000). Actor Network Theory may also help to address the complexity of power relationships within learning networks (Fox 2000). I address these issues more fully in the next chapter.

Jo Boaler and James Greeno use the term 'ecologies of participation' to describe the type of practices that students' participate in and the students' relationships to the practices (Boaler and Greeno 2000). Their notion of ecologies of participation uses categories developed by Holland and associates to discuss social systems in terms of figured worlds, positional identity and authoring (Holland et al 1998). They contrast ecologies of discussion based teaching and ecologies of didactic teaching. In their analysis they investigate the way in which different sorts of practice allow for and engender different forms of participation which are reflected in contrasting figured worlds of participants, mathematical identities that the students author[1].

I believe that thinking ecologically allows the complexity of formal institutionalised learning situations to be embraced. I suggest that social organisations in which learning takes place are best understood as *ecologies of practice*. The notion of an ecology of practice points to the way in which social organisations have more or less open boundaries in which the practices of the social organisation are linked and interdependent with other ecologies.

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[1] I developed the concept of ecologies of practice before becoming familiar with this particular piece of Boaler and Greeno's work. The use of the term ecology in my work serves to stress other aspects of classroom practice, for example the way in which ecologies have mechanisms for system maintenance and can be investigated in terms of the boundedness of the ecology.

The actors in an ecology of practice need not only be the human participants, but also the reifications of practices (physical or cognitive) and importantly the practices themselves. Thinking of the social organisation as an ecology focuses attention on the possibilities of emergent phenomena. Moreover, within a social group that is organised or organises itself for a particular purpose the existence of a variety of overlapping sets of practices is emphasised. At particular moments particular sets of practices will come to the fore as the purposes and positioning of the participants changes. Negotiation and contestation may occur around which sets of practices are foregrounded.

In community of practice theory, multimembership of communities explains the difference in people's trajectories within the community. The idea of ecologies of practice places the location of each individual in a complex web of different ecologies at the centre of a person's sense making of their experience of those practices.

Thinking in terms of ecologies also avoids the use of the term 'community' for social groupings that experientially are not very communal at all. It also avoids the universalisation of community of practice theory to social groupings such as the family that Wenger (1998) suggests are communities of practice but are very different, at least experientially for participants, to the apprenticeship learning situations.

One risk in broadening the description of learning networks and the social formations that arise through participation in social practices is that such a general description may have little analytical value with all and anything being describable as an ecology of practice. However, an ecology of practice has a number of features that are similar to communities of practices, though these are less prescriptive and more fluid. Any ecology of practice is situated in a local context (though this may or may not be geographically located) that has identifiable boundaries for the participants. The ecology has a history over a period of time, though this may be much shorter than that supposed within community of practice theory. As in a community of practice there are shared ways of doing things, though these are not necessarily indigenously produced. The ecology has various enterprises that reflect the diverse purposes of the participants. The existence of a single joint enterprise, in the case of a community of practice, is a particular case that is only one possible configuration.

Similar questions can be asked about particular ecologies of practice as communities of practice, for example the nature of sociality, the nature and diversity of enterprises, the

193

forms of participation, the extent to which different participants experience mutual engagement and the extent to which the shared repertoire of practices is indigenous or is an expression of a wider set of practices, relations of rank and power within the community, and the possible trajectories of identity. In the last piece of this chapter I compare some of the forms of ecologies of practice found in school mathematics classrooms with communities of practices. However, before turning to this question I focus on the nature of participation in usual school mathematics.

CHAPTER FIVE, THIRD PIECE: PARTICIPATION AND USUAL SCHOOL MATHEMATICS.

Legitimate peripheral participation and usual school mathematics

To recap on Chapter One, in the early formulation of community of practice theory Lave and Wenger contend that the form of participation is legitimate and peripheral (Lave and Wenger 1991). The term legitimate stresses the fact that to be part of the community the participants are actually engaged in the social practices of the community in a way that is recognised as appropriate and meaningful by the community. 'Peripheral' is a positive term that suggests relatedness and relevance. In Wenger's later account the term has less importance, instead Wenger stresses the more general active nature of participation (see Wenger 1998, pages 55-57). However, where he does discuss legitimate peripheral participation he expands on the discussion in earlier formulations to stress that peripherality:

> ... provides an approximation of full participation that gives exposure to actual practice. It can be achieved in various ways, including lessened intensity, lessened risk, special assistance, lessened cost of error, close supervision or lessened production pressures...To open up a practice, peripheral participation must provide access to all three dimensions of practice: to mutual engagement with other members, to their action and their negotiation of enterprise, and to the repertoire in use. No matter how the peripherality of initial participation is achieved it must engage newcomers and provide a sense of how the community operates (Wenger 1998, page 100)

In the institutionalised settings of school mathematics the form of participation expected of students in usual school mathematics classrooms, is not peripheral in Wenger's sense. The accounts of the learners participating in teacher questioning practices in Chapter Three, the account of Louise's lifeworld in the previous chapter, or the descriptions in the literature of the experience of usual school mathematics do not suggest that there is lessened risk, cost of errors or pressure.

It might be thought that the funnelling practices of school mathematics or the way in which procedures are articulated as fragmented algorithms are examples of close supervision or special assistance, but the essence of the practices are to participate in these funnelling practices or fragmented procedures; this is what school mathematics is. The lack of joint enterprise and mutual engagement underlie the lack of legitimate peripheral participation.

In order to describe the forms of participation in regimes of practice such as school mathematics and in other ecologies of practice (and so to have an indication of the extent to which they are communities) we have to look more deeply into the meaning of participation and what it is to participate.

The meaning of participation

In Lave and Wenger's account the focus of the meaning of participation is on the characteristics of the nature of participative social practices. Wenger (1998) argues that participation is a condition of engagement in social practice and is always "active". This is certainly true in a general philosophical sense that the basic condition of human life is social (Heidegger 2000/1926). However, this abstract meaning of participation is the necessary condition on which participation, in the sense in which I discuss it in this chapter, can develop (Ashworth 1997b). It may be helpful to distinguish between weak and strong meanings of participation here. The weak meaning of participation indicates the way in which we participate in social practices in virtue of being in the world. The stronger meaning points to active and full engagement in social practices. 'Participation' here echoes the idea of a participatory world-view (Reason 1994a, 1998b). I believe that a central theoretical weakness of Lave and Wenger's account is to fail to distinguish between these different senses of participation.

Wenger draws on the common usage of participation as meaning to have or take part or share with others in some activity or enterprise. However, there are different ways of taking part. David Bohm distinguishes two aspects of the meaning of participation as "taking part in" and "partaking of a particular event" (Bohm 1996, page 86). When we 'do' a social practice we necessarily are taking part in it. However, we may not be partaking of it in the sense of sharing in the same meaning of the practice. This distinction is echoed in the difference between a participant and participator. A participator suggests someone who is an actor and contributes to the form of the activity and so is a co-constructor of the practice. It is possible to be a participant without being a participator. When this occurs there is a more passive form of participation: somebody who is only at the effect of the event or accommodates to the practice[2]. One student in a study by Jo Boaler puts this succinctly:

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[2] Note that the form of participation and engagement cannot be read simply from the amount of observed 'doing' of the practice. Participants may be very still or silent but still be highly engaged and partaking of the shared meaning, where others may be very active, and doing much but the meaning of the practice is not shared.

...well actually as soon as the classroom starts you don't really know anything, 'cause you've switched off. You walk in and you think, 'Oh another boring lesson' and you're off. As soon as you've walked out, you've forgotten about that lesson. (Year 11 Student quoted in Boaler 1997, page 34)

In Chapter Three, I discussed the way in which participation in a social practice may mean very different things in different lifeworlds. Louise's lifeworld, discussed in the previous chapter, demonstrates the way in which not only social practices such as answering questions in class may have different meanings for participants in the practice, but that more explicitly mathematical practices or reifications may not have the same meanings nor be ontologically the same in different lifeworlds.

The meaning of participation for the participants in community of practice theory is developed from the notion of social legitimacy and trajectories of social identity. By stressing the social aspect of the social-lifeworld duality, Lave and Wenger tend to underplay the importance of meaning of participation in the lifeworld of the participants.

Peter Ashworth gives a phenomenological account of participation developed from a reading of an account of participation in what is, in Lave and Wenger's terms, a community of practice of nurses. This account describes essential features of what it is to participate fully or through legitimate peripheral participation in a community of practice. These features are: attunement to others stock of knowledge at hand; emotional and motivational attunement to the group's concerns[3]; taking for granted (and implicitly assuming the others take it for granted) that one can contribute appropriately; being able to assume that one's identity is not under threat (Ashworth 1997b, page 82).

These features, arising from research in a very different methodological paradigm, parallel some of Lave and Wenger's categories. The first three of Ashworth's features echo the notions of a shared repertoire, mutual engagement, and legitimacy. However, the fourth of Ashworth's categories differs markedly from Lave and Wenger's treatment of identity. In Lave and Wenger's account participation in social practice in which there is a shared repertoire, mutual engagement and legitimacy, leads to a trajectory of identity of fuller identification with the community. Although Wenger recognises that multi-membership of different communities requires an on-going negotiation of identity (Wenger 1998), Ashworth points to the way in which our relations to others are

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[3] Ashworth like Lave and Wenger, points out that such attunement still leaves space for conflict.

ambivalent and arise not only from social practices but our own personal concerns. Invoking Sartre (1969) and Goffman (1971) he argues that participation in particular situations must be read against a personal concern for presentation of self to others and maintenance of existing identifications. Such a concern is stressed in Set A's account of reasons for unwillingness to participate in teacher questioning practices discussed in Chapter Three, in Louise's lifeworld and also in the accounts that follow in subsequent chapters of students' participation in classroom social practices.

He concludes that there are two conditions for participation. Firstly, that the participant needs to be able to put aside the deep existential anxiety of "being exposed to the objectifying gaze of others". Secondly, to feel sufficient safety to overcome the "Goffmanesque anxiety due to the harried performers' concern to manage the impressions of others, and to the awareness that these typifications are moral matters – matters to do with their 'worthiness'" (Ashworth 1997b, both quotes, page 100)[4]. Participation requires one to be able to "suspend a central or thematic concern with the self which is being presented" (Ashworth 1997b, page 99).

In Louise's lifeworld of mathematics, her participation in the social practices is focussed on a central and thematic concern for the self. Of course, if this was only true for Louise, we might conclude that her lifeworld shows that she is an outsider to the supposed community of school mathematical practice. However, I believe that the relationship of the students to teacher questioning practices, interviewed in Chapter Three and the body of literature on students experience of school mathematics suggest that such a concern is central to many, if not all who are subject to the practices of usual school mathematics. The reason it cannot be put aside is precisely because school mathematics and particularly questioning practices, whether it be through intention or as by product is concerned with regulating the self. The experience of school mathematics, is one of being measured and measuring.

The lack of possibility of engagement in participation in Ashworth's sense or in Lave and Wenger's terms, legitimate peripheral participation means that usual school mathematics classrooms are not communities of practice. They are better understood as constituting a *regime of practices*. A regime of practices points to the ways in which the participation is predominantly passive and non-communal. The notion of a regime of practices echoes the poststructuralist concept of a discursive regime in which

practices are regulating and normalising (Walkerdine 1997). However, I intend the term to convey the way in which a wide range of practices and their reifications are productive of the phenomena and lifeworlds of the social grouping rather than giving ontological priority to discourse.

Dimensions of participation

Up to this point I have focused on participation as a binary dimension to emphasise the way in which actors can take part in practices without experiencing participation, or partaking of, the practices. However, in the complex interaction of practice, identity and other aspects of the lifeworld, our choices of how we participate in social practices is rarely as simple as participation or non-participation.

Participation is a multi-dimensional way of being in the world. Some possible dimensions or qualities of participation include: the extent to which public participation reflects involvement in the private lifeworld; degrees of enthusiasm and interest; imposed or forced participation and voluntary participation; appreciative or critical participation; the extent to which the concern with the self can be put to one side; and the degree of emotional, intellectual or embodied involvement and there are many others.

It is not my intention to develop a full taxonomy of different degrees or forms or degrees of participation. The boundaries in such a taxonomy would be endlessly redefinable. Moreover, such taxonomy would be of little use for "real time" (Reason and Torbert 2001) research or teaching in which decisions are made in relation to others actions. However, I believe, that it is worthwhile to offer an alternative category to 'legitimate peripheral participation' that better describes the form of participation in usual school mathematics regime of practices. To describe this form of participation I use the term *marginal participation*.

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[4] Compare with the quote from Wenger earlier about the importance of security and lack of threat as a precondition for legitimate peripheral participation.

Marginal participation

In an account of her experience of training as a teacher, Diane Hodges describes her alienation from the community of practice of teaching as arising from her previous historical location and identity as a person marginalised by "heteronormative practices" and concern with relations of power. She argues that:

> Marginalization is not negotiable and does not lead to more inclusive practices; rather marginalized persons are always outside the dominant social structure. Thus those who are marginalized by a dominant social order will indeed participate differently from members who have not constructed themselves historically on the basis of social exclusion...To participate peripherally, in other words, is to participate legitimately/inclusively within the community of practice. Marginalization, as a larger social effect, can be structured into participation in a community of practice manifesting itself as repetitions of alienation and isolation (Hodges 1998, page 285).

Hodges is concerned with exploring the range of possible forms of participation (or non participation) within a community of practice. However, I contend that *marginal participation* is the normal form of participation for students in the school mathematics regime of practices. Participation is marginal, because the students find themselves on the outside, they are not involved in the production of the practices. Moreover the practices may appear to be alien to them, for example Louise's description of mathematics as male or in Jo Boaler's account "from another world" (Boaler 2000). Certainly the language and routines of school mathematics arose through and are bound up in very particular social and class formations that are alien to many learners of mathematics in schools.

Their relationship is also marginal because of the extent to which the practices of school mathematics are marginal to their lives and concerns. This is true both in the sense that it is something they have to do rather than choose to do and only impinges on their lives to a limited extent but more so in the sense that the students' purposes whilst engaging in the practices are only tangentially related to learning school mathematics.

Marginal participation, like legitimate peripheral participation, is not necessarily uniform. Reflection on the trajectories of identity and participation both in school mathematics and in schooling generally indicates the extent to which some are more

marginalised than others. Some of this is related to students' more general marginalised positions by gender, race, class and other identities (see for example Boaler 2000; Anderson 1997; Walkerdine 1997; Zevenbergen 2000). In school mathematics a crucial aspect of marginalisation relates to student's historical location in the regime of practice due to assessment measures; put simply whether or not they succeed or fail. This is not only related to the history of students or background but also as Ole Skovsmose points out to the foreground of the students; what in the future they might reasonably expect to become (Skovsmose 1994). For some students success in mathematics is a passport to future academic or vocational identity and the procedures of mathematics may themselves be more relevant to these students' foregrounds (see Boaler, Wiliam and Brown 2000).

Although I do not have space to develop these points here, I believe the concept of marginal participation is potentially very useful for interpreting the forms of participation, classroom practices and student in different sets and class situations (Boaler 2000; Boaler, Wiliam and Brown 2000)

I wish to put forward a further point that is somewhat speculative and would require empirical investigation. I have characterised usual school mathematics as a regime of practices rather than a community of practice. I have indicated that the concept of a regime of practices is an ideal type and not necessarily one that is found in many or any school mathematics classrooms. Rather it typifies the essential nature of usual school mathematics. I suggest that the situation is somewhat more complex than that.

Some students have backgrounds and foregrounds and a history of success in school mathematics that means that their participation in the school mathematical practices is highly engaged and active, there is a joint enterprise of succeeding academically and a degree of mutual engagement[5]. In such situations, the forms of participation may be much closer to legitimate peripheral participation. Dialectically, it may well be the fact that the student's experience of participation is peripheral rather than marginal that may help to explain their greater success. This rests on an assumption that peripheral participation leads to greater knowing in practice than marginal participation[6].

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[5] Though this sense of mutual engagement may only be with the teacher and some of the other individuals within the class rather than a sense of mutuality within the class.

[6] Note that the concept of marginal participation does include the idea of learning in practice. The concept of marginal participation helps to answer the question raised by Anne Watson and Peter Winbourne, discussed in Chapter One, that in some sense school mathematics classrooms must be

Diane Hodges argues, from her own experience, that one response to communities of practice is nonparticipation when dis-identification occurs:

> Nonparticipation constitutes an identificatory moment where a person is accommodating in participation and yet is experiencing an exclusion from any "normative" or unproblematic identification with practice (Hodges 1998, page 272-273).

The non-participation that Hodges identifies here is "accommodating", that is the participant continues to ostensibly take part in the practices:

> I propose there are "lags" in participation, when a person is engaged in "doing" and yet is withdrawing from an identification with the practice. In these instances, identification is in relation to the practice but invokes an "agonized compromise" within the community (Hodges 1998, page 279).

Such non-participation is passive, the person continues to do the practice but from a withdrawn and disengaged attitude.

In subsequent chapters, I discuss more active forms of non-participation in the mathematics class that I have called Seven Blue, where non-participation or at least contested participation in questioning practices is shown through engagement in other non-legitimate practices. Hodges also importantly points here to the way in which there is not a simple causal relationship between "doing" the practice and identification. This is important in understanding and as an argument is reinforced by the dis-identification with mathematics of many learners in spite of their success both inside the classroom and in assessment in taking part in the practices of school mathematics (Boaler 1997b; Boaler and Greeno 2002).

However, in a regime of practices such as school mathematics, the normal form of participation is marginal and dialectically connected to this is the experience of alienation. Learners' alienation is not a contingent by product of the practices or a failure on the part of the learner to take part in a supposed community of practice but

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communities of practice because learning takes place even when local communites of practice are not present (see Chapter One and Winbourne and Watson 1998a,1998b). An additional reason is that the type of relationships between learners and teacher and learners found in local communities of practice may be more widespread in school mathematics classrooms. In individual interactions between teacher and students and between students themselves, peripheral participation occurs.

rather is at the heart of the nature of usual school mathematics. Such alienation arises from the lack of mutuality and joint enterprise in the class.

The concept of regime of practices may be useful in understanding the patterns of participation in relatively stable situations in which the practices of usual school mathematics dominate. However, it is not a good description of many school classrooms, particularly those in which there is a great deal of dis-identification from those practices and resistance to them[7], or in situations in which the practices are in the process of formation. In such situations considering the classroom as an ecology of practice allows the influence of the practices the participants bring with them, and the contestation between different sorts of practices to be identified. In Chapter Six, I describe some of the features of one such an ecology.

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[7] I suggest from my experience that in many school classrooms such a situation exists.

CHAPTER FIVE, FIFTH PIECE: COMPARING ECOLOGIES OF PRACTICE

Types of ecologies of practice

At this point the use of the term, ecology of practice, is something of a placeholder, proposed as one means of overcoming the fact that school classrooms do not have the features of communities of practices. The nature and functioning of different ecologies is an empirical question. However, it is possible to identify four different sorts of ecology based on the literature so far discussed: communities of practice, usual school mathematics regimes of practices, local communities of practice and learning communities (see Chapter One for discussion and references).

The detail of description in the literature varies, so for example, Lave and Wenger describe communities of practice in detail, whereas local mathematical communities of practice is a more recent and little researched analytical tool. In some cases there is a lack of detail about particular criteria. Thus the discussion that follows is necessarily somewhat speculative and involves in places 'filling in the gaps'. Nonetheless I believe it to be worthwhile, not least as a potential framework for further research.

A further caution relates to the difference between what has been proposed about particular formations and what may actually be the case. In the following discussion I assume that the theoretical analysis Lave and Wenger give of communities of practice is accurate. However, in Chapter One I reviewed a range of literature that argues that the theory requires revising in certain respects and in this chapter my discussion of the nature of participation is applicable to community of practice theory. What may be seen more clearly in ecologies of practice that are not communities of practice may also apply to communities of practice. The description of usual school mathematics as a regime of practices is a typified account, which does not allow for the way in which, in such ecologies, examples of more indigenous practices related to the particular teaching style and constellation of students may arise.

I discuss the four different ecologies in relation to the following criteria: forms of participation; sociality; nature of the enterprise; authority/power/rank; patterns of identification; trajectory of identity; origins of practices and repertoire;

boundaries; and questioning practices. This comparison is summarised as a table at the end of the chapter.

Communities of practice

Community of practice theory was developed from studies of apprenticeship learning. The form of participation is legitimate and peripheral. The sociality of the grouping is as a community in which mutual engagement, joint enterprise, and shared repertoire are found (Wenger 1998). Relationships of authority, power and rank are triadic with three identifiable positions, that of newcomer (apprentice), established member (journeyman) and old-timer (master). Power and authority are based on the length of time in the community and presumably on the level of ability to engage legitimately in the practices of the community and knowledge about those practices. The patterns of identification within the community are generally homogeneous; participants identify with the community. Where they do not identify this leads to non-participation. The trajectory of identity and participation and so of learning is also homogeneous from newcomer to old-timer. Individual identity is formed through a process of negotiating tensions that arise through multi-membership of communities. The origins of practices and repertoire within the community are indigenous. Even when practices are introduced from the outside or necessitated due to external effects on the community the particular form the practices take in the community are negotiated[8]; practices are local. The community of practice has clear boundaries, though these may not be institutionally or formally recognised. The community may be part of and linked to wider constellations of practices (Lave and Wenger 1991 and Wenger 1998).

Questioning practices in a community of practice are 'everyday', genuine attempts to elicit information or views. Substantive questions about the practices of the community are more likely to be asked by newcomers of established members or old-timers (see Chapter Three).

Usual school mathematics regime of practices

The regimes of practice of "usual school mathematics" (see Chapter One) differ from communities of practice in important respects. They originate in a different way and people become part of them differently. In communities of practice the development of

205

the community is organic with people joining over a period of time. The grouping in a school class regime is generally created by an act of power over the student participants through assessment processes (and in some situations over the teacher participant).

In considering forms of participation in a school mathematics regime of practice it is important to distinguish between the participation of the teacher and students. Indeed it is the distinction between the different forms of participation and enterprise that is crucial to understanding the school classroom as an ecology of practice. The teacher is engaged in two different sets of social practices. Firstly, they are engaged in the social practices of teaching school mathematics. In their engagement in these practices the teacher is a participant in an ecology of practice external to the particular class and one the students are not part of, that is the ecology of mathematics teaching practices. It is this ecology and ones connected to it, such as the school, with which the teacher most identifies and from which the enterprise and purposes derive. The practice of questioning the students is part of this practice and one that is concerned primarily with managing the lesson and assessing students' knowledge (see Chapter Three).

Part of the social practice of teaching school mathematics is to demonstrate school mathematics procedures. Thus the teacher is also engaged in the social practices of school mathematics, but they do so as a means to conduct their primary enterprise of teaching school mathematics. The participation of the teacher is legitimate and peripheral with respect to the community of practice of mathematics teaching. The students' participation in the regime of practice is often marginal.

It might be thought that when the teacher demonstrates the practices of school mathematics they are, at this point are engaged in the same practices as the students. Temporarily, they act as an old timer to the apprentice students. However, this is not really the case. The meaning in the lifeworld of the practice for the teacher and student is different. The practice cannot be separated from context and purpose.

The sociality of a regime of practice is not communal. Firstly, the teacher's primary relationship in terms of participation with the practices is to communities of practice the

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[8] Wenger gives examples where the claims processors he studies are required to adapt their practices due to new requirements of the organisation they are part of. However, he describes how the actual practices are altered and shaped in the local context of the community.

students are not part of. Thus the identification of the teacher is with the community of school mathematics teachers[9].

There is a lack of mutuality between the teacher and students. Moreover, there is generally a lack of mutuality between the students themselves. The students' primary relationship in terms of the social practices is with the regime authority, the teacher. Effectively, there is an individual relationship between each student and teacher. The social practices of school mathematics rank the students. This ranking occurs both through the assessment practices but also through on going practices. Students are active participants in this process, measuring themselves and each other. These rankings are also relatively stable and for the students who do not choose non-participation as a strategy comes to the centre of the students' enterprise.

Regimes of practice are essentially hierarchical with positions in the hierarchy in terms of the teacher and student roles being unchangeable. The teacher has social and mathematical authority. The students' possible trajectory of identities is complex and dependent on their historical and cultural location and importantly on their mathematical histories. Jo Boaler and James Greeno argue that part of being successful at school mathematics requires identification with the teacher and with the 'figured' world of school mathematics (Boaler and Greeno 2000). However, such an identification does not mean that there is an intention on the part of most to become a teacher of school mathematics. Where students' choose not to make this identification (and it appears that this is in the majority of cases) their experience is one of disaffection (Nardi and Steward 2003) and alienation (Boaler 2000). The students' trajectory is most importantly to success or failure. This occurs both in the day to day classroom experience assessment and ultimately in national tests.

The practices of the classroom are generally not indigenous. They are instances of a universal regime of school mathematics practices. Important factors or forces in the reproduction of practices are curricula, textbooks, and forms of assessment and school mathematics as a set of social practices. A school mathematics regime of practices is one in which disaffection and alienation does not manifest itself in the contestation of the practices to the extent that the social practices of school mathematics are much disrupted. In this sense the regime has strong boundaries in which the importation of

[9] In Chapter Six, I discuss Jill's lifeworld and indicate the extent to which this can constrain actions for the teacher.

other practices is not tolerated[10] and may be punished. Paradoxically, although school mathematics practices are strongly bounded and resistant to the importation of non school mathematics practices they are examples of universal practices, and so it is possible to go to other classrooms and see very similar practices.

Usual school mathematics regimes of practice are stable, resistant to change and ossified. However, it is worth noting that participants in usual school mathematics regimes of practices come together in most secondary schools and when working in sets temporarily for the duration of the mathematics lessons[11].

Questioning in the usual school mathematics regime of practices has already been described extensively in Chapter Three.

Local Mathematical Community of Practice

A local mathematical community of practice is characterised as a temporary formation that may arise within a school mathematics classroom. In Chapter One I quoted Peter Winbourne and Anne Watson:

> Such communities may be local in terms of time as well as space: they are local in terms of people's lives; in terms of the normal practices of the school and classrooms; in terms of the membership of the practice; they might 'appear' in a classroom only for a lesson and much time might elapse before they are reconstituted (although it may be possible to detect the subtle effects of the echo that remains after their passing in the trace of learners' trajectories or the development of other practices) (Winbourne and Watson 1998, page 94/95).

In the following description I draw on their description and my observations of the emergence of local communities of practice in Seven Blue and other of Jill's lessons.

Participation in local communities of practice is active. Often they arise as a result of engagement with the particular focus of inquiry or learning, thus there is a sense of curiosity and interest. Participation is legitimate and peripheral with the teacher and sometimes students acting as an old-timer to other learners similar to that found in longer standing communities of practice. The students and teacher work purposefully together; there is mutual engagement and a joint enterprise. Although arising in the context of a regime of mathematical practices or more complex ecology of practice in

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[10] In extreme case this lack of tolerance is not just of social practices of for example the students' external social lives but also mathematical practices found in other contexts.
[11] It is more complicated than this short description describes.

which social authority is held by the teacher, in a local community of practice students may exercise mathematical authority or at least be regarded as credible contributors to the development of practice. Although the practices developed in the local community may be part of the more generalised practices of usual school mathematics, within the lifeworlds of the participants they have the quality of feeling indigenous and that a shared repertoire is developed. There is a shared and homogeneous sense of community ('working together').

Given the local nature of the ecology, the trajectory of identity is not from newcomer to old-timer or an equivalent there of, but rather in a public and shared recognition of developing competence. The boundaries of the community are fragile, and are constituted by voluntary and temporary mutual engagement. A local community of practice is by definition an unstable formation, though subtle and continuing effects may detected.

Questioning in a local community of practice differs from a regime of practice in that questions are likely to be genuine ones. Questions by the teacher are likely to be scaffolding rather than funnelling. There is a different quality of listening and attention given to others by participants. A conversation in Gadamer's sense occurs. An additional feature of a local community of practice is that there is a possibility of surprise or unexpected events.

Learning communities

A learning community is constituted by placing learning at the centre of its practice (see Rogoff et al 1996; Wenger 1998). In the context of this study on formations found in school mathematics classrooms in the UK today, I consider a classroom learning community to be a hypothetical rather than an existing phenomenon. The description of the learning community that follows has two sources within the mathematics education literature[12]. Firstly, it extends the notion of a mathematics class as community of inquiry (see Cobb et al 1992, Cobb and Yackel 2000; Cobb, Wood and Yackel 1990; Wood 1994) by democratising the way in which the social practices of the classroom are developed. Secondly, it extends and develops the concern for participants to have the "space" to express and be present through a wider range of identities than narrowly constructed notions of the mathematics teacher or mathematics student found in the

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[12] The essential features of learning communities as described here do have rich and influential antecedents (see for example Rogers 1983)

notion of "spacious mathematics" (Angier and Povey 1999). It also develops descriptions of "author/ity in practice" which point to the possibility of:

> mathematics classrooms in which learners are the author/ity of knowledge, they have the opportunity to use their personal authority both to produce and to critique meanings, to practise caring in a dialogic setting where the effectiveness of their own narrative(s) and also those of others is refined (Burton and Povey 1999, page 237)

The description of the learning community also draws on the description of the groups that arise through co-operative inquiry (Heron 1992; Reason 1988, 1994a, 1994b, 1998; Reason & Heron 2001) and from my personal participation in affinity groups in social activism.

A learning community is a particular form of community of practice. Participation is active. I characterise the form of participation in learning communities as co-reflective in the self-awareness of the community as a community. Where learning is consciously the enterprise of the community the nature of participation changes. The sociality is as that of a community of diverse equals and is consensual. Authority is heterarchical rather than hierarchical with members demonstrating reflexivity about rank and status. Authority roles are shared and changing. Patterns of identification are homogeneous with strong identity within the group. There is a reflexive awareness of multi-membership of other communities that is used positively for the benefit of the community. The practices of the community are themselves subject to dialogue. Such a community is stable though the practices are fluid and dynamic. Questioning in such a community is reflexive.

Ecologies of practice compared

The four different ecologies of practice described, serve as heuristic categories for understanding the different forms of participation in school mathematics classrooms. In particular they act as reference points in the next two chapters to describe the different patterns of participation in Seven Blue, a more complex and changing ecology that shares features of all of the different categories. Below, I summarise the features of these different types of learning formations. The dimensions I use are taken from community of practice theory (with the addition of 'questioning patterns). Regardless of the limitations of the concept of 'community of practice' the form of analysis found in community of practice theory is helpful.

210

The table summarises this chapter. It helps to bring out starkly the way in which in usual school mathematics regimes of practices the differences between the purposes, focus of engagement and enterprise of the teacher and the students. When a local community of practice is enacted the nature of relationship changes to include a sense of mutual purpose and inquiry. In a learning community this is extended so that the 'teacher' disappears as separate category (this is not to say that 'experts' or 'experienced members' do not have particular roles or functions in such a community but this a wider question that I can deal with here).

If we wish to enact local communities of practice or indeed learning communities than one means to do this is to foster the sort of participation, sociality and so on that can help to bring this about. In the next chapter, I explore what sort of social practices occur in different sorts of ecologies.

Features of ecologies of practice

The danger with summarising in a table in this way is that the lines that form the rows and columns suggests that the world can actually be divided up into neat parcels in this way and that each part is completely distinct and separate from the other

	Community of practice	Usual school mathematics regime of practices	Local mathematical community of practice	Learning communities
Forms of participation	Legitimate and peripheral	Teacher: Legitimately peripheral to school mathematics CofP. Student: marginal participation or non-participation	Legitimate peripheral participation	Co-reflective participation
Sociality	A community: mutual engagement, shared repertoire	Teacher: Separate from students. Authoritarian. Students: Predominantly individual relationship to practices and others. Prime relationship to regime authority – the teacher Isolation	Working purposefully together: mutual engagement	Consensual, co-reflective, community of diverse equals
Enterprises	Joint enterprise that defines the community of practice	Collective enterprise centred on ranking and comparison.	Shared mathematical enterprise – including the teacher focussed on mathematical activity	Learning
Authority & rank	Triadic – newcomer, established, old-timer	Hierarchy. Most authority held by the teacher. Students ranked. Social practices of mathematics have rank and power.	Students exercise mathematical authority during the existence of the local community of practice	Consensual, co-reflective, community of diverse equals Reflexivity about rank and status Authority roles shared and changing
Patterns of identification	Homogeneously with the community	Teacher's primary identity is with community of school mathematics teachers. Students have range of possibilities including dis-identification dis-engagement. Alienation	Temporarily with the class and teacher with shared purpose and practice	Heterarchy. Homogeneous. Strong identification with the group

	Community of practice	Usual school mathematics regime of practices	Local mathematical community of practice	Learning communities
Trajectory of identity	Homogeneous from newcomer to old timer	Students: Success or failure	Public recognition of developing competence	Awareness of changing role within the community Reflexivity about roles taken
Origins of practices and repertoire	Indigenous	Instance of general regime of practices. External School mathematics universal regime of practices	Local within the context of more universal school mathematics practices	Indigenous
Boundaries & stability of practices and community	Bounded through shared practices, linked to constellations of practices Stable but evolve over time	External School mathematics universal regime of practices Stable, resistant to change Ossified	Bounded through temporary mutual engagement Temporary and local Subtle continuing effects	Reflexivity about multimembership of other communities Stable but practices are fluid and dynamic
Questioning patterns	'Everyday' questioning patterns. Questions to elicit information. Questioning of expert by novice	Teacher asks the questions to test assess, manage, control, or funnel students learning. Students do not generally ask questions in whole class situations. Questions are procedural	Questions are genuine, puzzling,	Reflexivity about questioning practices, range of subjects may include emotional states, and about the social practices

CHAPTER SIX

FEATURES OF A SCHOOL MATHEMATICS ECOLOGY
OF PRACTICE

> Many teachers struggle to find ways to enable individual expression
> in the classroom, including expressing mathematical ideas,
> confronting the paradox of teachers giving emancipation to students
> from their authoritative position. But this can fruitfully be seen as a
> dialectic, whereby all participants in an activity manifest powerfulness
> and powerlessness at different times, including the teacher. (Lerman
> 2000b, page 32)

FIRST PIECE: ABOUT THE CHAPTER

In the previous chapter I discussed ecologies of practice and described usual school mathematics as regimes of practices. In this chapter I consider one particular class, Seven Blue, as an ecology of practice developing and changing over time.

In the Second Piece of the chapter, I introduce Seven Blue as a class by describing the research context and giving an overview of the social practices of the class. In discussing Seven Blue in both this chapter and the next, I can only hint at the complexity of individual and group participation in the social practices and on the patterns of formation of identities and purposes of participants. Some of the issues I discuss or touch on have been the focus of much school ethnography (see for example Aggleton 1987; Mac an Ghail 1994; Willis 1977). The brief description and discussion of Seven Blue, cannot substitute for such a sustained ethnographic approach. However, I believe that the material presented here does enrich ethnographic accounts by suggesting a focus on engagement in specific social practices within classrooms as locations for the construction and creation of identity rather than more culturally based accounts. In addition ethnographic studies in secondary schools have tended to focus on older students, here in Seven Blue, we get glimpses of the ways in which identities are being formed in younger students.

In the Third and Fourth Pieces of the chapter I illustrate and discuss some of the features of Seven Blue as an ecology of practice, firstly in the Autumn term and secondly in the Spring Term of the research at North School (see Preface). The contrasting episodes show some of the ways in which the nature and form of the social practices and patterns of participation changed. The lesson used as an illustration in the Third Piece was a situation in which those aspects of Seven Blue's ecology of practice

that were closest to a regime of practices are most manifest. In the Fourth Piece, those aspects of the ecology of practice which showed a trajectory towards a more participative learning community were most manifest (see previous Chapter for a discussion of types of ecologies of practice).

Before proceeding I suggest caution on three points. Firstly, that there is always a danger in selecting material from a single lesson for illustrative purposes. I believe one of the most important and profound metaphors for the teaching and learning process is that of an on-going conversation (Mercer 1995) and thus there is a danger in presenting particular episodes to represent aspects of that conversation. The same metaphor of conversation is also applicable to the research process and the same risk applies.

Secondly, in contrasting the two lessons, it might be supposed that there was some clearly bounded change in practices over time. This is not really the case. In the Autumn term, I observed lessons in which many of the features described in the extract from the Spring lesson were apparent and the reverse was also true. However, between the Autumn and Spring terms, the usual practices did change in a more participative direction. To (mis)use a metaphor from Chaos Theory, in Seven Blue's ecology the regime of practices and a participative learning community, acted as two 'strange attractors' which the ecology sometimes approximated to. As time progressed the more participative practices became a stronger attractor. A discussion of possible reasons for these changes is largely left to the next chapter. My aim here is to both illustrate the change that took place and to use the two lessons from December and February as illustrations of the variety of different sorts of interactions and modes of participation in the class.

Thirdly, these two illustrations tend to evoke a 'before and after' narrative. Such a narrative sits easily with a technical rationalist discourse (Ashworth 1998) in which Seven Blue was a class in need of 'fixing' by application of an appropriate remedy. Such a discourse does not actually fit the messy evolution of the ecology. However, I do make reference to some of the action that Jill took which contributed to the changes between the two lessons and discuss this further in the next chapter.

In the Fifth Piece, I draw together some threads and discuss the extent to which the different features that I highlight in the two episodes are ones that are likely to be shared with other ecologies of practice and revisit some of the themes in the previous chapter when I compared different ecologies of practice.

CHAPTER SIX, SECOND PIECE: INTRODUCING SEVEN BLUE

The Context and Research Methods[1]

Seven Blue, a Year Seven class (eleven to twelve years old) of 23 students, were in the first year at secondary school at the time of the research. The school they attended, North School, is a large 11-18 school in London. The average attainment of students at the school is near national averages with a fully comprehensive range of academic achievement. Students come from a wide range of ethnic backgrounds with a significant proportion of children of asylum seekers and children whose home language was not English.

The school has a gender imbalance with more boys than girls, which is reflected in the composition of the class there being 15 boys and 8 girls. Seven Blue also reflected the diversity of the wider school population, with at least thirteen different ethnic backgrounds represented within the class of 23 students. Year Seven students were taught mathematics in mixed ability classes.

Jill was a committed, hardworking and thoughtful teacher who was deeply concerned about the experience of the children in her classes. I briefly described Jill's approach to teaching and values in the Preface and this is elaborated on in the next Chapter.

The analysis of Seven Blue's ecology is based on participant observation of 12 lessons over a period of three terms. The form of participant observation varied between lessons from being a participant in the lessons working alongside Jill, to more formal observation and note-taking particularly during the first part of the lessons in which there was greater teacher interaction with the whole class (see Preface and Chapter Two). During observations I paid attention to recording the interactions and who raised their hands or volunteered to speak. As a result field notes tended to focus on the more active participants in the class[2]. Abbreviated field notes were copied up as soon as

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[1] Further details of context and methodology are included in the Preface and in Chapter Two.

[2] The possibility of filming the lessons was considered, as this would have allowed more detailed analysis of the practices of those who were not active participants in interactions. However, the use of video raises other concerns about the degree of intrusion into classroom practice. In any case Jill was reluctant for interactions to even be tape-recorded. The question of the impact of observation on what is observed is of course an important one to consider and be aware of. In this regard it is worth noting that the students were used both in Jill's mathematics lessons and in other situations to having observers in lessons taking notes on other occasions due to observations of Jill as a Newly Qualified Teacher, the involvement in a curriculum development project and the use of departmental peer observations for developing classroom practice. In addition conversations and interviews with Jill support my belief that the practices described in the two lessons in this chapter were usual for Seven Blue's mathematics lessons during the two periods.

possible after the lessons, usually immediately afterwards and this was the case in the two lessons discussed in the Chapter.

In addition I conducted interviews with 10 boys and 7 girls in 5 single gender groups (3 groups of boys and 2 groups of girls) using focus group methods (Denscombe 1995; Morgan 1997; Vaughan, Shumm and Sinabug 1996). Participants in the interviews were volunteers, with four of the groups choosing their own composition and the fifth consisting of boys who did not normally sit or work together in class. Children in the groups represented a full range of the different ways students participated in the social practices of the class. The interviews were semi-structured. One particular and unusual feature of the interviews was my attempt to create a dialogue using earlier research material as a means to generate discussion within the groups. This material included views of the Year Eight class discussed in Chapter Three, interview material about the experience of adult learners such as Louise, and research material gathered at North School. In addition students were given a sorting/ranking exercise about teacher questioning interactions similar to the one described in Chapter Three. Interviews were tape recorded and transcribed.

In Chapter Two I described the methodological approaches that guided the analysis of this material. The discussion and analysis presented in this Chapter is based on the whole corpus of material gathered and on the lived experience of working with Jill as she effected changes in the social practices of the class. The two extracts from lessons have been selected to best illustrate this analysis.

Mathematics at North School

As in any state secondary school the school followed the national mathematics curriculum, which emphasises knowledge of facts and algorithms. At the current time, the preparation for national assessments is an important and regulating influence on classroom practice. Thus the actual mathematical practices that the students were required to engage in and learn were developed in the context of the regime of school mathematics practices.

The mathematics department schemes of work for Year Seven were based on the National Numeracy Strategy Framework suggested programme of study. This had been introduced at the start of the academic year during which the research was conducted. Although, the schemes were based on the framework, it was only during the course of the year that the department began to collectively explore and experiment with the three part Numeracy Framework lesson structure.

217

The Head of Mathematics in the school was innovative and encouraged all members of the department to explore and develop novel and alternative practices. For example, in the usual school mathematics classroom, one particular textbook or commercial scheme are often used to the exclusion of other resources. In North School most departmental members used textbooks as a flexible resource. The department had a strong sense of identity, supportive relationships, regular peer observation, team teaching, sharing of resources and ideas, and lively discussion of teaching and learning issues. In many ways it fits with the discussion of archetypal communities of practice and moreover itself has features of a learning community.

An important feature of departmental practice was the use of lessons produced by the Cognitive Acceleration in Mathematics Education (CAME) project that were used with Seven and Eight classes (Adhami, Johnson & Shayer 1998). The use of lessons was supported by on-going professional development and involvement in the CAME project. CAME lessons are scripted lessons that focus on the development of what are seen as key concepts and forms of reasoning ability. The principles of CAME are developed from a Piagetian approach to intellectual development. With regard to classroom practice the approach to learning also draws on Vygotskian notions of scaffolding and the importance of social interaction and discussion. The lessons are process orientated in that they are described to students as "thinking maths lessons" and any recording the students do during the exercise is deliberately discarded at the end. Students experienced these lessons once every few weeks.

The extent to which CAME lessons actually included the social and mathematical practices aimed for varied. However, often during these lessons, classes observed showed features of a local community of practice (Wimbourne and Watson 1998a; 1998b). Moreover in the explicit reference to and reflexivity about forms of social practice, participation and learning the students were engaged in, these lessons had some of the features of communities of inquiry or embryonic learning communities (Goos, Galbraith and Renshaw 1999; Rogoff, Mustov and White 1996; Wenger 1998).

The CAME lessons and approach influenced both Jill's and other members of the department's classroom practice more widely. Part of the departmental discourse or shared repertoire was to talk of "camey" type lessons to indicate similar investigative and discursive approaches were used.

Jill's influences and values

One issue I discuss later is the extent to which the ecology of the classroom was not simply a direct consequence of the social practices that Jill attempted to foster, encourage, negotiate, or indeed, impose during Seven Blue's mathematical lessons. Moreover, those practices themselves showed a multiplicity of influences and concerns.

An important factor was that Jill was a Newly Qualified Teacher. As such Jill was immersed in an intense experience in which every working day was filled with novel events. As a Newly Qualified teacher Jill was exploring what practices worked for her and for the students. Below I write of Seven Blue as a changing ecology, and I would contend that as class comes together and begins to get a sense of 'groupiness' regardless of how participative or communal it may or may not be, there will be change of some sort (even in the most rigid and static regimes). However, as a Newly Qualified Teacher Jill was actively engaged in exploring and trying out different practices that would not necessarily have been the case with a more established teacher[3].

Although Jill was a Newly Qualified Teacher, she was somewhat unusual or exceptional in her degree of reflexivity about her own practice and about teaching and learning more generally. Moreover, she had experience of teaching in informal settings in a project located in a South African township.

Jill was deeply committed to fostering enjoyment of mathematics, was critical of the constraints of the curriculum. Talking specifically about lessons at North School and the activities that the children were doing, she said:

> they're not necessarily doing mathematics they [just] have to do these certain things…you can bring in doing mathematics in some of your classes

> The curriculum has so little in it you teach the same things over and over again. You look in the modules and you think 'Oh I'm teaching this to year Seven and year Eight and to Year Nine and I wonder where the new stuff is

> I don't know if I am in a position to question that but I do question the wisdom of it. If we are really trying to teach them how to be mathematicians then we should be giving them new stuff all the time and not worrying about what they remember but be more concerned about the process…they can't do it in year seven so we teach it again in year eight and in year nine and each time you teach it maybe it gets a bit harder but basically it's the same stuff…

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[3] Though some of the aspects of Jill's experience of seeing what worked for her and for her students might be shared by a more experienced teacher moving schools or even beginning to teach a new and unfamiliar class.

...maybe that's why kids say maths is boring cause "we turning fractions into decimals again and I still can't do it" (Quotes from interview February 2001)

Asked to imagine an ideal lesson, free from the constraints of the curriculum

> Ideally it would involve them discovering some things for themselves and getting excited about that, like they do sometimes...and maybe taking a little bit of responsibility for what they are doing...and that's part of the school system, children come into classroom and expect to be fed something really, whereas if it was a bit more of a discovery thing... (Interview Feb 2001)

With regard to teacher questioning interactions in Seven Blue she expressed her ideals in this way:

> Ideally I would like all students to feel prepared and able to contribute either by answering a question, or in a class discussion. At the same, I would like all students to have an awareness of whether they are dominating the discussion, Q & A, or not pulling their weight.
>
> I would like all to be following the discussion/Q & A as far as they are able, and not to be disheartened and frustrated by lack of understanding.
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> I would like the students to see each other as a source of learning, so that it is considered as important to listen to one another during discussions, as it is to listen to me. (From Email November 2000)

It will be clear from the classroom accounts presented later creating a classroom ecology in which such values and ideals flourished was not an easy task. A particular issue was the marginalisation of girls in the class:

> that I am aware of the gender issue and I think I did kind of assume that because I'm a feminist I would kind of give the girls in my class a better deal but its not that simple. Because I'm seeing more and more that the boys are so vocal that they are getting a better deal, and I'm trying to think what am I going to do about it. I am conscious of huge gender divisions in the classroom, like in Seven Blue, there are a lot of difficult boys and there is not a single difficult girl. I guess that I did not allow for boys that are already socialised into their aggressive roles. (From email January 3rd 2000)

In presenting the extent to which Seven Blue's ecology differed from Jill's ideals, particularly with regard to the first lesson described, there is a danger of pathologising her or indeed her students. However, as Stephen Lerman notes in the quote that opens this Chapter, both the teacher and students' may experience powerless in the classroom (Lerman 2000b). One of my contentions is that in the context of school mathematics, enacting more fulfilling social practices is difficult. Certainly, that was true in the case of Seven Blue. It must also be remembered that Jill was a relatively new teacher.

Obviously, Jill was also influenced by the co-operative inquiry we were engaged in together. Although we had an agreed focus on teacher questioning interactions our discussions ranged more widely. In terms of questioning strategies I encouraged Jill to reflect on the nature of questions, the value of student discussion before answering, and to explore alternative forms of response to the traditional hands up approach. Particularly looking at alternatives that engaged the students kinaesthetically, allowing them in some way to embody their answers and/or to respond collectively. This is illustrated in the discussion of the February lesson.

Between the two lessons discussed below, I conducted a number of interviews and had shared insights from these and from my observations of the class with Jill. Undoubtedly, this changed and affected her practice in many ways. Indeed, changing her and the students' practices was part of the aim of 'opening dialogue'.

A Changing Ecology[4]

In Seven Blue's mathematics lessons a complex and changing ecology of social practices emerged. The children in Seven Blue engaged in a variety of ways with these practices particularly in the context of interactions with the whole class[5] and the degree of participation varied. Some students were "quietly disaffected" (Nardi and Steward 2003). Others were more fully alienated and they accommodated to situations in which they were required to listen to the teacher or others (though they frequently only gave the appearance of listening) and looked for opportunities to continue their social interactions or personal withdrawal into their private worlds.

As previously stated the class had a large gender imbalance that served to both underline and strengthen the differences in the level of forms of involvement of girls and boys. However, as in the Year Eight class discussed in Chapter Three, the class behaviour should be seen as gendered rather than strictly demarked by gender. A number of boys in the class adopted similar responses and forms of participation to the majority of girls, passively participating with varying degrees of engagement. Some of the 'loud' boys as I describe below did not always conform to required forms of

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[4] In discussing 'Seven Blue' I move between considering Seven Blue as the form group of children, and Seven Blue as an ecology of mathematics. In the latter case, Jill, their class teacher, was a key part of the ecology. I hope that it is obvious when I move between these two meanings. The need to shift between two meanings in this way underlines the extent to which the teacher is both outside and part of the class learning formation in the context of institutionalised school mathematical learning.

[5] It is worth reminding ourselves that "whole class interaction" a current buzz word in government discourse in mathematics education does not necessarily mean interaction with the whole of the class but often individuals within it.

engagement and behaviour. Instead they created particularly disruptive forms of socialising and shared practices.

During the period of research, the students in Seven Blue were new to the school and were in a process of transition from primary schooling. In interviews students often used the primary experience as a reference point or a means of comparison in relation to classroom practices. Unsurprisingly, these comments indicated that the social practices they experienced in secondary mathematics were different in various ways, particularly with respect to more widespread use of textbooks and changed assessment practices. These changes in social practices acted as challenges to the students' mathematical identities. As in any group these students had complex and individual mathematical histories. Interviews demonstrated that some students were already alienated from mathematics due to their primary schooling.

Importantly, Seven Blue were taught in a form group that was together for nearly all of its lessons. The class were attempting to create relationships and establish a sense of position and identity within the class. In the autumn term personal relationships, position within the class and shared practices and ways of doing things were being established. Not only did the forms of participation between different students vary but also the participation and practices of many students varied considerably and often unpredictably over time. Consequently it is an understatement to say that Seven Blue were a difficult class to teach. The children's forms of participation themselves impacted and influenced Jill's strategies and approaches to teaching both in terms of planning and in the moment to moment situation in the classroom.

The formation of identity was also related to complex issues of ethnicity, which I do not have the space to fully consider here nor was it the focus of my research activities.

Part one: Episode from December lesson

8.56 am Jill asks the children to do the "starter"

On the board she has written the following

Starter

Put these heights in order of size with the smallest first and find the median height

Group 1	Group2	Group3	Group4	Group5	Group 6
143	156	159	163	170	1.41
152	139	158	156	144	1.45
160	141	149	158	165	1.42
	139	156	166	155	1.46
	129		130	171	1.39
				146	1.50

Jill goes to the corner of the classroom she is talking to Juan, Paul, and Lewis about homework and commendations

8.57am Ryan is tapping the desk

Then Dave begins to bang the desk. Juan bangs too, making the same rhythm. Dave looks over and smiles at Juan

Jill: *I don't want to hear anyone banging*

The banging stops

Jill: *Put these heights in order*, [reading from the board] *Monday we were looking at this in the CAME lessons, how do we find the median?*

Juan: *How do we find the median?*

Jill: *We did this on Monday*

Juan: *I wasn't here on Monday*[6]

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[6] Juan is withdrawn every other week from maths lessons for numeracy support. Jill has mentioned how this can cause difficulties of re-adjustment. Perhaps Juan is reminding her that sometimes he is not in maths lessons

Jill: *Yes you were*

Whilst this exchange occurs, other boys are shouting out responses to how to find the median,

Paul: *Add them up and divide by how many there are*

others (boys) shout: *The middle one*

Jill: *Put your hands up*

Dave has his hand up and one or two others. Dave is asked to respond

Dave: *Add all the numbers up and divide by how many there are*

Jill: *That's how we find the mean...Abdi*

Abdi: *The middle one*

During this exchange six or seven other students are talking.

The students now continue to do the starter questions.

Someone calls out: *Is this the data from Monday?*

Jill: *No it's made up but you might get these numbers for a year eight, they are probably about right for year 8*

The boys in the corner declare:

Lewis: *I'm one hundred and fifty six*

Paul: *I'm one hundred and fifty seven*

Dave: *I'm five ft three*

Jill: *Quiet please*

Juan is banging, Dave is banging, the rhythm and body language show there is a connection and communication with each other. Lee and Joe are also banging but their rhythm is different.

A discussion begins between various students and Jill about homework and commendations. The banging stops whilst the boys engage with the interaction about homework and commendations. Joe and Lee are nearest me. Joe has a commendation

Lee: *I've never had one*

He goes back to banging.

9.05 Some people are getting near the end...

Susan's hand goes up, she sits waiting. Dave is tapping, Ryan and George are banging together

9.07 **Jill:** *Two more minutes Seven Blue and then we are going to talk about it*

The students continue to work on the questions, they all appear to be engaged in ordering the numbers and finding the middle ones. Some of the children are working together (checking answers?) some are working on their own in silence. Some are talking about other subjects.

At some point Susan's hand goes down

Jill: *Can you put your pens down and look this way.*

Only a few children respond, most are still engaged with the task

Jill: [louder] *Can you put your pens down and look this way*

More respond, there are still third to half who are either continuing with the questions or are talking to each other

Jill: *C'mon Seven Blue I've asked you to put your pens down and to look this way*

Paul: [loudly] *I've got to group 4*

Three more boys call out how many questions they have got.

This appears to be the same boys who called out their height before.

Jill: *Hsh*

The class quietens; most of the children are looking at her

Jill: *Today we're looking at averages. Last lesson we looked at the median and today we're going to look at the mode and tomorrow at the mean. Some of you will already know them, some of you are going to learn about them....*

Jill: *Can somebody give me answers to the first group?...If you have an answer then put your hands up*

One or two hands go up

Jill: *Everyone should have their hands up*

Lee: [loudly] *What's the median man?*

Lee's question is apparently unheard, someone is called to give the answer to the first one, *One hundred and fifty two.*

Part Two: Discussion

A regime of practices?

Seven Blue's mathematics lesson, did not conform to a fixed pattern, however, the episode described does highlight frequent features of the lessons during the second half of the Autumn term. The lesson begins with a 'starter': this was a strategy Jill often used at the beginning of lessons with this and with other classes partly to quieten and focus the children at the start of lessons. The use of the 'starter' on the board was a conscious choice to avoid verbal questions as the first mathematical activity of the lesson. Her reasons for this were complex. One reason was because she wished to avoid closed factual questions that might be perceived by students as testing them, or put them at risk of embarrassment, and in part due to a lack of confidence at this point in her development about being able to maintain purposeful interaction until the students had focussed on written tasks. She also expressed a lack of confidence about 'oral and mental work' meaning the short oral and mental session suggested in the Numeracy framework.

The 'starter' questions fit with the regime of school mathematics practice. Although in the previous CAME lesson the students had investigated the median as a measure of average, here they are asked to practice what they know. Although the data they are presented with are related to the previous lesson as they are heights there is an element of having to enter into the "maths world" (Boaler 2000) of a disconnected and artificial context. The questions are organised sequentially into a perceived order of difficulty, with the third set requiring an appreciation of the need to find the mean of the two middle points of data. Such hierarchical ordering of questions is typical of practice exercises in school mathematics.

In the lesson extract, Jill manages the exchange, as is typical in such interactions in school mathematics lessons. Of Jill's fourteen speech acts, eight are 'managerial' (requests for students to participate in classroom practice in the desired way), three are statements, two closed questions are asked, one a funnelling question (see Chapter Three) and one evaluation of an answer. Not all the students' speech acts during the episode are fully recorded and identified. Only boys speak and often by not waiting to be asked but by, what Jill called, "shouting out". This sort of boys' behaviour is not uncommon in school mathematics settings both amongst working class boys (Zervenbergen 1999) and middle class boys (Barnes 2000).

Some of the boys who are calling out assert or claim some of the public space of the classroom for their own private concerns, for example when three of the students declare their heights or Paul says where he has got to. In so far as these students answer

226

the questions asked or contribute to the lesson in this episode it appeared to be often to show that they personally know the answer, rather than to contribute to their own or others' learning.

Two students, confused and unclear about the lesson content, ask what the median is. It is impossible to know fully their intentions but these two students' questions do highlight the extent to which the lesson is concerned with finding the median for a list of numbers rather than what the median is or what it can be used for[7].

Later in this lesson (and space precludes providing transcript) other questioning practices occur. For example, students are asked to discuss the word average and generate their own sentences and are asked to discuss in pairs. There is a resonance back to the previous CAME lesson and the nature of student engagement changed with more students participating and less predictable and arguably more mathematical discussion taking place.

Contestation

The flow of the lesson is not 'smooth' with frequent interruptions, a vocal group of students do not recognise the procedure of putting hands up to speak, but speak as they choose, and when the students are explicitly asked to put their hands up before speaking, the request is initially ignored and Jill has to ask for this again.

The extent to which very few students were involved in the interactions up to this point is noticeable. In a description of an observation in which my attention as observer was focused on recording speech the extent to which most students participate passively has to be read by their absence from the transcript. Even more striking is the positioning of girls. If it were not for my attention to recording who raises their hands at particular points and so recording Susan's request to speak, the girls in the class would be completely absent from the record of the interactions[8]. Those students who do participate in the interactions with the teacher, do not do so with mathematical engagement or purposes as the motivating factors of their participation. The main purpose of boys who 'shout out' answers is to be the first to answer.

The norms that Jill attempted to establish were not as simple as 'speak when invited to do so after putting hands up'. What constituted acceptable interaction for Jill was more complex than this, there being situations in which students were expected to speak

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[7] However, it is worth noting that this had been the subject of the lesson on Monday.
[8] The dominance of boys in interactions at this time, was a common feature, though in this part of this lesson it is somewhat extreme.

without raising their hands. After reflection and discussion one change she made to her practice was to attempt to name the practice that she thought appropriate, to allow for 'calling out' at particular times.

In some lessons Jill was able to compel students only to speak when invited to. If she selected a student who answered correctly both the selection of the individual and the correct response would be met with verbal and non-verbal signs of frustration and anger by others, and when the correct answer was given, this would often be greeted by cries of "I was going to say that". For many of the students it was not enough to be correct: but they also competed for the teacher's attention. The teacher's attention is a valuable commodity in classrooms, even in this one where the ratio of teacher to students was favourable in comparison to the norm in UK secondary schools.

The episode does not reveal the purposes or meaning of questioning for the less vocal members of the class. I return to this issue in the next chapter when I describe some of the different patterns of participation of students in the class in terms of the meaning of teacher question interactions in their lifeworlds.

Banging or drumming

In this section I focus on the social practice of banging and or drumming on the desk. This existed prior to the start of my research involvement with Seven Blue and was raised at the start of the inquiry by Jill as a matter of concern. Often, when she attempted to initiate whole class interactions or provide explanations a number of students, all boys would, in Jill's terms, tap or bang on the desk. The banging would also occur during other parts of the lesson. The boys who would bang would also not conform to the required norms of how and when to speak but were the ones who would "shout out".

The banging and shouting out can be seen as examples of resistance and contestation of schooling practices that have been much reported in ethnographic and other educational research literature and (see for example Willis 1977; Mac an Ghaill 1994; Zervenbergen 1999)[9]. Such practices can occur in classrooms as conscious means to transgress and challenge the power of the teacher.

Transgression was necessarily part of the nature of the practice: students risked sanction and Jill's displeasure, and by banging they chose to publicly break the rules and norms of the classroom. Moreover part of the game on occasion was to bang or tap

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[9] Focussing on social practices in the classroom shifts the sociological focus from 'culture' and similar notions to the social practices through which culture and identity are created.

228

without being identified by Jill. However, for at least some students the main purpose of the 'banging' was not transgression. Indeed, the same practice that Jill saw as banging, was in the lifeworlds of at least some of the participants, more akin to drumming[10]:

> Paul: like you can make up a silly song

> Lee: like you can sing with your hands

> (From interview with Seven Blue Boys A)

In February, the drumming/banging occurred less frequently. When I asked students if they thought this was because Jill was better at preventing it ("is it because Miss is stricter now?"), they tended to disagree

> John: ...so people wanted to show each other beats and stuff so they just done it

> George: someone would come up with a new one and then it might be really long and everybody started doing it and everything

> (From interview with Seven Blue Boys B)

Undoubtedly, the banging is an example of alienation from school mathematics practices. However, there is a positive desire by these students to find 'entertainment' in the classroom (though the behaviour was not restricted to mathematics lessons). When asked why students engaged in the banging, others talked of boredom but the boys centrally involved said:

> Lee: It's entertainment

> Paul: Entertainment

> (From interview with Boys A)

A local 'drumming' community of practice?

In previous chapters, I discussed the concept of a local community of practice as a means of describing the type of social practices, engagement, enterprise and emergence of shared meanings that might occur temporarily in mathematics classrooms (Wimbourne and Watson 1998a,1998b; see Chapter One and Five). The network of

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[10] The meaning of the practice in the lifeworlds of the different students varied, partly in relation to the extent to which students fully participated or were peripherally located in relation to it. For some students who took part rarely they adopted Jill's referent of 'banging', for core participants the practice was referred to as singing with your hands, or drumming, or tapping out a tune. When girls in the class spoke about it, they adopted Jill's discourse and talked of banging.

boys engaged in drumming in the classroom also has features akin to a local community ofpractice and indeed this network had more features expected in community of practice theory at this point in the autumn term than in the social practices of the mathematics class as whole.

This local community had both a core and more peripheral community. The core group would bang most lessons, and would continue to bang after being asked not. The characteristic way of banging of the core group of the was to bang with the wrist hitting the desk first, and then the knuckles of the hand flicked down. More peripheral (generally white)[11] bangers would, initially bang with the knuckles on the desk. Over a relatively brief period of time (some weeks) a trajectory of participation occurred with students learning to band in a way that indicated fuller participation. Within this local community of practice there was a greater sense of mutual engagement than in learning mathematics. The students had a joint enterprise and a shared repertoire.

The social practice was not simply to bang or tap randomly but were "songs" to be learnt and copied:

> Juan: it's like you can make up a song

The students' enterprise was to create, all be it temporarily, a shared repertoire of songs to be learnt and copied. This enterprise was certainly indigenous.

The claim that the drumming constituted a local community of practice is not made strongly. In Wenger's later account of community of practice, there are indications that he would argue that the drumming is better seen as part of the class community of practice. He states that, "...taking a spelling test and shooting spitballs can be part of the same practice" (Wenger 1998, page 82). However, I believe that the differences in social meaning for the participants in Seven Blue mean that it is not helpful to think about it in this way.

Alternatively, and remaining in a community of practice theory framework, it is arguable that the drumming is a set of social practices within a wider community of practice of being Year Seven boys, that extends beyond their mathematics lessons, or indeed the particular class. Such a view highlights the extent to which different sets of social practices are in dynamic relation. These are interesting questions. However, the

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[11] I do not claim to have full insight into the general culture amongst the students but in this school and in Seven Blue, general societal racism did not mean that 'white' culture was seen as better. Much of the fashion and speech was very influenced by black culture. In Seven Blue the dominant boys, in terms of influencing behaviour, were black students. This does not mean to say that issues of racism were not important, but within particular communities of practice the way this is played out is complex.

ecological perspective I am proposing suggests that seeking to draw boundaries or label in this way is not necessarily helpful. Although asking questions of the boundedness of particular groupings or practices may be. Rather we must be alert to the fact that social space is not smooth and well ordered and neither are social formations. Ecologies of practice, including Lave and Wenger's exemplar communities of practice, are not neat formations but rather intertwined felts and non-linearly connected. At times it may be useful to focus on the group as a whole or totality of practices, at others on the networks out of which the web of relationships is formed. At root the notion of a community of practice is a geographical metaphor and two or three-dimensional space is not always helpful for thinking about social space.

In the previous chapter, I indicated that the idea of local communities of practice was useful, it was important to take note of Wimbourne and Watson's formulation of them as temporary and to distinguish them from community of practices that have a longer history (Wimbourne and Watson 1998a,1998b). In that discussion, the value of the notion of local communities of practice lay in identifying the extent to which participation in networks was different or similar to that in communities of practice. Similarly, identifying a local community of practice of drumming is valuable because it contrasts with the lack of felt mutuality in the regime school mathematics. In Chapters Three and Four, I contended that the enterprises or purposes of participants in questioning interactions was often not primarily concerned with learning mathematics but rather issues of personal security and identity were central influences on forms of participation. Seven Blue reminds us that such concerns may not simply shape or colour the personal lifeworld of participants, or fashion individual forms of participation to questioning practices but may lead to a shared forms of participation or even new practices emerging.

Identity

Identity should not be seen as a stable entity – something that people *have* – but as something that they *use*, to justify, explain and make sense of themselves in relation to other people and to the contexts in which they operate, in other words identity is a form of argument (MacLure 1993, page 287)

Regardless of what might be the best way to describe the drumming network it was clearly identity forming. Some of the students believed that banging was associated with getting to know each other and making new friends as they didn't know each other at the start of the year. There is an element of finding their position in the group. For some of the students in the core of the group, mathematics was particularly alienating. They found it and school more generally a negative experience and one at which they didn't succeed. One boy who often initiated episodes of drumming and continued to drum or bang or tap throughout the year even when most of the others stopped, was sometimes withdrawn from lessons for additional support. Significantly, he was also hearing impaired. Through drumming some of these boys and others could gain status or rank in the group which was not available through school mathematical practices. These students' would rarely contribute unless required in class. Of course this is not unique to these students or to drumming or tapping, more generally, disaffected or transgressive practices offer students the opportunity to be good at something when normal school activities do not offer this. The strategy of being "laddish" as a means of preserving self-worth because of lack of academic success has been identified previously (Jackson 2000). However, lack of academic success was not a motivation for all the drumming boys as some of these students' were successful during questioning interactions and willing participants.

One of the powerful aspects of Lave and Wenger's account in the way in which identity is connected to engagement in practice: it is not only a theory of doing but of becoming. However, in the communities of practice they analyse identity is a by-product of participation. In Seven Blue, amongst the drumming boys, whatever reasons the practice of drumming emerged, for entertainment or to transgress, it is possible that the formation of identity had moved to being at the heart of the enterprise they were engaged in. At least it alerts us to the fact that this may be the case. This distinction may appear to be subtle, however, it adds weight to the contention of Diane Hodges that our form of participation is connected to our degree of identification or disidentification (Hodges 1998). Similarly, Jo Boaler argues that some students' disengagement and

alienation with mathematics may arise from a disidentification with teachers of mathematics (Boaler 2000).

The students' development of their own local community of practice also serves to stress I believe, the urge for mutuality, sense of connection and belonging. I take the position that what makes a practice social is not only that it is socially created and has meaning socially or phenomenologically because part of being in the world is being with others, but moreover that it is through practice we express our sociality. Social practices for participants have the purpose of being social. Here there is an echo of the importance of this for Louise and in my earlier discussion of Hannah Arendt and being with others (see Chapter Four).

The banging by students serves to emphasise the urge to experience mutuality and solidarity. It is not novel to recognise that students can misbehave in school nor in mathematics, though there is a tremendous paucity of research *asking* the students the reasons for their social practices. However, focus on transgressive behaviour, both by teachers and in more academic discussion, tends to focus only on the refusal to accept the regime of practices. This can miss the other side of what the students are doing through their transgressive behaviour, in this case the development and expression and exploration of masculine identity.

One theme that emerged from listening to students throughout the inquiry and particularly when they were asked about how mathematics lessons could be or ought to be different, the common response was to have more "fun" (see also Nardi and Steward 2003). That eleven and twelve year olds want to enjoy themselves is not a very original finding (though it is perhaps worth reminding ourselves once again of how little pleasure is derived from mathematics for many learners). However, what this example underlines is the extent to which, when the opportunity for, from the perspective of the students' lifeworlds, engaging and purposeful activity is not available, other alternative local communities of practice can emerge.

Power

In my previous discussions of community of practice I have identified the issue of power and authority as ones that are problematic both in community of practice theory generally and in the particular application of community of practice theory to school classrooms.

233

To recap on earlier discussion, relations of authority and power in communities of practice are fused with the key triadic learning relationships of old-timer, established member and newcomer. In their first account of community of practice theory, Lave and Wenger indicate that relationships within community of practices are inevitably relations of power and conflict is inherent and important (Lave and Wenger 1991, Contu and Wilmott 2003). They state that full exploration of these issues is work to be done. However, in Wenger's later account power relationships are even less fully analysed. Lave and Wenger suggest two sources of conflicts in communities of practice. Firstly, conflict arises due to the way in which communities of practice are embedded in commodified relations of production. Secondly, the conflict occurs due to the tension between continuity and displacement within the community. In the archetypal apprenticeship communities of practice, the trajectory of newcomers is to eventually displace the old timers. Such conflict is worked out through everyday participation in the social practices of the community.

In Seven Blue's mathematics lessons both these types of conflict appear, although in a modified form. Schooling is not separate from commodified relations. Indeed, the current emphasis on testing and target setting increasingly commodifies classroom relationships and much has been written about this (see for Apple 1979, 1995, 1996; Boylan 2000; Cabral and Baldino 1998; Chassapis 2000; Dowling 1998; Ernest 1991, 1999; 1997; Segarra 2000; Skovsmose 1994). I do not propose to add to this general discussion here. However, one particular feature of teacher questioning interactions within the class is that for some students their concern was not with being the person who is correct, but rather being the one who answers first. The students seek an individual relationship with the teacher and the teacher's attention is the most valuable currency.

Conflict arising from the potential for displacement and the arrival of newcomers within the community clearly is not directly applicable to the school classroom, in the sense that the students' are not going to take the teachers role. However, Lave and Wenger's identification of the fact that relations of power are influenced by this feature echoes, Hannah Arendt's more philosophical and phenomenological argument about the importance of natality within the human condition. Understood in a wider context than a classroom as a specific community of practice, there is a generational conflict. Regardless of the content of the curriculum or the social practices of the classroom, and frequently in spite of the curriculum and social practice, school classrooms are an

234

important site in which children are legitimate and peripheral participants in the wider ecologies of practice that are enculturated in young adulthood. The socialisation function of the social practices found in regimes of practice means that the teacher is invested with a very particular sort of authority to impose (or at least to attempt to impose) particular practices on the children.

However, issues of power related to the drumming indicate some of the issues that are not addressed in the community of practice model that are apparent within Seven Blue's ecology. For example the gendered participation of the students (of which more later in the chapter) and more generally the different forms of participation or non-participation by individuals or sub-groups within the class in the social practices. Various writers have pointed to the discursive production of identities as important to analysing these issues (see Hodges 1998; Linehan and McCarthy 2001; 2000; Walkerdine 1997). Carol Linehan and John McCarthy analyse the complexity of control relationships within a primary classroom that they discuss as a community of practice. They indicate the way in which the nature and forms of participation and the practices engaged in by students may shift and change through interaction as students attempt to position themselves in relation to the teacher as central authority. They stress the importance of the individual student's concerns and purposes as consequence of and in seeking to produce identity. They conclude:

> This perspective gives full weight to the sense of lived dilemmas and conflicts faced by individuals engaged with practices. Thus we can think of individual and community as mutually emerging from particular relations, which entail the sociocultural and personal historical contexts from which they emerge. Relations in which conflict and control may necessarily emerge as part of the process of negotiating who you may become in a community (Linehan and McCarthy 2001, page 146).

In thinking about classrooms it is important to recognise that such lived dilemmas are not only important for students but are acutely felt by teachers as well.

I believe that both transcripts included in this chapter (the one already given and the one to follow) give many additional illustrations of such control relations. Rather than giving space to a discussion of these, I add to Linehan and McCarthy's analysis by focussing on the implications for control relationships of the existence of local communities of practice or networks such as the drumming boys within ecologies of practice. Drumming or banging was not simply an individual response to conflicts and dilemmas presented by participating in Seven Blue's mathematics lessons, but was rather a group response. If identity has value as an analytical tool then the concept

must include the real lived and experienced sense of solidarity, mutuality or at least connection with those, in any situation with whom, in our lifeworlds we identify. In Seven Blue a group of boys exercise power within the classroom in a way that they could not do individually.

CHAPTER SIX, FOURTH PIECE: A CHANGING ECOLOGY – A LESSON IN FEBRUARY

Part One: Episode from February Lesson

Seats facing the front in pairs.

Lesson starts with Jill checking that students are sitting in the right place.

Jenny, Susan and Kerry want to work in a group they ask if they can they have sat themselves in a group of three, Jill refuses.

The tests are being given out (tests are half termly)

Lots of general discussion about the test, some shouting and raised voices.

Jill raises her voice: *Seven Blue please, shhh*

The class become silent

Jill explains that she will ask a question and they will all answer together by holding up the right number of fingers when she invites them to do so.

Brent calls out: *Do we shout out*

Jill: *No you keep your hands under the table until I say show me the answer…*

During this explanation Jill stops – there is still some noise…

Activity commences – to begin with some students answer straight away by holding their hands up immediately.

Jill: *It isn't important who knows the answer first…what's important is that everyone answers together*

As the activity progresses the whole class begins to answer simultaneously, holding up their hands on "show me". Some of the boys are using the game to make rude, two fingered and one fingered gestures – Jill does not make a big issue out of it, accepts that this will happen, the mood is relaxed.

Jill: *What is 22 divided by 2 … oh you can't do that one.*

But some of the children have held up two hands and are putting a foot in the air, this is accepted and then a number of questions follow in which feet are used. This is a comical interaction

There is a lot of smiling and laughing,

Jill: *Sadly we've just had three people shouting out, we'd done quite well up to then, lets stop there*

Jill: *I'm going to put four questions on the board*

Dave calls: *Aw miss... questions* disgusted tone

Jill: *You've got to put the title as well, there are four questions and you have to choose one of them, do one that you think is appropriate for you, and I want you to find an approximate answer*

On the board is written

$1000 \div 7$

$100 \div 7$

$10 \div 7$

$1 \div 7$

Jill: *you may want to set it out like this* writes

$7 \overline{)1000}$

Jill: *You have four minutes*

9.08

Lewis calls out "I can't remember....

Jill goes and has a conversation with Lewis

Ahmed begins tapping and this draws my attention to the fact that there has been much less banging – there was some when the students first came in but Jill's instructions were given without interruption.

9.11 Jill is circulating round the classroom: *If you've done one then try another*

At this point most (all but apparently three students are engaged in the task)

9.12 George begins to bang

Jill: *I see you've got lots of different answers and they're not different because some are right and some are wrong but because some are more accurate than others.*

Jill indicates

$7 \overline{)1000}$

on the board: *Lee can you tell me the answer to this one*

Lee: *No I didn't do it*

Jill: *Then you need to listen especially well now*

Jill: then interacts with the 'whole class' in an IRE, cloze passage type interaction to create an answer like so

$$142 \, r \, 6$$
$$7 \, \overline{)1000}$$

Interaction is done by students calling out answers to different parts, this sometimes is simultaneously, it is difficult to record who is involved.

Jenny calls out: *you can round it*

Jill: *What would you round it to?*

Jenny: *one hundred and forty three*

Jill: *you are right, why one hundred and forty three and not one hundred and forty two?*

Jenny: *because it's more than five*

Jill: *often when we round we look at the last number and see if it's more than five but that's not why this time because the six is a remainder*

Emily has her hand up

Jill: *Emily...*

Emily: *because six is more than half of seven*

Jill: *that's right, I'm going to show you how to find a more accurate answer*

Ahmed calls out: *Can I do it miss*

Jill: *Ok, come out here*

Ahmed comes to the board

During the interaction with Jenny and Emily there has been a low level hum of talk from some of the students, now the noise level drops there is an increase in concentration, less noise, faces turn to the board.

Ahmed begins to set out the question at the bottom of the board, Jill stops him and wants him to do it at higher up,

Ahmed: *Miss I can't do it here*

Jill: *But people won't be able to see down there*

Ahmed does the calculation higher, he has to reach high to write.

He writes

$$7 \overline{)1000.0000}$$

then does the calculation

239

Jill: *Why have you written it like that?*

Ahmed: *Because the answer is not a whole number?*

$$1\ 4\ 2.$$
$$7\overline{)1\,0^30^20.0\,0\,0\,0}$$

Jill stops him and asks him to explain what he is doing

Paul calls out: *why have you done that?*

Dave calls out: *I remember doing this*

Jill: *Some bells are ringing*

Ahmed carries on: *you can put the remainder here, which is like sixty and the sevens into sixty is eight* [writes 8 after the decimal point]

Paul: *Can we just keep repeating?*

There is an interaction which leads to points to indicate recurring decimal being placed over the answer.

$$\overset{\Large .\quad\ .}{142.875142}$$
$$7\overline{)\ 1000.00000}$$

Li: *Miss where do those numbers come from?*

Jill: *lets look at this one and I'll show you it*

Jill writes down $1\overline{)7}$

Who wrote that?

pauses

No one? fantastic because that's an easy mistake to make, to seven can't go into one so to try to do one into seven

(9.22 Engagement of the class is much greater than in previous lessons, they are generally focused on the activity)

After Jill's deliberate error is corrected she invites the students to come out and do the calculation

Jenny volunteers to come out, she gets in a muddle some people call out the answer to particular parts, someone calls out 0.1428751.

Jenny pauses and looks unsure then she appears to realise the algorithm

240

The answer is produced, Jill then asks Jenny where should the dots go, the class is becoming lost at this point, the answer that is given is over the 8 and 2. Jill asks Jenny to sit down

Jill: *Why will the numbers in the answers repeat?*

The lesson continues with discussion of pattern in the decimal answers and students go on to investigate patterns of fractions with same denominator and different numerators. Students are given a choice about which denominator to chose and thus the difficulty of arithmetic involved. With the exception of two students, the whole class engages in the task.

Part Two: Discussion

In February there is clearly continuity from the practices that pertained in the December lesson. In terms of the content and the mathematical practices that the students are expected to learn, the content of the lesson is also firmly situated in the context of the regime of school mathematical practices. However, there are significant contrasts with the first lesson.

Collectivity and a shared repertoire

The lesson begins with a "mental and oral" activity in which the students answer kinaesthetically as a form of unison response (Watson 2003). At the start of the research project, Jill and I had experimented with the use of hand signals as a means of all students participating in whole class interaction. In suggesting this, I drew on my experience as teacher but also as a participant and facilitator of meetings seeking consensus in the ecological direct action movement. The use of hand signals appeared to have encouraging consequences, however, as described in the Preface, these more adventurous research activities were curtailed. In this lesson Jill draws on this experience in creating the activity but in adapting earlier suggestions makes the practice her own. Moreover, during the activity the students themselves add to the practice by extending the possibilities for the range of answers that can be given by responding to Jill's 'error' of asking a question that has an answer that is more than ten. The use of legs to go beyond ten, is comical and enjoyed by all, and it represents and indicates the way in which a shared repertoire within the class can develop[12]. There is a sense of collectivity developed as the students answering together. This collectivity is reinforced by Jill's appeal to the class that what is important is answering at the same time rather

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[12] Another example of this is Jill's reference during other lessons to 'Thinking maths lesson': thereby creating a shared resource of ways of working to be drawn on.

than being first. I develop my discussion of the value of different means by which students can respond in the next two chapters.

The questions on the board

The second activity of the lesson consists of students individually attempting one of four questions on the board. These questions are still ordered hierarchically, but rather than them being expected to start at the first and work through the students are asked to choose one of them. Jill's aim here is for the class collectively to generate answers to all four questions. She wishes to remind the students of the skills needed to do long division, but the purpose of the activity and the lesson is not simply to practice long division algorithms, but also to explore patterns in recurring decimal fractions.

Dave's response of "Aw miss... questions" is representative of a number of boys who during interviews indicated that they did not enjoy starting lessons with written questions from the board. Jill's change of practice to reduce the individual repetitiveness of the task responds to the views expressed in interviews. By giving students a choice she creates the possibility for a sharing out of tasks between students so that the contribution of other members of the class becomes important. It helps generate the conditions under which students need to listen to each other and indeed the teacher. She builds on this in the subsequent activity in the lesson where an investigation of patterns in decimal equivalents of fractions is divided amongst students in the class.

Changed participation

In the comparison with the lesson in December it is clear that both the nature of participation and who actively participates in the interactions has changed. Whereas in the first lesson girls were noticeable by their absence here they are much more involved in the lesson. Although the banging/drumming still occurs, it is occasional and much more individual. The boys whose enterprise in the December lesson centred on banging or drumming are now mainly involved in the mathematical interactions through which shared practice develops. There is a sense of shared purpose by many of working together on a problem. The lesson has features of a local community of mathematical practice

Questioning interactions

The interactions during the discussion of the questions on the board at times form a classic IRE cloze passage of the type that were discussed extensively in Chapter Three.

242

However, at the same time different types of questioning are interspersed that are similar to those described in research on inquiry classrooms (see Cobb et al 1992; Wood 1994, 1999). In such classrooms questions are often aimed at eliciting explanations from students of processes or conceptual understanding. In the above episode Jill does this on a number of occasions. Interestingly, students also share in this practice and ask question of this type of each other, possibly because of the model Jill provides. However, the difference in the social meaning of the type of questioning that Jill engages in cannot be easily read from the text of classroom discourse. This is a reminder that differences in the nature of social practices between usual school mathematics and more collaborative classrooms are subtle and often depend on context rather than particular form of words used.

In the episode from the December lesson, student's calling out answers was not welcomed by Jill, and generally as previously discussed was an individual assertion of being correct. Here students call out both answers and questions as the class together works on the problem. Interestingly there is a contrast here between students calling out or contributing at this point in the lesson and earlier during the first activity.

During discussion with Jill, we explored the complexity of her implicit desired forms of interaction with the students. In the Autumn term sometimes she would accept students "shouting out" and at other times would admonish them for doing so. When I asked about this she recognised the seeming inconsistency and said that she thought she accepted spontaneous speech when it was "helpful". I use the phrase 'seeming inconsistency' because through discussion it emerged that that Jill actually did have implicit 'rules' about the times she accepted 'calling out' and times it was not acceptable. One strategy that she used in developing greater engagement by the students and to decrease 'unhelpful' shouting out, was to be explicit about her expectations and reasons for them, essentially reflecting on the reasons for the social practices that she wished to foster. The extent to which this is important in explaining the change is an open question. However, it is the case that in the February lesson the class is beginning to moving towards being capable of engaging in the productive "cacophony" reported as occurring in open inquiry science classrooms (Gallas 1995; Van Zee et al 2001).

The use of the board

Again similar to inquiry classrooms students are expected to come to the front and explain their thinking and then be prepared to answer questions from other students (see for example for comparison Cobb et al 1992; Wood 1999; Yackel and Cobb 1996).

This tends to interrupt the physical expression of the relationships of authority within the class referred to earlier. The teacher as writer on the board is a mark of authority and power, by using the board in the way she does, Jill indicates and demonstrates a desire for the board to be public shared space. I asked Jenny later in interview about this episode, and why she volunteered to come to the front even when she was not sure of how to complete the algorithm and how she felt about this. She told me that she liked coming to the board regardless of whether she had knew the answer to the problem, she simply liked writing on it, and being at the front of the class.

The board is a key artefact and reification of practice in school mathematics classrooms. Often the way the board (with or without the use of an overhead projector) was used during a lesson was a marker of the extent to which the practices were being pulled towards a regime of practice or a community of learners. In the former case the board acted as recorder of teacher generated or funnelled algorithms or of tasks to do. In the latter case the board was a means for the class to communicate or work on a problem together. Although one of the strengths of community of practice theory is the scope it gives for the analysis of artefacts and tools within a community of practice, this is underdeveloped both in community of practice theory generally, and in its application to mathematics education. The way in which boards are used as tool in classrooms is an area requiring considerable further research.

Power

There is an apparent paradox in the lesson. One the one hand Jill appears to be more firmly in 'control' of the class than in the December lesson: she is interrupted less, the transgressive drumming behaviour is less prominent, and generally students participate in the ways she desires. Indeed, the lesson begins with Jill ensuring the students are correctly seated. Between the two lessons she has imposed a seating plan on the students and rearranged the desks in to rows[13]. In doing this, the form of seating in the

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[13] This should not be taken as meaning that the form of seating arrangement that Jill adopts is her preferred choice or the best one at all times, nor that I endorse this, but rather that at this particular point in the ecologies development it was a necessary and helpful action to take. This is discussed further in the next chapter.

classroom was more in keeping with the 'norm' in usual school mathematics regime of practices. Yet the actual practices were more participative.

However, the lesson also indicates that there the students are also more powerful in the sense of having greater opportunity to act in certain ways. The first oral and mental activity, requires the students to answer in a constrained way. However, the boundaries that Jill imposes means that those boys who wish to transgressive the normal rules of schooling by using the form of answering to make 'rude' gestures can do so. Jill chooses to ignore this. By doing so she allows for more "spacious" relationships (Angier and Povey 1999). More speculatively, Jill unintentionally creates a space in which those boys who normally drum can express their 'rule breaking' identity whilst also engaging in the mathematical activity[14].

In the subsequent activity, students have a choice about what calculation to do but more importantly during interactions with Jill and others in the class, have greater freedom to speak naturally and spontaneously. Collectively, they are able to exercise greater "author/ity" (Burton and Povey 1999) as they author the mathematics together. Most dramatically, the girls in the class, who in the previous lesson extract, are largely invisibly and silenced by the transgressive behaviour of the boys, here are active, engaged participants in the lesson.

The lesson demonstrates that power is not some finite quantity which is divided up between participants in practice as in a zero sum game. I contend that Jill has greater authority and rank in the class and so do the students. In the next chapter I return to this and extend the discussion to consider the implications for democratic classroom practice.

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[14] From personal experience and observation, a similar space is opened when individual whiteboards are used with similar groups of children. The students having 'space' to write more than a simple answer in 'show me' sessions.

CHAPTER SIX, FIFTH PIECE: COMPARING SEVEN BLUE WITH OTHER ECOLOGIES OF PRACTICE

In the previous Chapter I compared different ecologies of practice using a number of dimensions or features. As an end piece to this chapter I consider Seven Blue as an ecology odf practice.

The ecology of practice in Seven Blue is complex with shifting patterns of participation. I described above the nature of Seven Blue in the first lesson described as one in which a modified form of a regime of usual school mathematics practices occurred. In this lesson a group of students resisted these practices through the assertion of practices from other ecologies and the emergence of a local community of practice of drumming.

At the same time Jill attempted to establish local communities of practice ("camey type lessons") and more reflexive awareness of social practices similar to those found in learning communities. Thus a summarised description of the ecology necessarily tends to simplify this complexity. The following description should be read in the context of the previous descriptions of other types of ecologies as, at various times, features of all these different ecologies could be found.

Forms of participation in the ecology are heterogeneous and dynamic with respect to school mathematics. The student's participation at those times when usual school mathematics practices dominated was generally passive. Various forms of non-participation occurred, including more passive 'switching off' and quiet disaffection and more visible and more active non-participation as the practices were contested by some students. More active participation occurred in subgroups within the ecology and when local mathematics communities of practice emerged.

The sociality in the ecology was often conflictual. Conflict existed between teacher and some students and also between various groups of students, importantly between the 'shouting' boys and girls. The students' primary identification was frequently with various sub groups or local communities such as the 'quiet girls' or 'drumming boys'. These communities themselves were not stable but in complex interaction with others and with the regime of mathematical practices. There was a polarity between instances of unity or at least more shared experience (either when Jill as able to temporarily impose a local regime of usual school mathematics practices or when a local community of practice emerged) and more fragmented forms of interaction.

Although Jill as teacher had a unique position in relation to power and authority in the ecology, her authority was contested and power challenged. Students were aware of and concerned about their social and mathematical position within the class and questions of rank were important to the students. During inquiry lessons both the students' and Jill had greater authority.

At this point in the evolution of the ecology the main trajectories of identity were to do with establishing rank and relationship to other students rather than relationship to mathematics. The students found ways to assert their identities in conflict with school mathematics identities. Many students were alienated from the school mathematics practices but were more engaged when opportunities for collective problem solving, alternative forms of responding to question and more open approach to learning mathematics was used.

Although the usual school mathematics practices were not generally indigenous, more localised practices occurred as local communities of practices emerged. In conflict with the regime of practices the students 'imported' or exercised other practices from outside the mathematics classroom. The boundaries of the ecology were porous with contestation of practices from other ecologies, thus the particular practices found in Seven Blue were closely connected to other ecologies. The practices were unstable and changing.

The questioning social practices were mixed with the teacher using a variety of styles and introducing different means by which the students could respond. The students' willingness to participate in the questioning practices varied.

CHAPTER SEVEN

LIFEWORLDS AND TEACHER QUESTIONING:

STRATEGIES, MOTIVATIONS, AND CHALLENGES FOR

DEMOCRATIC PRACTICE

> Our fear creates a contracted and false sense of self. This false or "small" self grasps our limited body, feeling, and thoughts, and tries to hold and protect them. From this limited sense of self arises deficiency and need, defensive anger, and the barriers we build for protection (Kornfield 2002, page 104).

FIRST PIECE: ABOUT THIS CHAPTER

In the previous chapter I described some of the features of Seven Blue as ecology of practice by considering the nature of different classroom practices and the students' participation in them. In this Chapter I illustrate the diversity of meaning of teacher questioning for participants within ecology of practice who are located in different lifeworlds. I am concerned with the sense the students make of this aspect of classroom interaction and how, from within their particular lifeworlds, they exercise (or do not exercise) agency in questioning interactions. Moreover, given that the participants are potentially conscious co-creators of classroom practice, I consider their diverse views on how questioning interactions ought to be conducted and the challenges this implies for democratic classroom practice.

The discussion in this Chapter develops and draws on the ideas discussed in Chapter Three, where I reported on one group of students' experience of teacher questions and views on preferred forms of interaction with the teacher and each other. However, the discussion here differs from the earlier study in that the individual students' views are located in particular lifeworlds and in the context of an ecology of practice. In Chapter Four, I explored one lifeworld of school mathematics in depth. Here the lifeworld perspective is used as a framing perspective rather than giving a full and complete exposition of each individual's lifeworld. I also stressed there the pluralistic nature of the self. In the current Chapter, this is simplified to treat the participants as unitary selves participating in the different practices with the process of negotiation being primarily the self with different practices rather than within the self. Nevertheless, in the case of some of the students discussed the pull of different identities is clear.

In the Second Piece of the Chapter I detail the research practices, the materials these generated and the forms of analysis. In the Third Piece, I focus on the meaning of

teacher questioning for eight of the students in Seven Blue, and how this affected their participation in different practices and their accounts of their preferred forms of interaction. I describe aspects of the selected participants' beliefs, strategies, and purposes with regard to teacher questioning practices in the context of their general participation in the ecology of practice and consider the participants' motivations in adopting their particular forms of participation and engagement. In the Fourth Piece I argue that behind the diversity of identities and participative strategies, all the participants have common purposes: care of self-worth and a desire for engagement. I then extend my discussion by considering the role of play in the classroom. In the Fifth Piece I consider the implications of the material presented in this chapter and earlier ones for democratic classroom practice.

CHAPTER SEVEN, SECOND PIECE: RESEARCH MATERIAL AND ANALYSIS

Below I discuss the beliefs and participative strategies of eight students in Seven Blue. I have selected the eight students to represent some of distinct perspectives and strategies of different members of the class. In the interviews with the students I used similar research tools as those used with the students interviewed in Chapter Three. Before the interviews all members of the class completed a short questionnaire about their experience of mathematics lessons. The survey provided a starting point for discussion in the interviews, as did a prompt sheet about different types of social practices that occurred during their lessons and a ranking task about different ways of responding to questions. In addition, I used selections from the research material presented in earlier Chapters as foci and prompts for discussion. At the end of the year the students carried out a review of the year. This material is supplemented by the observations of the class described in the previous Chapter.

The interviews with the students were conducted as focus groups (Denscombe 1995; Morgan 1997; Vaughan, Shumm and Sinabug 1996). Such groups are one means to address the issues of power inherent in the interview process that are particularly acute in interviewing children. However, using focus groups presents a methodological problem. In any interview there exists the possibility that the interviewees' responses are tailored to the interview: put bluntly that they say what they think you want to hear or might meet approval or to maintain particular identities. In the interviews with Seven Blue, the importance of relationships within the interview groups were apparent and on some occasions both from the audio record and transcript, it appears that the some of the students echo or agree with more vocal group members. I have therefore reduced the importance of this issue in the material presented by selecting to report on students who represent the diversity of views in the class as a whole.

In the Third Piece I present the students' beliefs about teacher questioning in the context of their participation in the class, their mathematical identities and more generally their experience of mathematics. I give a further interpretation of this material for each student. I make suggestions about the underlying, existential and psychoanalytical factors that inform the students' forms of participation. Here my interpretation and analysis draws not only on Gadamer's hermeneutics but also that of Ricoeur (Gadamer 1975; Ricoeur 1970 and see Chapter Two and Four for discussion): "Often, there is a lot happening silently underground" (Blagg 2003, personal communication). In the case

of some of the students, I infer possible unconscious or partially conscious motivations or feelings that are not fully expressed by the students. There is a growing body of research that seeks to use psychoanalytical frameworks and tools to explore such unconscious factors. For example, Valerie Walkerdine, Helen Lucey and June Melody use tools from the context of therapeutic interviews to analyse unconscious process in their "psychosocial" study of gender and class (Walkerdine, Lucey and Melody 2002).

In the Preface I discussed different senses as metaphors for knowing and argued for the inclusion of feeling as representing a visceral knowing similar to that which arises through touch. The term 'feel', in its multiple meanings within the English language, also refers to emotional knowing. Often when we wish to know what is happening "silently underground", we first feel it. In describing the students' motivations with regard to teacher questioning practices I go beyond simply an interpretation of text or discourse to what I *feel* to be the case from spending time with these students in discussions and in the classroom and what makes sense in terms of the way people act and behave. In particular when students generalise about other students I take this to be indicative of their own feelings or perspectives that they do no fully 'own' in the interviews. In conventional academic terms there is thus a degree of conjecture about the students' strategies and reasons for them and in places I move beyond the 'evidence' presented in the text.

However, the purpose of presenting the students' views is to illustrate the diversity of opinions on, and experiences of teacher questioning within the class as a means to consider the implications for democratic or engaged classroom practice rather that generalising about what students think or feel about teacher questioning practices. For the purposes of the thesis, it is, I believe, enough for the conjectures to have "face validity" (Lather 1991): they may not be 'true' for the particular individuals but it is enough that they could be true for individuals within the sort of ecology of practice that pertained in Seven Blue's mathematics lessons. In a living context, practitioners have to make assumptions about the different lifeworlds that they are in relationship with, act on these assumptions and then review those assumptions.

In any case, my concern is to assert the importance of diversity of meaning of teacher questioning for different students and conversely the commonality of purpose and motivation. I organise the interpretation of the research material to highlight two common threads that inform the students' adoption of diverse strategies with regard to teacher questioning interactions. These themes can both be viewed as aspects of

existential care (Heidegger 2000/1926): preservation of self-worth and a desire for engagement. Moreover, I argue that Jill, the class teacher, shares these two concerns. I have already described some of Jill's background and influences on her developing practice as a teacher in the Preface and in the previous chapter.

CHAPTER SEVEN, THIRD PIECE: PARTICIPATING IN TEACHER QUESTIONING - STRATEGIES AND BELIEFS

Nikita

Nikita's family are recently arrived migrants from Eastern Europe[1]. Conversations and interviews with her reveal a strongly expressed belief in the importance of education that she shares with her family. Mathematics is "a very good subject for people because it's useful for the rest of your life."

In the written survey and interviews, many students responded that they liked mathematics lessons when they used computers. The reasons they gave included the possibility of playing mathematics games, of learning independently or not having to do written work. However Nikita's 'work' orientation is demonstrated by her focus on the utility of computers: "in your spare time from school you can do your homework on the computer."

Nikita believes that the role of teachers is to explain well, and for students to listen properly and to work hard. A person who is good at mathematics is someone who does homework and can "repeat everything you've done in your book". People who learn mathematics more quickly or know more do so because they "study more".

She finds mathematics lessons easy and often unchallenging. During teacher questions Nikita rarely volunteers to contribute although she says she does not find teacher questions a cause of anxiety. Sometimes, rather than appearing to pay attention to the teacher during questioning she continues to do another task. Nikita accepts that it is part of the teacher's role to ask questions but within her lifeworld such times are a delay to being able to start written exercises. The part of the lesson she prefers is when she is working from a textbook; she explains her reasons for this in the following way:

> because like teachers they have to explain a lot or explain a little bit and if
> you understand it there's lots of questions in the book and if you understand
> them you can do them and in the book they have different explanations from
> the teacher which is different from the teacher's explanations.

She wants the teacher to exert control so that the ritual of asking questions can be gone through as quickly as possible.

Nikita recognises that closed teacher questions can be threatening for people. When discussing with others an extract from Louise's interview about the times table competition on Friday afternoons (see Chapter Four) she understands why others might

find such situations intimidating "other people laugh at you when you get the answer wrong". She also recognises that others "like it when you have a chance to discuss with the person next to" but she does not think that this is a good strategy for the teacher to use as "sometimes they don't discuss it"; as a consequence she tells us that "I think its better if someone just asks questions and picks someone".

Nikita's strategy in mathematics lessons is focussed on written questions or tasks. If she has mathematical tasks she can do during interactions between Jill and the class then she will do those rather than pay attention to the discussion. Nikita chooses not to participate. She does this successfully because the tasks she does engage in as alternatives show her to be studious, she does not interfere with questioning episodes, and often Jill's attention is focused on the more transgressive behaviour of other students. For Nikita teacher questioning interactions are an interruption to that which more fully engages her, "working hard" and completing textbook or other practice questions. Discussion in interview suggests this reflects both her previous experience of classroom practices and more importantly her families beliefs. In any case when working individually Nikita has control over her engagement. Nikita's sense of success in mathematics is related to how hard she feels herself to be working and questioning interactions can distract from this. Moreover, in such interactions when students respond individually, part of the 'currency' of the interaction is whether or not one is chosen to speak rather than being right or wrong. Volunteering to answer risks not being chosen. Nikita can more easily maintain her self-worth by not involving herself even though she generally knows the answer.

Susan

Susan is from a white English family. She finds mathematics difficult and she began the year unconfident about her ability and describing herself as a person who disliked mathematics. Over the year her she slowly began to feel more confident though this is punctuated by lows when she is given test marks: "I hate maths because I got my test result back."

Susan is very sociable and interacts with many of the other members of the class. She prefers working in groups "because you can help each other with the answers and everything" although she recognises that when in groups often she will talk about other things and "then you just lose your concentration." Susan finds textbooks "annoying".

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[1] I give brief description about the ethnicity of the different students in order to convey some sense of the ethnic diversity in the class.

Although she wants to do written activities in groups this desire for discussion does not extend to discussion of answers in pairs or groups before sharing with the whole class during questioning interactions. She says this is not helpful to learning: "… it just gets too boring and you're just like can we stop now and do the work". Although Susan says she finds mathematics difficult in such situations "complicated questions are better." It appears that being asked simple questions that she knows the answer to, invalidates the need or desire to discuss with another person. However, there is also a possibility that Susan is positioning herself in the interview as more mathematically confident than she actually feels.

Susan wants to be involved in teacher question interactions. However, teacher questions are a source of anxiety, a wrong answer risks being laughed at[2] "and then you get all… you just get all urggghh and the teacher tells them to stop."

For Susan the fear of embarrassment means that for her the situations that make her most nervous and those that she finds least helpful to her learning are the same. So when asked to select the situations that were most helpful she responded "the one when we write it down and the teacher tells us instead of us getting embarrassed when we put up our hand."

In addition, Susan talked favourably about the whole class answering simultaneously. This indicates the cause of embarrassment is not having to respond publicly in itself, but rather having to respond individually in a public way. In addition these means of answering would mean that there might be more time to arrive at an answer so:

> You don't get cut off like, where there's brainy people and they like know the answer, and when you go to get them [answers] they just cut you off and tell you the answer when you could have tried.

For Susan, the relationship with the teacher is central to feeling secure about engaging mathematically. When asked to imagine how mathematics could be better she says:

> I wish that everybody had a lap top so that they could actually be on the computers and there would be one side of the computer screen with the questions and on the other side you'd do the answers and then you could say keep it and then the teacher has them in like. Then the teacher has it on her computer and see if it is right and everything and that would be easier.

She is a frequent protagonist in argument with boys in the class who, due to their greater numbers and loudness, tend to dominate interactions. She describes the boys in

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[2] The actual incidence of being laughed at is difficult to determine. I did not witness this during observations of a lesson. However, from within Susan's lifeworld this is what happens; if you are wrong then you are laughed at. This illustrates the power of considering the lifeworlds of the students. Regardless of what an observer sees as happening, Susan experiences the classroom as one in which students laugh at each other if they get an answer wrong.

conflictual terms. She is aggrieved when the class is told off and "the girls get in trouble because they're in the same class but the boys they always they get told off but we have to be involved as well because we're in the same class as them."

Susan's strategies are more complex than Nikita's. The most risk free activity in terms of public status is doing textbook exercises. However, for Susan the connection with the teacher is very important as evidenced by the quote above. She speaks about how Jill had helped to develop her confidence and she frequently looks for reassurance from her or others. She also resents the domination by the boys of these parts of the lesson. So Susan would like to be involved in questioning interactions but also is aware of her own position in the class in relation to others and does not want to risk being wrong. If she is not required to give verbal answers then she avoids the risk of being laughed at so prefers unison responses or the privacy of an individual computer response to the teacher.

Lee

Lee is a British born Afro-Caribbean student. He is sociable and popular in the class with strong friendships.

He finds mathematics uninteresting and sometimes difficult: "I think it's hard, it's a bit boring". Socialising with others is his priority. Lee is one of the core members of the drumming boys discussed in the last lesson, who communicate and entertain themselves by means of "making tunes" through tapping or drumming on tables. For Lee this is "sing[ing] with your hands." During teacher questions Lee socialises with whoever he is sat near or surveys the classroom, interacting with other boys non-verbally. Lee's open lack of participation during questioning interactions means that sometimes Jill would specifically ask him by name to contribute (see Episode Two in the previous Chapter). He does not appear to care if he is not able to answer correctly in such situations.

However, during one lesson when tests were given out Lee was clearly disappointed by his mark, and appeared embarrassed. He says that education is important to his family and this is a motivating factor at school. He says that he wants to do well in tests so that his family will be proud of him.

He says that the times he likes mathematics lessons are when he works in groups. During lessons Lee would sometimes be in conflict with the girls, particularly with Susan. In lessons he is extroverted but in interviews he is shy and speaks less. Where other students give reasons and explanations for their participative strategies, Lee is

256

more taciturn. When asked, "what would make you feel more comfortable about speaking or answering in class?" he gives the one word answer "team". More generally, he says the times he likes mathematics lessons are when "you work in groups".

He also says that rather than putting hands up or being chosen by the teacher he would prefer for everyone to write down the answer before being given the answer. The reason for this is "because it's not embarrassing".

Lee's strategy is to appear to be uninterested and to transgress the accepted social practices. Lee is one of those drumming students who, I have suggested previously, protects their self-worth through transgressive behaviour. In Lee's lifeworld questioning is a situation in which he may be shown to not understand, so that both in terms of his sense of self-worth and his status with his peers it is preferable for him to not participate at all. Mathematics is difficult and unintelligible and thus Lee chooses to engage in what is more interesting and enjoyable "sing[ing] with your hands". When Lee is asked to answer because of his obvious lack of involvement in questioning interactions he chooses to simply not engage or say anything. Lee wants to engage with others, he does not have the opportunities he wants through mathematics practices and so finds alternatives.

Paul

Paul is an Afro-Caribbean student. In mathematics lessons Paul appears to have a number of different identificatory pulls. Like Lee, he is also one of the core group of 'drumming' boys. In interviews he provides articulate explanations of the reasons why the boys drum. His sociality means that he too likes group work.

However, unlike Lee, Paul also involves himself in teacher questions. He often knows the answer to questions and will 'shout out', rather than being invited to speak. He is competitive about not only being correct but also about being one of the first to speak. This means that sometimes when another student is invited to give an answer that he knows he will shout "I was going to say that" or similar. His concept of a person who is good at mathematics is someone who "can work out stuff quickly". At the same time Paul wants the pace of mathematics lessons, particularly explanations, to be slower.

Paul's concern to be involved in the mathematical learning means that sometimes he uses his confidence to speak over other students to attempt to cajole them into listening to Jill or even each other; he will loudly 'shhhh' others who are speaking or indeed tapping or drumming on the desk. As well as engaging in trangressive behaviours, Paul also positions himself in class as someone who seeks to conform to the expected social

257

practices of the classroom – to be a good student. He carries this aspect of his authoring into the discussion group where Paul complains of others "talking" when explanations are given and how he is sometimes, in his view, unfairly blamed for this. He also says that the most important thing about going to mathematics lessons is "learning maths." Significantly, Paul says that the reason he wants to do well in mathematics is that his grandmother is a teacher.

He is also ambivalent about tests. Paul is keenly aware of his position in class, particularly in relation to other boys. So that when Jill would attempt to give private feedback on test results, Paul would be one of the students who would initiate students sharing marks with each other. At the same time he complains that "the thing is that when we are going to have a test they make it all major, we gonna have a test on Friday and keep on saying it."

Like many of the boys Paul does not like arriving in the classroom to find 'starter' questions on the board. Partly this appears, as with other boys, to be part of a general dislike of written work and partly, a resentment of the disciplining nature of this practice (which is one of the reasons why Jill uses it). However, Paul also refers to the difficulty of being immersed into a new situation:

> You see sometimes when we're new to the subject, when we start a new subject, then she just has new subject on the board and we don't really understand it we just come in and see a new subject on the board.

The repetition of 'new' here is significant. School mathematics does have a feature of moving quickly from one topic to the next. The students are continually presented with novel situations against which they are tested and against which they test themselves and clearly this causes anxiety. A distinctive feature of school mathematics is the continual novelty for many students. This is not fully appreciated by teachers. This was encapsulated for me by a student I taught in my first year of teaching who, in what was for me an epiphanal moment, greeted my attempt at explanation with "but it's alright for you, you already know how to do it." In Chapter Four, Louise's lifeworld gives a detailed account of the continual strangeness and otherness of the mathematical entities and procedures encountered in learning mathematics. It is interesting that Paul is does not appear to share the same level of anxiety as Louise yet newness is an important concern for him.

A learner's mathematical rank and identity is continually tested in usual school mathematics lessons. One response to this is to choose disinterest as Lee does. However, Paul positions himself as one who is able to answer questions is important to

him. Thus he is continually put into a situation where the material and objects he encounters are new. Of course in part this is an aspect of the human condition, "the world must be answered – authorship is not a choice" (Holland et al 1998, page 272).

In any case, it is clear that new topics cause anxiety for Paul. With regard to teacher questions this may be part of the reason he wants an opportunity to discuss before answering, although he also focuses on the way in which discussion can help learning: "because you get to know the answer better and you can change it or something".

John

John is a white English boy. He finds the mathematics in lessons easy and is often bored. Sometimes he is interested and responds in the way the teacher wants. During other lessons, including times when Jill is interacting with the class, he spends time talking quietly to the person he sits next to. John likes mathematics lessons when he can use computers, partly because he does not like writing. One reason why he does not like starting the lessons with written questions on the board:

> ...as soon as you get in there's writing all on the wall all over the board as a starter and we have to start writing straight away.

John also does not like working from textbooks and when asked about writing answers down when asked questions rather than verbally responding he says that would be "boring".

He is cynical about the world in general and teachers in particular. He notes the way in which the frequency of games has decreased and believes that they played games at the start of the year as a "bribe to get you to like maths":

Teachers and the world are waiting to trip him up. He has a world-weary humour that belies his age of eleven years. He does not like the teacher choosing who answers without the students showing that they want to answer:

> John: When she asks you for an answer and everybody in class knows it except you, she'll pick you!
>
> Mark: How does she know, how does that happen?
>
> John: I don't know why. Some things happen like that. Like if you've got a bunch of money in your hand like a pound and a five p you'll obviously drop the pound it just works like that

Sometimes John does participate in teacher question interactions. However, he is as cynical about the teacher's motivations as the way the fates conspire against him. He also summarises some of the dilemmas students have in adopting a strategy in the 'game' of teacher questioning:

259

> If you're like that [raises his hand, leans forward in an eager pose] and you really want to answer it, they look at you and then start looking at everyone else.

John is very concerned about fairness, he believes the boys are treated unfairly in relation to the girls. Firstly, because they are less likely to be told off for talking at inappropriate times, and secondly because during questions he believes that girls will be asked to respond in preference to boys. John believes that the fairest way for students to answer questions is to take it in turns.

Answering questions for John is not primarily about contributing to a process of learning mathematics but about status and identity. Commenting on times when the whole class answers together, he complains that people copy you and in any case:

> I think that sometimes just one person should be right...

> ...yeah, if we all bring it up at the same time and someone things I really know this, I'm getting clever or something like that and everyone has the same answer they worn' feel down like but they won't feel clever. We should all have our hands under the table and should just pick someone and if they're wrong she could go onto somebody else

John's competitiveness is underlined by his strategy during questioning interactions. In class, John appears to select the questions he will volunteer to answer, generally these are the more challenging questions. At such times his disinterest can transform into fierce engagement as he competes to be the one chosen if hands up is being used as an answering strategy.

John's competitiveness is tempered by his sociability:

> It's good to discuss with someone else because if you don't have it and someone else does then you can discuss it together and if you've got a wrong answer and they come over to help you they don't have to tell you they can help; you and you can get closer.

John's strategy in mathematics lessons is to choose when he engages in activities. Often he does not listen to the teacher's questions. If the teacher picks a student to answer he may be caught out and given that part of his status in the class is based on generally being able to answer correctly, this social practice is one he dislikes. In the context of state schooling the teacher's time is a scarce resource and becomes an important commodity in the classroom through which position, rank and status can be generated and asserted. John is frustrated by those times when he wants to answer but is not chosen. To put his hand up risks not being seen or recognised by the teacher, so not putting his hand up is a form of self-protection. If, in the usual school mathematics classroom, the teacher's attention and engagement with each student is a scarce

resource, John appears to have come to the conclusion that his engagement and attention is a resource he also can use to negotiate with. Thus John withdraws his attention if he feels the mathematics is too easy.

If John was to put his hand up more often and answer questions he perceives as unchallenging he would position himself very differently in the class. He would appear to be 'trying hard'. John may be choosing a trajectory of identity of some high achieving students that has the consequence in older students of avoiding being seen to work hard (Mac an Gahail 1994; Jackson 2003); achievement ought to be effortless.

Jenny

Jenny is an Afro-Caribbean student. Her participation in mathematics lessons varies considerably. Sometimes she does not actively take part in interactions with Jill at the start of the lesson; at other times she is only one of two girls who put their hands up regularly to volunteer answers. Jenny is a confident individual; when the opportunity presents itself she likes to come to the board. In the incident described in the previous Chapter, she does not feel embarrassed when she does not know the exact algorithm, but is happy to get the attention.

Like Susan Jenny also has conflictual relationship with the boys in the class and complains, "the boys normally stand up for other boys...but when it comes to the girls they start teasing the girls 'you got it wrong'".

Jenny wants to get on with "your work" and does not value teacher exposition:

> Jenny: they keep talking and talking and say if you don't understand everybody listen, it's really boring because you want to get on with your work
>
> Kerry: it's boring 'cause your always listening init
>
> Jenny: instead of doing

There are indications that Jenny is not happy about the pace of lessons

> yeah because even though you think that they [students] don't know a lot they do know what you mean. If they didn't know what you meant they'd probably put their hand up [and] the teacher would come round but most nearly all the time we always know what to do. That's why we get bored and start writing on our book and then we get so we don't listen.

Jenny claims, through the use of the general 'they', that she usually understands the mathematical content of the lesson. However, observations in class such as the one reported in the last chapter shows that this is not always the case and certainly when Jenny does not understand she does not appear to ask.

261

When asked what the "best bits about maths" are she says when she can do "practical" work. She speaks positively of CAME lessons (see previous Chapter), recalling them as the lessons "when you just throw your papers in the bin". The reason she likes them is because "you don't have to get everything right" and "you just put things in your head instead of writing it down." Similarly, a positive aspect of using computers is that it avoids "weary" writing. Jenny was one of only a few students who identified questions asked by the teacher as being a good feature of mathematics lessons.

> Mark: Is there anything there that strikes you about being particularly good about maths lessons, thing you like or thing you don't like? [Shows a list of different activities that happen in Seven Blue's lessons]
>
> Jenny: I like "the teacher asks questions which have a short one or two word answer" because...I don't know...it's like your own thing what you think the answer is.

She prefers short closed questions rather than situations in which she is required to explain:

> but sometimes it's complicated like you know the answer but your have to say how you have to explain your answer and it's really hard to explain it like you can't say it in words but you know how to do it

Jenny positions herself as confident and able when she speaks about working in groups:

> It's all right but sometimes they won't listen, they have their own opinions sometimes and you have to like talk about it to make them understand what the real answer is or something

Jenny's strategy in class is to appear to be carefree. For example, in the previous chapter (episode from the February lesson) I described how she came out to the board to attempt to demonstrate an algorithm that she was unsure of. She says in interview that she simply wanted to come out to the board because she likes it. However, being careless is I believe, paradoxically, a sign of Jenny's care and a particular means to preserve self-worth. She describes her strategy in an algebra test that she found difficult, "I didn't understand in the test, I don't understand, I just wrote any answer down". This suggests that her claim (above) that she stops listening because she is bored and understands the mathematical content may not always be the case and indeed might never be the sole reason. She like other students may be finding strategies that conceal the challenge of understanding (see for example Denvir et al 2001). Certainly, Jenny's strategies of participation are complex and based on the research material gathered no definite story can be told. However, within the conflicting readings of Jenny's actions and speech, there is certainly a concern with presenting herself as mathematically competent.

Seera is a British Asian girl who finds mathematics difficult. Seera said very little in the focus group and this reflects her silence in class. In class, particularly at those times when the 'loud' boys were most vocal, she could easily be invisible and I include her here precisely because there were a number of girls whose way of being in Seven Blue was predominantly to be in silence (Belenky et al 1986). The use of the word 'silence' denotes more than simply verbal silence, but rather a relationship to knowledge about and a way of being in the world. It signifies the extent to which Seera is subject to the other's authority; she is passive, reactive, and dependent. Undoubtedly this is not only due to the practices of the mathematics classroom but is a feature of her general life experience; Seera's school mathematical way of being in the world is part of, and an expression of, her general day-to-day way of being in the world. Seera's verbal silence during the focus group interview was particularly acute in a situation where she was in direct relationship to me as a representative of male authority. However, Seera is also generally not communicative with her peers. Seera's relative verbal silence in the focus group is different from, for example, Lee's who in other contexts is confident and vocal.

Seera does not put her hand up in class as there is a risk of being the only person with their hands up. Regardless of whether she knew the answer or not she would feel "embarrassed". She prefers to "talk to the person next to me" rather than being asked straightaway. This strategy also limits the risk of having to speak publicly as only one of the two students has to report for the pair. She does not like times when the teacher is asking questions of the class but says, "I like working from textbooks". In response to being asked to compete the sentence "Maths would be better if…" she says "work as a group". This response is particularly poignant, as I believe that even when working in a group Seera does not often have the experience of being part of the group.

For students so far discussed in this section, participation strategies are affected both by their attempts to maintain self-worth in the context of authoring their identities and their desire to find something that will engage them. However, in the case of Seera, fear of exposure, indeed even public attention, means that she adopts a strategy of invisibility at the expense of social engagement. The strategy of invisibility is one that Melissa Rodd and Hannah Bartholomew discuss in relation to female A level mathematics students (Rodd and Bartholomew in Press). They consider the nature of the invisibility of a character in Phillip Pulman's His Dark Materials Trilogy, a witch queen called Serafina Pekkala. Serafina Pekkala is able to make herself invisible through a concentration of

will to maintain "a fiercely held modesty" that enables her to move unseen to achieve her goal. However, Seera's goals appear to be to maintain her invisibility and through 'hiding' to avoid the risk of public exposure.

With students such as Seera it is difficult to know how they experience classroom practice. Indeed one potential weakness of qualitative classroom research is that it can tend to focus on vocal participants. However, Seera gives some indications of her perspective. Although she says she likes working from textbooks which for Nikita and others can be an individualistic practice, she also tells us would like to be part of a group and to discuss with others. Seera does not want to feel on her own and in spite of her relative silence wants to engage with others.

Kamal

Kamal is a British Asian boy: in current discourse Kamal would be categorised as a gifted and talented student. He doesn't "particularly like maths because it's not very fun because you have to work on paper and your hand goes all funny." In interviews and in informal classroom conversations with me, Kamal expresses negative views of mathematics regardless of particular classroom practices; "most of them [mathematics lessons] I hated, I dreaded it". However, he had not liked mathematics lessons at Primary school either. Kamal generally found schooling alienating although Art and Drama lessons were more enjoyable. His views on mathematics are reminiscent of students alienated from mathematics due its perceived impersonal nature (Boaler 2000; Williams and Ivey 2001) or indeed those of Louise.

Kamal was an outsider in the class; he did not have any strong friendships. He is academically able, and very articulate. Mathematics lessons lacked challenge for him; he said that every lesson repeated what he already knew, although he also felt like that about lessons in other subject.

Kamal described a typical mathematics lesson in the following way:

> There's three parts, the first one is explanation which is boring, the second one is questions which you have to answer which is also quite boring and the third on is what you've found out and that's what I call discovering and if you've already discovered it it's quite boring.

He would like more opportunities to discover things and "more practicals and more kind of not working through a book and more games". His preferred means of responding to teacher questions is for discussion before contributing because, "I think...if you discuss it you are also practicing your co-operation skills as well".

264

When speaking to Kamal a sense of ennui and despair pervaded his responses. His unhappiness was probably not only due to his experience in the mathematics classroom or in school more generally. However, he found little in his mathematical experience that prompted him to participate in any engaged way in the classroom practices.

CHAPTER SEVEN, FOURTH PIECE: DISCUSSION

Alienation and marginal participation

The perspectives of the eight students described above are representative of the general sense of alienation that students described about aspects of their mathematical lessons. This might appear surprising given that, in the last chapter, I discussed the ways that the ecology had one trajectory or pull in the direction of a learning community and gave an example of a lesson in which the students' engagement was greater. However, it is important to consider the timing of the interviews. They were conducted between December 2000 and February 2001. Thus the practices that are presented in the lesson in February 2001 in the previous Chapter were still being established. Moreover, in order to create the conditions in which greater student participation could occur, Jill had become, as some of the students put it, "stricter". This was resented by some of the boys. There is a paradox here, in that in order to ensure greater mathematical agency and author/ity (Burton and Povey 1999), Jill had restricted the students' social agency. I discuss this more fully in the last piece of the chapter. In addition I conjecture there is a lag between changes in social practices and the changes in the lifeworld. Hermeneutically, the meaning of social practices is created by the 'prejudice' in the lifeworld as much as the social practices help create the lifeworld. Previous studies of the experience of school mathematics tend to suggest that alienation from mathematics is deeply rooted (see for example Nardi and Seward 2003). Nevertheless many of the students who were alienated from the more traditional practices were more positive about alternative forms of response.

Care and self-worth

> The more I go about the place the more I realise just how much people feel themselves to be unlovable. (Roth 2003)

The eight students have different views of preferred forms of response to teacher questions and on the various social practices of the classroom. These arise from and can be understood in relation to different participative strategies that they adopt towards school mathematics and to the meaning of it in their lifeworlds and their ongoing project of authoring themselves (Holland et al 1998) in the mathematics classroom. Although the strategies they adopt are different, underlying them are the common themes of existential care and the preservation of self-worth.

In a philosophical sense the fact that the students care about the nature of their participation is not surprising. Heidegger argues that care is a "primordial" feature of being in the world; we care because we are involved in the world (Heidegger 2000/1926). In this primordial sense Heidegger's notion of care echoes the Husserlian notion of intentionality as a necessary feature of experience. However, beyond this the notion of care points to the basic anxiety of being in the world and the need to care for the self in an unpredictable, complex, and potentially painful environment[3].

In Chapter Five, I discussed Peter Ashworth's contention that the nature of participation was premised on a personal concern for presentation of self to others and maintenance of our sense of self. In the last Chapter, I pointed to Carol Jackson's analysis of "laddish" behaviour as a way, for some students, of avoiding the risk of failure. Jackson argues that one of the prime motivations for learners is the preservation of self-worth (Jackson 2003). The students' discussion of their various strategies tends to support the view that such concerns are paramount in the students' choice of strategies in relation to the practices and their preferences for particular forms of response.

This is summarised by the students with the term "embarrassment". The term embarrassment arose in all the interviews to describe firstly the danger of being wrong and secondly even the risk of simply standing out, of being the only one. Embarrassment appears to have two components for the students. Firstly, a relational concern connected to being-with-others. However, at least as important is their sense of being comfortable with themselves, of being secure in the identity they are fashioning for themselves. The dual aspect of embarrassment is an echo of the fear of public and private shame of the students discussed in Chapter Three. However, here the quality of the emotion is connected to being singled out or the only one. In this regard it is significant that these students are eleven and twelve years old, on the threshold of adolescence and presented with the task of more fully individuating themselves (Coren 1997; Roth G. 1990). I contend that it is precisely the delicateness of the sense of self at such a time, the almost painful tenderness of trying to know who one is in relation to self, others, and the world, which underlies the students' strategies[4]. This is in spite of

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[3] The applicability of aspects of Heidegger's notion of care, particularly its relationship to being-unto-death (see Heidegger 2000/1926, page 376-382), in relation to children is an interesting one and one worth investigating. Here, I will merely state that in so far as Heidegger offers us insights into the nature of being in the world, we ought not to assume that the nature of Dasein for children is the same as for adults.

[4] This is not say that the task of being oneself in the world is not painful and delicate for adults too at times. Indeed, perhaps this is always the case but we become better at finding strategies to avoid experiencing it.

the way in which some students do not immediately appear delicate or tender but rather to engage in conflict and struggle.

However, descriptions of practices and students' emotional response in inquiry or discussion based classrooms both in mathematics (Cobb et al 1992) and science lessons (Roth 1996; van Zee et al 2001) indicate that embarrassment is not a necessary feature of class discussion or questioning. In such classrooms the existence of a conjecturing atmosphere (Mason 2004) means that students' contributions are not evaluated in an individual way for their correctness as such but rather for their helpfulness in the whole group moving forward. Indeed, in the previous Chapter, in the lesson in episode two in which a local mathematical community of practice was enacted, students showed a much greater willingness to engage in discussion and certainly contributing or being wrong did not appear to have the same level of risk. Clearly, the forms of response that are preferred by most students, some variety of unison response or after discussion with others, all lessen the risk to self-worth.

Testing and comparison

> Who ever told you that the bamboo is more beautiful than the oak, or the oak more valuable than the bamboo? Do you think the oak wishes it has a hollow trunk like the bamboo? Does the bamboo feel jealous of the oak because it is bigger and its leaves change colour in the fall? The very idea of the two trees comparing themselves to each other seems ridiculous, but we humans seem to find this habit very hard to break. (Osho International 1994, page 126)

Given the research material presented in this thesis and of other studies concerned with the experience of learning school mathematics (see Chapter One), I believe that it is arguable that usual school mathematics social practices generally tend to undermine learners' sense of self-worth. It is not the questioning practices as such but the context in which they take place. One aspect of identity and our sense of self is relational; we know who we are in relation to others. In Heidegger's terms it is through our encounters with beings in the world like ourselves that the world is meaningful. However, in usual school mathematics lessons the particular form of this relationality is comparative: better or worse, quicker or slower, higher mark or lower mark, or indeed the restricted and constructed meanings of boy and girl.

Of course this is not only true of school mathematics but schooling more generally, particularly the context of testing which tends to colour the social practices and thus the way in which identity and identifications arise. The students' discussion of questioning indicates the extent to which there is an implicit assumption that questioning is about

268

testing knowledge. Some of the comparative aspects of questioning are more clearly articulated by students when talking about tests. In Seven Blue, the half termly tests brought with them the prospect, at least in some of the sub-groups within the class, that "when you have a low level people might laugh at you or take the piss" (Juan). For the 'drumming boys' a low mark leads to the label of "loser" but a high mark risks being called "a goody two shoes". In the locality that I teach in pejorative terms are 'boffs' and 'duggies'.

However, tests do not only involve comparison with other people but also with a more abstract notion of being able to do mathematics, or knowing 'enough' mathematics. We measure ourselves against each other and against mathematics. There is a second relational aspect of identity: comparison with abstract, reifications within our lifeworld. Such reifications can have archetypal power. In Louise's lifeworld (Chapter Four), at least as important as being compared to others is her struggle with numbers and mathematics and the representative or embodiment of mathematics: the teacher. When some of the girls in Seven Blue talk about tests this aspect is also hinted at. The topic of tests was introduced by the students when asked about aspects of mathematics that they do not like:

> Kerry: I hate it when there're tests because I get really nervous and that's how I get really wrong answers, I can't think...When you get the test when you write everything down that's what they [teachers] think that you can do but it's not like that because sometimes I write things down but I forget them but I do know them and I haven't written it down because I'm so nervous that I don't write it down.
>
> Susan: you get frustrated and you're hot and you're just like oh god and then you just want to rip up the paper and just throw it away.
>
> Jenny: you think of the answer you know the answer but it just gets out of your head, you know it it's still in your head but there is something covering it.

In the above statement Kerry says that it matters what the teacher thinks you can do. When asked why tests are important she says "Look at your tests, that's what you think". One reading of this reply is that the tests inform you of the extent to which you can think mathematically. This is supported by the extent to which Kerry dislikes tests because she finds that she "can't think" when she is tested. On this reading she points to the way in which the tests are a means for her to know her self. Although knowledge of 'self' here is alienated and distorted through the refracted lens of testing. For both her and Jenny there is a sense of the way in which the test interrupts their relationship to their mathematical knowledge; there is an echo here of Louise's description of fog. In

both this more abstract sense of comparison, 'comparing oneself with mathematics', and in relation to comparing oneself with others, the nature of school mathematics practices means that most learners are always at a disadvantage. There is always more to learn and more to know. If a student finishes a task they are given another. The current emphasis on individual targets can lead to continually being required to give more. When comparing themselves with others necessarily only a few learners can come top.

Based on the material presented here the above discussion is tentative and speculative. However, there were both boys and girls who articulated clearly that they did not like tests and if they could choose one thing about mathematics to change then it would be to stop tests or reduce there importance[5]. Reflecting on personal experience suggests that being discomforted by tests involves a combination of both the relational and more abstract aspects of comparison for all learners. It may be that the difference between this group of boys and group of girls is indicative of a wider gendered difference in relation to tests and testing. Constructions of masculinity and femininity may affect the extent to which comparing ourselves to others or comparing ourselves against more abstract and personal ideas of what we ought to be able to do or whether we know enough matters . This is a question deserving further exploration.

> Tansy Hardy and Tony Cotton offer a sobering account of a group of ten and eleven year olds approaching their end of Key Stage mathematics tests (S.A.T.s) with much anxiety. One of who says: "if I come out with a level 2 I will kill myself" (Hardy and Cotton 2000, page 284)

Teachers too

I have identified the protection of self-worth as a key shaper of students' participation strategies. The same is true of teachers. The teacher questioning interactions are not risk free for Jill. Given that the meaning of 'teacher' is closely tied to being the person who asks questions of students, (particularly in current discourse about teaching mathematics), during questioning interactions Jill is in a situation of risking her identity as a 'competent' teacher. However, the risk is to something more than that particular identification. Even though questioning interactions take place in the context of schooling, they remain interactions between people with all their anxieties. When a person is not listened to or ignored, including the teacher, it may be felt personally. Regardless of the general applicability of this, it was true for Jill:

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[5] All students did not articulate this, and some, such as Nikita, appear content with the testing arrangements. However, those who did would do so repeatedly or interrupt or divert discussion back to these issues. In a psychoanalytical framework such as process orientated psychology, such interruptions of even disruptions have a particular significance whereby individuals help to articulate unconscious group processes (see Mindell 1994;1985).

I don't think they can learn anything if they are not prepared to listen. It undermines my sense of myself as a human being; they have absolutely no respect for me at all. Not that I go in for this whole thing, 'I'm a teacher, I'm an adult, you must respect me', just 'I'm another human being'.

The teacher is also involved in the process of authoring themselves, protecting their sense of self-worth, and maintaining and developing their identifications. The teacher is also subject to the measuring quality of assessment and practices. The half-termly tests do not only measure the individual students but also are a means of measuring the teacher.

Engagement

Although protection of self-worth is a central factor in the choice of forms of participation another important facet of care for many, and perhaps in a refracted way for all, of the students is a concern to experience engagement[6]. As well as being concerned about being embarrassed, the students often refer to boredom as a feature of their experience of those parts of the lesson where usual school mathematics procedures dominate. In this they echo students in other studies (Boaler 2000; Nardi and Seward 2003).

The nature of what engagement means for different participants and what they wish to be engaged in is mediated by the students' identities. There is also clearly a tension between engaging in some of the classroom practices and the ensuing risks to self-worth. Nevertheless, I contend that in imposing particular practices on children we may overlook their desire to be engaged mathematically and with others. Earlier I pointed to the way in which we have no choice but to author our identities (Boaler and Greeno 2000; Holland et al 1998). However, it is important to recognise that we also desire to create our identities though engagement with self, others and the world. It is through action in the world that we "disclose" who we are (Arendt 1989/1958).

The shift between times when individuals, and at times the whole class, become engaged mathematically or even socially, within lessons and over longer time periods, are noticeable but difficult to describe. Peter Wimbourne's and Anne Watson's notion of local communities of mathematical practice goes someway to describe the features of times when a class is mathematically engaged (Wimbourne and Watson 1998a). Corinne Angier and Hilary Povey's notion of a spacious classroom suggest some of the social practices that may sustain and develop engagement over longer time periods (Angier and Povey 1999). However, Jill had to struggle with Seven Blue to create or

271

find moments of such engagement or to bring such local communities of practice into existence.

To some extent in this thesis I focus on those factors which act against student engagement, for example the context of usual school mathematics practices and the wider social practices in which schooling is located such as the construction of gender identities, rather than on those which foster it. Although there are plenty of accounts of alternative practices to usual school mathematics (see Chapter One), what is less clear is how to bring this about in the school contexts most teachers find themselves. There is a need for further research in sites where ecologies exist which are not always participative but which, as with Seven Blue, oscillate between engagement and disengagement. Or indeed with individuals such as the ones described in this Chapter who move between engagement and disengagement. I return to this in the next chapter; however, as a prelude to that discussion, I offer the following account from Seven Blue of a time in their mathematical lessons where they all were engaged.

Mouldy Chocolate

In every focus group, when asked to describe a good episode in a mathematics lesson or to imagine how mathematics lesson could be better, or indeed without prompting, a discussion would occur about a game played at the start of the year called 'mouldy chocolate'. Whenever one student in an interview mentioned this game, other students in the group would invariably smile or laugh. Amidst the diversity of student experience, 'mouldy chocolate' was a shared and common experience that had a similar meaning for all the students interviewed.

The game of 'mouldy chocolate' is played by drawing a rectangular grid, split into squares; this is the chocolate. One square of the grid, usually in a corner, is shaded; this is the mouldy piece of chocolate. The players take it in turns to 'eat' the chocolate by rubbing off a piece. The piece eaten must be a row or rows or a column or columns, which can be removed with single 'break' in the chocolate. The person who at the end must take the last piece loses the game. The game may be played by the teacher against a student or students or by two students against each other.

As in my discussion of students' concern to avoid embarrassment, there is of course nothing particularly novel in stating that children have a desire to play games. However, given the current emphasis in schooling on targets and assessment and

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[6] Again, as I noted in Chapter Five, I distinguish between engagement as way of participating in ecologies of practice and being engaged as a methodological approach to research (see Chapter Two).

'raising standards' it is worth reminding ourselves of this. Indeed the one thing that nearly all students interviewed in all the different phases of the research agreed on is that they would like more 'fun' in lessons. A view shared with students in other studies (Nardi and Seward 2003). However, there are two interesting features of this particular game and its meaning for the students. Firstly, it appear to be a collective signifier of what the students would like in mathematics lessons; the students would participate in and enjoy mathematics lessons more if they were more like playing 'mouldy chocolate'. Secondly, and in seeming contradiction to the students' concern to protect self-worth, the game does not appear to be risk free.

The game does not appear to be risk free because there is a clear winner and loser. Indeed it might appear that the game is not dissimilar to the times table competition described by Louise that is a public contest. Indeed, the scenario of being left with the mouldy chocolate would appear to potentially humiliate the loser in a similar way to the tables competition. Discussing the tables competition in their focus groups, students generally agreed that such a competition was embarrassing and they did not think it was right that children be made to do this. However, although the game of 'mouldy chocolate' appears to be a similar context, it differs in important ways. It does not test players knowledge of closed facts but rather offers a puzzle that the students do not expect themselves or each other to immediately be able to solve to find the optimal strategy. Most importantly, the game can be *played*.

Play

The relationship between play and learning is an important feature of influential educational literature and theory (see for example Dewey 1965/1915 and Piaget 1973/1929), although, arguably, the focus has tended to be on younger children. In mathematical education literature Brent Davis makes an important contribution to the discussion of play and learning for all learners (Davis 1996, page 211-225). He notes that in the secondary classroom play tends to be counter posed to "the serious business of schooling" (Davis 1996, page 212); it is recreational rather than productive. He draws on Gadamer's analysis of play (which along with conversation is a central metaphor used for the hermeneutic process) and contends that:

> ...he [Gadamer] uses the concept of play as he attempts to decenter the notion of subjectivity, for this movement is impersonal and not subject to subjective control. Rather within play, subjectivity loses itself; at some point the game takes over. In retrospect we say "I forgot the time," "I don't know how I did that." There remains, however, a subject of play, but that subject *is the play itself*. The game takes primacy over the players, just as

the subject of play takes primacy over the subjective consciousness of individual players (Davis 1996, page 215, original emphasis).

Going beyond Davis, I believe that when immersed in play through letting go of our subjective consciousness a more authentic self can emerge. The letting go of subjectivity here does not mean putting aside who we are but who we think we are. This is what Jack Kornfield in the quote above refers to as the "small self" (Kornfield 2000); for Gabrielle Roth the distinction here is between the ego and the soul, the unified expression of body, heart, and mind (Roth 1999; 1990). Paradoxically, in dropping self-consciousness, when people play more of who they are is immanent not less.

I believe that in their delight in their memory of 'mouldy chocolate', the students in Seven Blue instance the way in which the loss of subjectivity allows for self-worth to be risked. If it is the case that the need to protect self-worth may keep some learners from engaging in particular classroom practices, then one way of addressing this is by seeking to introduce the spirit of play into classroom activities.

Indeed, it appears that more participative classroom ecologies have such a spirit. In the previous Chapter, I discussed the February lesson as one in which something approaching a local mathematical community of practice was enacted. Although the content of the lesson does not appear to be very playful, the start of the lesson helps to create a playful context. One feature of play is that it "open[s] a space of possibilities" (Davis 1996, page 216), where the unexpected can happen. In that lesson both Jill and the students 'forget' themselves to allow a new practice to emerge. As the lesson moves on, even though carrying out a long division is not particularly playful the spirit of the game is maintained. Significantly, in this regard, the students are given a choice about what questions they can do. The desire for choice emerged in the interview groups, though examples given of enjoyable choices were generally from other subjects. For example, one group of girls contrasted mathematics with PE. In swimming lessons the students could choose the level of difficulty of their engagement:

Jenny: we get a choice in swimming

Paula: If we wanted to be piranhas, sharks or whales and they don't assess you

Kerry: you can choose which one is the hard one

Paula: they don't asses you so if you're not very good at one you go to the shallow end or deep end.

Significantly the issue of assessment is contrasted with choosing appropriate tasks.

Brent Davis gives an evocative description of what the role of the teacher is as a facilitator of mathematical play:

> And so the teacher is a learner with particular responsibilities. He or she is assigned tasks of presenting possibilities and, through attending to students' responses to these possibilities, opening spaces for play. Such play-fullness is only feasible when one allows for departure from the anticipated (play), fluidity in the structured (play), and uncertainty in the known (play) (Davis 1996, page 223).

I suggested above that play helps to overcome the defences of our subjectivity and self-worth that often prevent us from participating with others and experiencing the engagement we desire. At the same time our subjectivity and sense of self-worth can act as a barrier to entering into play. Thus in addition to the responsibilities of the teacher that Davis proposes I would add that of modelling a willingness to, at least at times, put aside one's subjectivity, ego, and 'teacher' identity. In the next Chapter I consider more fully alternative questioning and interaction practices and the possibilities of what it can and could mean to be a teacher.

CHAPTER SEVEN, FIFTH PIECE: LIFEWORLDS, TEACHER QUESTIONING AND DEMOCRATIC PRACTICE

Diversity of lifeworlds

In this piece of the chapter I address the way that this diversity of lifeworlds creates challenges for democratic classroom practice. The eight students considered in this paper have a wide diversity of strategies and forms of participation in questioning interaction. When asked about forms of response to teacher questions a variety of views are put forward:

> Nikita wants teacher questioning episodes to be got through as quickly as possible so she can begin individual work. The teacher should pick people rather than people putting hands up.

> Susan wants to avoid answering publicly and would prefer if answers were written down individually with the teacher giving the answers. A second preference is for forms of unison response.

> Lee would like to be part of "team".

> Paul wants time to discuss before answering.

> John has two conflicting views. Firstly, he wants people to be chosen 'fairly' to answer without putting hands but he also feels that opportunities for discussion are valuable.

> Jenny wants short closed questions that there is a straightforward right or wrong answer to. Forms of response are not a particular concern for her.

> Seera does not want to speak publicly and would prefer no verbal questions. If questions are asked she would prefer to discuss first before answering.

> Kamal would welcome opportunities to practice his "co-operation skills" before answering.

Although there is a tendency towards valuing discussion similar to the students discussed in Chapter Three there are also contradictory views. Indeed some of the students have internal tensions about their ideal. These are eight students of a class of twenty-three. Within the class we can expect an even greater range of different perspectives and viewpoints. This is certainly evidenced by the other students interviewed. Two students suggested that the teacher ought to accept responses from everyone with their hands up regardless of whether a correct answer had been given and then evaluate all responses. This was preferable to unison response for these two students. They emphasise the way in which for some students, the act of being the one who answers is at least as important as the mathematical content of the answer. This

gives further insight into the extent that the different social meanings of questioning practices for different students are not necessarily connected to learning.

An ecology of political practices

Seven Blue demonstrate that ecologies of practice are political ecologies. This should not be surprising given that the notion of an ecology of practice is a development of community of practice theory which partially addresses political and conflictual relationships that arise in social groups in which situated learning takes place (Contu and Wilmott 2003; Lave and Wenger 1991; Wenger 1998). This has led to the term communities of political practice to be put forward to stress this aspect of communities of practice (Boylan 2003[7]; Valero 2003). In Chapter One, I pointed to the way in which the practices of school mathematics are open to political analysis in a similar way to more general critiques of schooling and in Chapters Five and Six to the way in which notions of power and positioning between individuals and groups are important to understanding the nature of participation in practice. The political nature of Seven Blue as an ecology of practice does not arise only because the class exists in context of wider political ecology (as important as this is) but rather is endemic to any group of people in relation to each other who exist in different lifeworlds. The idea of political practice here follows the contention of Hannah Arendt that political action is part of the human condition (Arendt 1989/1958). Understood in this way, politics is unavoidable in a school classroom. Whether she or he likes it or not, a teacher's (and students') actions in the classroom are necessarily political in virtue of being in social relationship.

Classroom ecologies of practice are sites for political action in a number of different ways. They are social networks in which individuals or groups hold authority and status. This is most obviously the case in the relation between the teacher and class, but authority and status is also distributed amongst students in complex ways. Authority may be contested. There is a diversity of life-worlds, identity, and interests. This diversity means that there is a continual negotiation not only of practices but also of lifeworlds themselves. As in other social situations, in classrooms resources are scarce. In usual school mathematics classrooms, the way in which the teacher's attention and mathematical rank are commodified can add to this sense of scarcity. Such scarcity means that negotiation over practices and meanings may create conflict, for example in the conflicts between boys and girls in Seven Blue[8]. There are of course other more

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[7] In this paper I propose the notion that Seven Blue is community of political practice. This was prior to more fully critiquing the application of community of practice theory to school classrooms.
[8] This is of course a simplification. The roots of this conflict in Seven Blue between genders is complex and multivariate.

positive features of political life such as agreement, shared experience and purpose and solidarity. These too exist within Seven Blue and within and between sub-groups.

Democratic Practice

There are many and varied perspectives on the nature of democratic classroom practice with contributions from different traditions (see for example Apple 1999; Dewey 1965/1915; Friere 1972: Goodman 1956; Harber 1995; Holt 1963; Patterson 1973; Rogers 1983/1996). These have informed discussions about democratic practice in mathematics education which I briefly discussed in Chapter One (see Angier and Povey 1999; Burton and Povey 1999; Noddings 1993; Povey and Boylan 1998; Frankenstein 1990; Gates 1997; Harris 1998; Knijnick 2000; Noddings 1993; Mellin Olsen 1987; Christiansen 2000; Skovsmose 1994; Skovsmose and Nielsen 1996; Valero 2002; Vithal 2000). My aim here is not to evaluate or even discuss these different perspectives but rather but to add to them by considering two challenges for what democratic practice means for teachers that follow from the discussion of Seven Blue in this and the last Chapter.

Diversity of lifeworlds

One aspect of democratic practice is that learners should shape the social practices of the classroom. A simple reading of what this might mean in Seven Blue in terms of teacher questioning practice is that the students ought to be able to decide how they respond to questions. The diversity of lifeworlds present in Seven Blue indicates that this is not a simple issue as the students have very different ideas of what classrooms should be like and very different needs and desires. There is no universal ideal that the teacher can implement that will accord with the expressed desires or needs of all.

I described this as simple reading of democratic practice. It accords with a static or discrete or mechanical notion of democracy that underlies, for example, electoral democracy where once a vote is taken then democracy is over; some will win and some will lose. An alternative to this is participatory democracy that focuses not only on outcome but also on process. Such a process view does not regard participants' initial positions as fixed but rather seeks a democratic process which allows for and fosters fluidity and change. Such an approach to democratic decision-making informs the participatory action research tradition (Reason 1994b, 2001b, Fals Borda 2001, 2002). Methods that can facilitate such processes are many and varied with different emphases. Often the aim is to achieve consensus or a decision that 'everyone can live with'. Attention is paid to the importance of embracing the emotional aspects of people's

278

perspectives as well as interpretation and reasoning in making decisions (see for example ICA:UK 2002; Seeds For Change 2003; Stanfield 1999). Some participatory processes also pay particular attention to ensuring the widest possible participation by bringing awareness to factors that inhibit participation and to relations of power in groups and avoids quick consensus that might conceal hidden relations of power. One approach to this is through the concept and practices of "deep democracy" developed in the context of process orientated psychology (Mindell 1995). From a deeply democratic perspective, each lifeworld not only involves a legitimate viewpoint on, in this context, teacher questioning that ought to influence classroom practices but also is an integral part of a collective group field. Each lifeworld and the beliefs and desires that arise from and within it, contains a truth that not only the individual but also the collective needs to have expressed. Deep democracy also posits that individual positions are aspects of powerful intrapersonal and interpersonal psychic forces. As such relations of rank and power can be processed.

Taking a participatory democratic approach to the diversity in Seven Blue would require a dialogue between different participants. Such a dialogue creates the possibility not only of arriving at decisions that everyone can consent to, but in that process what is likely to emerge (with appropriate facilitation) are the underlying factors such as the students' (and teacher's) fears and anxieties.

From such a standpoint the teacher has the challenge of finding ways of facilitating dialogue between the different lifeworlds within the community. From this perspective, democratic practice is concerned with creating the conditions for the opening of horizons of understanding (Gadamer 1975) between members of the community or in an alternative perspective of creating the conditions for fuller participation.

As I write now, the notions of participatory democracy and deep democracy appear far removed from the sort of school ecology in which Seven Blue came together for their mathematics lessons. They also appear far removed from the everyday pressurised lifeworld of the teacher. I ask myself, am I suggesting one more thing that teachers will not have time to do, something else to add to the burden of 'teacher guilt'? I am also minded of the extent to which (some) students resist such more participative, discursive and democratic practices and the challenge this causes for democratic practices (see for example Goos, Renshaw and Galbraith 1998; Lather 1991; Quicke 1994).

Yet at the same time, the re-identification of the teacher as facilitator is prevalent in accounts of more participatory classrooms (see for example Angier and Povey 1999;

Roth 1996; van Zee et al 2001). Regardless of the difficulties of fully enacting such an approach in the current schooling context, the participatory approach does supply a range of 'tools' that can be used to effect 'openings' in the social relationships in the classroom. For example, in Seven Blue, the students had relatively sophisticated analyses of the reasons for each others' forms of participation. This could have formed the basis for a discussion about how people were or were not participating. In dialogue I return to the issue of how to create 'openings' in the final chapter.

Democratic practice and engagement

Enacting democratic practice in the school mathematics classrooms is no easy task. In the case of Seven Blue, material in the previous chapter illustrates the extent to which the social practices and related identities prevalent in the wider social ecology inhibit participative practices. Democratic participation requires a prior agreement on and willingness to: respect and listen to others, to focus and engage with the group process, abide by agreed procedures, and acquiesce to the facilitator's authority. It requires openness from everyone who is involved (Spencer 1989), respect for diversity and a sense of collective responsibility.

These dispositions are also products of and are generated by experiencing participative processes. The self-affirming nature of participative processes is part of their power, but as with any virtuous spiral, the spiral has to begin somewhere. In Seven Blue there were clearly barriers to the spiral beginning. Moreover, the way some students engaged in the social practices of the classroom actively worked against the participation of others. This creates a dilemma for the engaged educator. In Chapter Two I wrote about the way in which the concept of engagement developed, in part, in response to the difficulty of wanting to foster participative processes in situations where others do not immediately want to act participatively. Such a situation existed in Seven Blue during the Autumn Term 2001. In order to begin to address the question of what engaged action in such a situation might be for a teacher, I will explore the dilemma presented to me as a researcher.

Challenges for an engaged researcher

In December 2001 I conducted my first interview with a group of girls from Seven Blue. At this point the social practices of some of the boys was a particular issue for Jill. Indeed our work together had begun with a focus of how to create a more discursive atmosphere in the class where students would listen to each other. During

the interview with the girls it became clearer that the boys practices were experienced by the girls very negatively, as shown by these comments made during the interview:

Mark: Do you tend to be able to understand the teacher?

Seera: Yeah sometimes if there's not a big racket in the class

Mark: A big racket?

Seera: Yeah and boys and people are talking

Angela: It's so annoying when you're trying to listen to the teacher

Nikita: And they like interrupt the teacher and the teacher has to stop shout and she gets mixed up sometimes

Nikita: I'd get rid of all the people who bother the teacher and disrupt her when she discusses something.

Jade: I think there should be a girls' class and a boys' class because then the girls would learn more

The extracts do not convey the emotional strength of the contributions (similar views were expressed by the girls interviewed in February). The girls experience presented me with a dilemma. These girls were being adversely affected by some of the boys actions. I was reminded of the students interviewed at East High School and the way that there were a significant group of boys also marginalised by particularly forceful constructions of masculinity. From observation and informal discussion I also had empathy for these boys; disenchantment from school mathematics is understandable. I had positioned myself as a participant observer in the class. I had an analysis and understanding of the dynamics of drumming and shouting out as social practices in this particular class. Moreover, as a teacher with experience of similar classes, I also had an understanding of ways to prevent or change these practices.

My dilemma was whether to intervene by sharing my knowledge with Jill to help her change the situation or whether to remain disengaged. I chose intervention. I did so giving up the pretence that the students could be democratically involved in participatory action research with the class in the way that I hoped for or to be a neutral facilitator of dialogue. Effectively I was choosing to take sides.

In so doing I also transformed myself from participant observer to a conductor of surveillance (Foucault 1977; Hardy 2000; Hardy and Cotton 2000). This did not mean that I told Jill everything I saw or heard, or that I made transcripts of interviews available. Rather I chose to share what I judged would further create the conditions in which participation could take place. This involved a responsibility of care to the students and Jill. The details of what this meant in practice could itself be the subject of another thesis and as I wrote in the Preface I have chosen not to make the research

281

process the subject of the thesis. However, the principle that I adopted was to use the power that I had because of my identity, experience, and rank productively.

This productive use of power also guided my support for Jill. Participative classrooms involve the teacher developing students' author/ity (Burton and Povey 1999). In so doing there appears to be a transfer of power from teacher to students. But you cannot give away what you do not have. Jill needed to have more power in the classroom to create the conditions for participative practices to be successful. As I wrote in the previous Chapter, one reading of the February lesson is that both Jill and the students have greater power in the classroom than in the December lesson. If this is the case it must be recognised that this occurred in part through the exercise of what would appear to be quite traditional classroom practices and an exercise in relatively authoritarian ways of being in the classroom, such as seating the students in rows. This is not to negate the importance of more participative practices such as providing reasons for classroom practices or involving students in choosing where they sit.

Although the research context in this case is limited it has implications that go beyond the particular case. Some of the questions that it raises are: is it justified and advisable to act in a non participatory way to foster participation and if so when; how do participative groups and organisations deal with people who are not committed to participative frameworks, or even listening to each other; how far is it acceptable to impose discipline as a necessary part of the discipline and freedom duality? I am aware that I could be accused of offering another version of 'it's for the good of the children'. (Jardine 2002). Schools currently do not generally support participatory processes; however, even in more favourable conditions some of the issues reverberate. In a consensual framework, a facilitator's role is to support the group process, regularly getting consent (or not) for the group process to proceed (see ICA:UK 2002; Seeds for Change 2003). Nevertheless, even in such situations the facilitator has a great deal of power and authority sometimes obscured by the participatory language. Perhaps, even more reflexivity is needed in what appear to be easier contexts.

In the context of the wider ecologies of practice that each class exists in and is part of, there are powerful social practices that prevail. The field in which we attempt to foster greater participation is not neutral. In Seven Blue, prior to Jill's increase in authority in the classroom, the social practices that enact a very particular if dominant form of masculinity were prevalent. These did not disappear later but there was greater space for alternatives and in a very concrete way greater space for girls in the class to speak.

Moreover, I believe that the observed experience of all students changed, with all students, at times, experiencing the sort of engagement that they desired and less of therisk to self-worth that they feared.

CHAPTER EIGHT

THE LAST CHAPTER: TYING, KNOTTING, LOOSENING, UNRAVELLING, AND UNDOING SOME THREADS

> It is not merely a question here of confronting ideas but of incarnating them and making them live, and in this respect we cannot know what they are capable of except by trying them out. This attempt involves taking sides in a struggle. (Merleau-Ponty 1963, page 27)

FIRST PIECE: ABOUT THIS CHAPTER

Final chapters traditionally are places to review and recapitulate what has already been stated, bringing together and perhaps critiquing some of the earlier conclusions. Returning to the textile metaphor introduced in the preface, in this chapter I select some of the major threads of the thesis and variously try to tie them or tangle them together, to loosen or unravel fibres, knots and tangles. Yet I also find that as I approach the end of this project, I still have things I want to say that are not yet said. If I still have your attention this may be my last chance to say what needs to be said[1]. In the textile metaphor there are still places in the weave that call for additional threads or threads that call to be woven in.

Given these different, and to some extent, conflicting concerns the form of this Chapter is more akin to a montage or collage than a straightforward narrative, with different parts to some extent standing separately from each other. In order to bring some organisation to the Chapter, I have separated it in to five more pieces that give space to reflexivity about the research as a whole, both in a formal academic and a more personal sense, and to the foci of the research denoted in the title. These five pieces are: Limitation of the Research, Ecologies of Practices and Lifeworlds, Teacher Questions, Questioning School Mathematics, And So?

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[1] And as the final act in a performance my last opportunity to impress. Some of characteristics of participation in the social practices of teacher questioning and school mathematics also apply to mine and others' participation in the social practices of research and research writing. I do not have the space here to develop this fully In the last piece of this chapter I briefly consider one aspect of this.

SECOND PIECE: LIMITATIONS OF THE RESEARCH

The scope and applicability

The research on which this thesis is based shares with all other research limits in terms of its scope and applicability. Indeed part of the methodology of the research was a commitment to seek local knowledge. The research and thesis has multiple concerns and the extent of the limitations of the claims and conjectures in the thesis, and what 'local' means, varies with these. I will focus here particularly on the learners' experience of teacher questioning, mathematical lifeworlds, the nature of participation in school mathematics and the concept of ecologies of practice.

Although the material presented here is part of a wider corpus generated during the research studentship, this corpus itself is still small and as such does not lead easily to generalisation if it is considered in isolation. Nevertheless, given other evidence on students' general experience of school mathematics I believe that I am justified in arguing that many students experience the practices of teacher questioning in usual school mathematics in a negative way.

In addition it is clear that the meaning of teacher questioning in the lifeworld of different participants is not the same. However, even in the analysis of the students' views on, and forms of participation during, questioning interactions in Seven Blue there is a degree of conjecture about the meaning of questioning of students and purposes and dispositions that inform their participation.

I also make more abstract and general claims about the nature of social formations that arise in classrooms, the nature of participation, and the importance of the lifeworld as an analytical tool. These more abstract theoretical claims with respect to ecologies of practice and the nature of lifeworlds have been developed through methodologies and approaches, which do not seek absolute truth and certainty but rather interpretation and greater understanding. Nevertheless, the claim that school mathematics classrooms that I worked in and with during the research are not generally communities of practice is one which I believe is one that has more general applicability not least because my claims in relation to this are based as much on argument as on evidence.

The focus on questioning

The thesis has focused on teacher questioning interaction in classrooms as a context to understand more about mathematical lifeworlds and ecologies of practice. Yet questioning practices are part of, and contextualised in, more complex and varied

discursive patterns than grammatically direct questions (see for example Mercer 1995). Arguably the questioning as a unit of analysis is overly restricted.

Brent Davis proposes a radical way to reanalyse the meaning of the teacher-learner relationship by focussing on listening. He argues that three distinct modes of listening occur in mathematics classrooms: evaluative, interpretive, and hermeneutic listening (Davis 1996). Descriptions earlier in the thesis of the teacher's role in the social practices of usual school mathematics, particularly during question interactions, typify the nature of evaluative listening. The teacher is detached, seeks to move according to a plan which is not altered by student responses. The teacher's central practice is to evaluate student answers. Interpretive listening involves the listener, in this case the teacher, attempting to understand the perspective of the student; the aim is "to *access* subjective sense rather than to merely *assess* what has been learned" (Davis 1996, page 53, original emphasis). Such listening can be identified in some of the alternative practices discussed in the thesis and in particular below in inquiry classrooms. Hermeneutic listening is "more negotiatory, engaging and messy, involving the hearer and the heard in a shared project" which requires "an ongoing interrogation of the taken-for-granted and the prejudices that frame perceptions and actions" (Davis 1996, page 53).

I do not have the space here to give as much attention to Davis' thoughtful, insightful and challenging perspective that it deserves: particularly the relationship between different modes of listening and play. To do so briefly would, ironically, be to evaluate or interpret his ideas rather than to respond hermeneutically in the way they deserve. Nevertheless, his work should alert us to the fact that changing the nature of social practices in the classroom is not simply a question of adopting particular techniques. The same question or indeed ways of expected response will have different meanings in the ecology depending on how people listen to each other. Rather, it challenges us to consider how we can develop our ability to listen more fully to others.

However, teacher questions and forms of response are a concrete means to enter into dialogue with children (and teachers) about their experience in the classroom in a concrete way. The hypothetical situation (Vithal 1999; 2000) of a more participative ecology is not one that is generally part of the experience of children or teachers, at least with respect to mathematics in schools, but it is relatively easy to create an arranged situation (Vithal 1999; 2000) of changing the ways in which students respond to teacher questioning. As I have I argued previously, teacher questioning practices are both

indicative and productive of wider school mathematics practices: it is through such practices as how students answer and how they speak to each other that ecologies may be changed. I will return to this central issue below.

Participation

Throughout the thesis there is an implicit assumption that participation and interaction with the teacher in classroom discussion is a good thing. I believe this is a justifiable position to take. Nevertheless, this involves an view that it is unacceptable to be silent in class and that all should speak. In the previous Chapter I reported on Seera's uncomfortableness about being the centre of attention, and that this is not simply to do with the risks of being wrong in front of one's peers but simply being in the vulnerable position of being given their and the teacher's attention. I believe that all of us ought to be able to receive each other's attention and an inability to do so is indicative of the way in which we often grow up wounded[2]. To overcome such wounds at some point(s) we need to subject ourselves to the gaze of the other as painful as this may be. But it is important, not only morally but in terms of efficacy, that each person can exercise agency as to when it is and when it is not an appropriate time for them. Whilst I may be uncertain about much in relation to what ought to be done in the classroom I do know that it is wrong for teachers to seek to embarrass children.

Constructing the learner

Traditional questioning practices construct the learner in particular ways, these include being able to: answer quickly, defer to the teacher, show eagerness by raising one's hand to answer questions, be prepared to only speak occasionally, and to sit still. Below I describe alternative questioning practices that arise or have been developed in more inquiry-based approaches to learning mathematics or indeed other subjects such as science. However, it is important to note that such approaches also act to construct the desired learner albeit in different ways.

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[2] The fact that some people appear more comfortable with others' attention or indeed demand it, for example teachers, is not necessarily an indication of less wounding. One reading of the constructed identities in relation to teacher questions of children in Seven Blue is that some identities are constructed as 'masks' through which attention can be received without more vulnerable parts of these children being exposed. Speaking personally whilst I feel comfortable about being given people's attention whilst in the role of 'teacher', I find it much less comfortable to receive others' attention when it is simply given to me for being me. Note the construction in that sentence of the commodification of attention: it is something that is exchanged for something else. In any case, you could try getting together with a group of friends and take it in turns for one person to be given the attention of the others in silence for a brief period and see what you feel about it.

Valerie Walkerdine argues that 'progressive' primary education[3] normalises and regulates the child as a subject that is able and willing to 'reason' in ways required of her or him according to constructed notions of 'normal' child development (Walkerdine 1988,1996,1997). Thomas Popekwitz develops a similar argument in relation to reform mathematics in the United States that notions such as 'self-motivation' and 'self-esteem' and 'autonomous learner' can be incorporated easily into policy without challenging the ideological nature of schooling (Popekwitz 2002). Popekwitz extends his argument to the notion of 'community' which he argues is "a salvation narrative" and points out that "community participation and decentralized political decision-making for example, co-exist with centralizing processes of [the] new educational management schemes" (Popekewitz 2002, page 47).

Both Walkerdine and Popekwitz rightly point to the way in which whatever classroom practices we adopt or attempt to foster, learners (and indeed teachers and mathematics) are constructed in particular ways. This is unavoidable, the teacher has power in a classroom ecology and whatever they do, even if it is nothing, will have consequences in the ecology and for the way in which the learner authors or does not author their identity.

The way we expect learners to involve themselves in classroom practices clearly involves issues of equity. Material presented in the thesis highlights the question of gender but this is not the only issue. Robyn Zevenbergen conjectures that one reason that working class students have lower achievement rates in school mathematics (measured in terms of qualifications) than middle class students is because working class students are less comfortable with the sort of triadic exchanges (see Chapter Three) that pervade mathematics (Zevenbergen 2000). However, it is also possible to argue that the more discussion orientated practice would also be a "code" (Zevenbergen 2000) that middle class students would find more familiar or be more comfortable with.

Popekwitz also alerts us to the way in which the discourse of community can be used as a means to conceal continued marginalizing and oppressive practices and as a tool of "micro-management". His argument can easily be extended to 'participation'[4]. The discourse of participative communities could be employed to avoid substantial changes in social relations. However, they can also be locations in which new more integral relations are explored and created and thus be a means for social transformation.

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[3] In more recent terms what might be called a discovery orientation (Askew et al 1997).

In one sense there is no 'way out' of the post-modernist argument about the construction of the subject or indeed of the way we construct discourse about the social formations in which the subject is constructed. One possible response to this leads to nihilism and despair. However, in Chapter Two I discussed the possibility of a post-modern hermeneutics and, parallel with this, engaged practice. From this perspective it is possible to be simultaneously involved in the 'construction' and aware that a construction is taking place. This dual awareness gives space for 'fooling around' with the expectations, practices and constructions in classroom. Tony Brown and Liz Jones address this dilemma through the notion of the teacher as transgressive agent whose: "Transgressions interrupt and as a consequence create an uncertain space where boundaries, including those that shore up notions of self, are made insecure (Brown and Jones 2001, page 154). Actually crossing boundaries is not so difficult if one remembers not to act like a teacher. I return to this in later.

The focus on school mathematics

The argument that the research is too narrowly focused on teacher questioning can be extended to my more general focus on "usual school mathematics", as opposed to schooling as whole. From this perspective focussing on usual school mathematics represents an acceptance of dominant forms of thinking in which mathematics is given an ideologically central place in the curriculum (Coldron 2003). This criticism certainly has weight in terms of addressing the question of why usual school mathematics practices are dominant in terms of policy. This question is not one that I have examined in any depth for the purposes of this research. However, the focus on school mathematics arises out of my own personal identity and situation; this is the part of the world that I am located in and here it is that I should act. Moreover, my research was aimed at finding the spaces to act to change particular school mathematics ecologies of practice. 'Schooling' is not only an abstract concept but consists of the myriad practices and ecologies in which participants act and make meaning. I believe one weakness in Foucault's conception of the specific intellectual (see Chapter Two) is that it is not specific enough. The focus for social change must not only be on the 'big picture' (and it must be) but also on the moment to moment situation; this relationship, this interaction, this 'here and now'.

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[4] Others have pointed out the way in which Lave and Wenger's term community of practice has been depoliticised by some organisational learning theorists (Contu and Wilmott 2003).

In addition, I believe the mathematical experience matters. One of the reasons that school mathematics is given a prominent place in the curriculum as a core subject is because of the way in which mathematics has a "formatting power" in society (Skovsmose and Yasukawa 2000); mathematics is part of the way we are in the world in this society. Moreover, I suggested in my analysis of Louise's lifeworld that this is not simply some ideological construct but is part of our way of being in the world.

I believe that one of our most urgent tasks in education is to find ways to reconnect learning to an awareness of our relationship with the earth and universe. Some have suggested that truly "transformative learning" that can bring about such reconnection calls for and requires a renewal of a "universe story" (see O'Sullivan 1999; Swimme and Berry 1992). I believe that mathematics has a contribution to make to this. The worlds we create in mathematics are social worlds: real living people have created them. They are full of beauty surprise, coherence, order, chaos, clarity, mystery, certainty and much, much more and this is a testament to the power that we all have to manifest these qualities in our lives. And it is in the relationship between these imagined worlds and the natural world that we can find an affirmation of our relationship with the rest of existence. That worlds of human imagination are so embedded in the universal ecology shows we are not separate from the greater web of being.

Gender

The issue of gender is one that emerged during the research but one that requiring further analysis and investigation. In any research about the experience of learning mathematics the question of patterns of participation and gender will arise (see for example Barnes 2000; Boaler 1997a, 2000; Mendick 2002; Povey 1995; Walkerdine 1988,1989; Walkerdine, Lucey and Melody 2001; Zervenbergen 1999). However, perhaps, the question of gender is particularly stark because in this research both of the two key classroom research sites, the unequal power relationships between boys and girls in classrooms was made more manifest by the unequal numbers of boys and girls in the class. Although I have attempted to address some of the questions of gender differences in participation and lifeworlds in the thesis, these issues remain relatively unexplored. The material presented in this regard is therefore open to further interpretation and more specific gender orientated research on the experience of participation in teacher questioning interactions.

Dialogue

I began the second year of the research project with the working title "Opening dialogue about the experience of learning mathematics". My belief and intention was to effect change in the classroom through such dialogue, but in the event a dialogue did not really occur between Jill and her classes. Perhaps a better characterisation would be 'some opening remarks that might start a conversation'. I have already give details about why this was the case earlier and will not repeat them here. However, some of the material and analysis I have presented indicate some additional embedded reasons why achieving dialogue is difficult in mathematics classrooms. Conversation and dialogue requires an openness towards others that is rarely present in situations of anxiety about our sense of self-worth. This is true for the students but also for the teacher. To embark on a process of conversation with one's students is to enter a process in which the outcome is necessarily uncertain. Secondly, the social practice of dialogue itself needs to be taught and requires a certain degree of structure and tacit agreement to allow it to occur (for example, turn taking in speaking). In retrospect the extent to which Jill was willing to begin entering into dialogue with the students and being willing to work with me is quite remarkable. Moreover, in doing this she was opening herself up to, and risking criticism from, her students.

Whilst a full dialogic process did not take place, some of the research tools and methods I used do have a wider applicability for those seeking to foster dialogue. In the interviews with Seven Blue, I used research material from earlier cases to generate discussion. An additional step would have been to offer my interpretations of the different students' strategies to them for comment. This was not possible in this particular situation, not least because much of my analysis occurred after I was fully involved with the class. However, in classroom situations we do not need a full analysis to attempt to enter into dialogue with our students.

Recent socio-cultural research that seeks to understand the experience of learning mathematics has gone a long way to question assumptions about the efficacy and 'ethicacy' of school mathematics practices. A further step is to begin to enter into dialogue with different groups of learners. I hope I have contributed to that process. Researchers working in other paradigms are much more concerned with issues such as validity and triangulation than I am. One way of triangulating research 'findings' about

291

what happens in classrooms would be to summarise these in a form that is understandable to the subjects of the research and to ask them to respond to them.

Learning together mathematics

In the Preface to the thesis I discussed the extent to which this particular text only reports on some of the research activities that occurred during the studentship. During the second half of the year working at North High School, Jill and I worked together on exploring ways to develop more co-operative practices in her Year Nine class. This involved a similar dialogic process as with Seven Blue, of survey and interviews both with her class and another Year Nine group. One outcome of this work was to produce a set of materials called "Learning together mathematics lessons: promoting community and group work in the Year Nine Classroom"[5] (See Appendix V). Although a 'complete' document and set of resources were produced and some, though not all, used in the classroom, this could easily have been the starting point for further co-operative inquiry.

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[5] This work was supported by the Mathematics Education Research Group of Sheffield Hallam University who financed time for Jill to participate in the production of materials.

THIRD PIECE: ECOLOGIES OF PRACTICE AND LIFEWORLDS

The value of concept of ecologies of practice

In Chapter One I described the way in which Lave and Wenger's concept of communities of practice has been an important reference point in some recent mathematics education literature. It offers a way of linking social formations to social practice in learning contexts. It also highlights the connection between learning, practice, and identity. However, as I discussed, its adoption and use in mathematics education has been with reservations as various writers have pointed to ways in which it does not fully or accurately describe school classrooms (see Chapters Two and Five). I believe that I have developed a strong case A that it is not helpful to describe usual school mathematics classrooms at least as communities of practice and this rests in part on an analysis of the nature of participation in usual school mathematics classrooms.

Introducing the concept of ecologies of practice does not in itself explain all the phenomena in question and there are alternative ways of understanding them. For example, Jo Boaler and James Greeno proposed the notion of ecologies of participation in figured worlds to analyse what might be seen as the sedimentation of participation in practices, students' experiences and identities in different situations (Boaler and Greeno 2000). Carol Linehan and John McCarthy use the idea of positioning to analyse particular moments in the classroom (Linehan and McCarthy 2000, 2001). The material presented in this thesis could also be usefully reanalysed using, for example, the sort of Foucauldian tools that Tansy Hardy and others bring to looking at classroom practice (Hardy 2000; Hardy and Cotton 2000).

However, I believe the particular contribution that the notion of ecologies of practice makes is that it encourages us to continue to ask some of the questions that Lave and Wenger ask about communities of practice: what is the nature of participation, what are the trajectories of participation and what are the boundaries of the community or ecology? The notion of ecology not only conveys a sense of the diversity in the classroom (I believe under-theorised in Lave and Wenger's account), but also of the links and locations of the practices in and as part of wider ecologies. The concept of an ecology also allow us to ask how similar and how different school classrooms are to communities of practice and other existent or theoretical learning networks. In Chapter Two, I discussed the way in which two different theoretical meanings of community of practice theory are conflated in Lave and Wenger's work: firstly a generalised theory of learning and secondly an anthropological theory about the social formations in which

293

learning takes place. The position that I take is that it is deficient as a generalised theory of learning and has limited applicability as an anthropological theory. However, I believe that one once we recognise that school mathematics classrooms are generally not communities of practice simply because learning takes place in them, there is a possibility for Lave and Wenger's insights to have greater impact in formal education settings. Communities of practice and the type of relationships that arise within them are ways of being together that people can choose, where appropriate, to create. In the thesis I have focused on the applicability of community of practice theory to the classroom. However, the some of the issues I raise about the theory would apply to other contexts that are more recognisably communities of practice.

Participation and different types of practices

The nature of participation is central to my argument about ecologies of practice. In order to understand the different types of participation in school classrooms then the notion of legitimate peripheral participation needs supplementing. In particular, the nature of participation in usual school mathematics classroom is best described as marginal. This concept was generated largely through a consideration of the students' experience of school mathematics. I believe that the concept of marginal participation is congruent with findings about the different type of learning that occurs in different sorts of classrooms (see Boaler 1997).

In this thesis the term 'participation' is also used in a different way, in the sense of 'participative inquiry' or 'participative democracy'. This different use of the term opens the possibility for confusion and generally I have tried to keep the use of the two terms separate, although, in places, I have also referred to the notion of creating a more participative experience or developing more participative practices. However, there is a connection between the different uses that distinguishing between different modes of participation helps to bring out. 'Participative' in the sense of participative democracy at least involves full participation that occurs for old-times in a community of practice and perhaps involves the type of reflexive participation found in learning communities.

For simplicity, when discussing social practices I have tended to make few distinctions between different types of practice other than between those practices that are most obviously mathematical and those which are not. In so doing I have largely ignored considering practices according to their particular nature and purpose in the ecology. For example, Etienne Wenger contrasts practices which are aspects of the 'work of community maintenance' amongst claims processors is with that of processing claims

294

themselves (Wenger 1998). I believe that the analysis of the importance of self-worth and similar issues in Seven Blue suggests that theories of social practice do need to take account of the qualitatively different types of practice that we engage in. In particular considering those social practices that are relatively invariant across different ecologies.

Lifeworlds

In this research the concept of the lifeworld has acted as a means to address the different meanings that social practices have for participants in mathematics classrooms. The case study of Louise's lifeworld indicated the extent to which the experience of mathematics is for some people a cause of deep anxiety. This anxiety is related both to the relationship with other learners of mathematics (public shame, embarrassment, ranking and so on) and a more direct relationship with mathematics. The ontological nature of mathematical entities in Louise's lifeworld was not generally that of tools but rather more like 'beings-in-the-world like ourselves'. There is clearly scope for further detailed phenomenological research of this sort into the mathematical lifeworld of different learners. The lifeworld analysis in Chapter Four interrogated and adapted categories drawn from Heidegger's phenomenology. Other ways of analysing lifeworlds are possible. For example, Peter Ashworth suggests that lifeworlds may be considered using the following 'fractions': selfhood, sociality, embodiment, temporality, spatiality, project, and discourse (Ashworth 2003). My discussion of Louise's lifeworld overlaps or makes reference to many of these fractions however, reconsidering her lifeworld more fully in these terms would be worthwhile and useful.

Louise's lifeworld alerts us to the way in which the mathematical lifeworld of the learner can be very different to that of the teacher. I believe it is also a powerful argument for change in the social practices of school mathematics; not every learner has such a painful experience but I believe that if some do it is reason enough to seek to change classroom practices.

In the discussion of the practices of Seven Blue, the notion of the lifeworld served as a background epistemological and ethical commitment rather than a central analytical tool. The nature of the interviews and the fact that the participants were relatively young children means that a detailed description of their learner's mathematical lifeworlds was not generated. I contend that just as the questioning practices had different meanings for the students in Seven Blue, so would mathematics itself.

Asserting the existence of the lifeworld is congruent with a commitment to deep democracy. In the last Chapter, I introduced the notion of deep democracy as an

existential-ethical-epistemological standpoint that views the practices and views of *all* actors in a community or ecology as being valuable. They are valuable existentially and ethically because they are expressions of different aspects of existence and so require attention and understanding even when not agreed with. They are valuable epistemologically because they are all 'parts of the puzzle' of understanding. A lifeworld perspective is deeply democratic in its attempt to appreciate others' worlds as they are[6]. It also privileges a first person account by the research participants. The lifeworld perspective, if nothing else, urges us not to assume that the meaning of a social practice for different participants in a practice is the same simply because they all take part. If we wish shared social meanings then we need to find ways to ensure all partake (Bohm 1996).

Lifeworlds and ecologies of practice

In seeking to understanding other's lifeworlds we ought to avoid the mistake of believing that the others world is completely separate from us; the children's world is different from the adults but they are still both in the world together (Jardine 2002). If they were not then there would be no possibility of conversation or understanding between them. Understanding ourselves and others as in and indeed as being lifeworlds is important not as a prelude to connection but as a way of remembering that we are connected; I am in your world and you are in mine. One way to think about the apparent paradox of distinct lifeworlds existing as part of a single world is to consider each lifeworld is as a distinct way in which the universe knows itself.

In the thesis I have generally used the notion of the lifeworld and of ecologies of practice as two distinct frames of reference. An obvious question arises as to the nature of the relationship between ecologies of practice and lifeworlds. One way to think about this is that different participation in different ecologies creates or causes changes in the lifeworld. It might also appear that the nature of our lifeworlds, both in terms of structure and detail, is productive of the nature of our participation and so the shaping of the social practices. This suggests that the lifeworlds and ecologies of practices exist together in a relationship of dependent co-arising (see Appendix V and Varela Thompson and Rosch 1991; Macy 1991). However, even this is misleading, because the lifeworld is not the experience of ecologies of practices rather ecologies of practices

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[6] A similar democratic concern is found in the work of some Participatory Action Research practitioners who stress the importance of describing and relating to the 'vivencia' (lived-experience) of participants (Fals Borda 2002). The term vivencia appears as a translation of 'Erfahrung' indicating, perhaps, the influence of the phenomenological tradition.

are at least part of and possibly all of the lifeworld[7]. They are two different ways of speaking of the nature of being-in-the-world, one starting from the personal and the other from the social.

Regardless of the relationship between the lifeworld and ecologies of practice as concepts it is clear to me that we do need to have ways of speaking of these two aspects of being-the-world. It is interesting that theorists such as Dorothy Holland and associates posit the notion of figured world as an integral part of their analysis of social practice and agency (Holland et al 1998). Even if the concept of lifeworld derived from phenomenology is rejected, I believe some similar notion is necessary to make sense of the people's participation in and their experience of social practices.

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[7] Such a view depends on a deeply ecological perspective (see for example Macy 1991, Seed et al1988), in which we do not restrict the notion of meaningfulness and social only to human actors but understand that a plant, and animal, or indeed a rock, sun or moon does have in its own way meaning in relation to the whole of the rest of existence and not only in relation to that part of the universe which has particularly human consciousness.

FOURTH PIECE: QUESTIONING IN SCHOOL MATHEMATICS

> Don't say you are right too often, teacher
> Let the students realise it
> Don't push the truth
> It's not good for it
> Listen while you speak
>
> (Brecht 1979, page 436)

Questioning questioning

In reviewing earlier research (see Chapter Three), I summarised previous work that calls into question the value of the forms of questioning that dominate in school mathematics classrooms in terms of their productive power to generate discussion, participation or indeed learning. Material in this thesis adds to this critique. Regardless of issues directly connected to learning, what is clear is that some questioning practices are stressful and in some cases distressing for learners in the context of usual school mathematics. Where questioning is experienced as testing of knowledge then questions may have this effect. Teacher questions can engender feelings of shame and embarrassment. Moreover, participation strategies in questioning and response practices often have little to do with learning or engaging mathematically for many learners but rather are concerned with protection of self-worth and position in the class. There are important issues of equity, particularly with regard to gender in dominant questioning practices.

However, the way in which questioning is experienced and the nature of participation is related to the wider classroom ecology. For example, in Seven Blue at times in which the students became mathematically engaged, their willingness to answer questions (and to ask them), and to risk being incorrect was greater. In all the focus groups interviewed both in Seven Blue, other classes of Jill's and at East High School there was an agreement that questioning was helpful to learning. Indeed, when asked to rank a series of statements on teacher questioning, in all groups the students placed the statement 'The teacher does not ask questions', as least helpful to learning, even though they also placed this as a situation that would decrease their anxiety. In Chapter Three, I wrote about the way in which the practice of asking questions is a core aspect of what it means to be a teacher both in learners' and teachers' lifeworlds. This may help to explain why the children interviewed did believe that being asked questions is helpful to their

learning. However, an alternative explanation, and conversant with the desire for engagement discussed in the previous Chapter, is that the students did want to be challenged by their teachers and recognised this as important to learning. I choose to adopt the hopeful view that the desire to learn, grow and develop is a basic human disposition, and when students show countervailing tendencies it is because of personal wounding or systemic failure to provide a nurturing, supportive and challenging learning ecology.

Although the number of participants in my research has been limited, I do believe that both their accounts of their experience and my analysis of questioning indicate that changing questioning practices in school mathematics classrooms is a worthwhile goal in itself and also can be a way of changing the wider social practices of particular ecologies.

Alternatives to usual questioning practices

> When a teacher asks a question, and then is able to hold silence and attract students to want to express themselves, she or he displays being. It takes considerable self-confidence and considerable effort (often in holding back or withdrawing, in creating absence) in order to generate conditions in which students are willing to participate in a conjecturing atmosphere. When a teacher invites students to talk in pairs about some issue it takes considerable being to bear the loss of immediate control, in the expectation that the action generated will produce individual and collective construal.
> (Mason 1997, page 375)

If we wish to move school mathematics classrooms in the direction of learning communities then this entails a change in questioning practices. Happily, descriptions of inquiry based classrooms, both in mathematics and in science, indicate that there are alternative questioning practices that do encourage greater participation.

John Mason provides a straightforward and applicable summary of ways to help create what he terms a "conjecturing atmosphere" (Mason 2002). He suggests that "controlling" questions and funnelling recitations ought to be asked rarely, focussing questions[8] (Wood 1994) sparingly and with reflection. Instead he urges "genuine enquiry" that the teacher does not know the answer to, though as he points out this will not necessarily avoid a learner experiencing such questions as a form of testing:

> It is important to remember that no matter how genuine a question is, the fact that it is being asked by a teacher is likely to lead the learner into

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[8] Terry Wood identifies a pattern of interaction, which she refers to as "focussing". In a focussing interaction questions, even when asked to individuals, are aimed collectively at the whole class. The questions serve to focus the classes' attention on the important or critical aspects of the mathematical situation and invite the class to problem solve (Wood 1994).

believing that the teacher knows the answer and expects the learner to know it too, and/or that what the learner has been doing is not correct or not appropriate. Thus the fact that a question is being asked is likely to generate a defensive stance. Unless of course that a different working atmosphere has been developed in the classroom. (Mason 2002, page 250).

Although I concur with his view that the way inquiry questions are experienced varies according to the type of "working atmosphere", I offer the following anecdote as a reminder of just how ingrained our experience of questioning as testing can be. At a group facilitation training workshop, the trainer was illustrating a focused conversation method by using a short video sequence. After watching the sequence she began by asking people to say what they had noticed. There was not a single correct response; any answer could be correct if that was what one had noticed. The facilitator was warm and empathic, appeared to be genuinely interested yet was met with silence. The first woman questioned was clearly anxious. My interpretation, and this was borne out by our discussion later, was that the woman questioned was not sure what she was being asked and perhaps there was something important that she had not noticed that everybody else had. I was immediately reminded of Louise when she told me how when faced with a calculation she was not sure of that she was "totally nine again" (see Chapter Four). As the woman became more embarrassed the empathic facilitator relieved her distress by moving on to the next person who was now in the spotlight, but fortunately was able to stammer out, "what do you mean?".

This was one particular incident; however, what I believe was significant about the incident was that we as participants did not yet know the 'rules', we did not know it was okay to say anything, nor did we really know where the practice we were taking part in was going. This was not because it had not been explained to us, rather because we had not yet experienced it. To partake of a practice rather than simply take part requires familiarity and an understanding of the purpose of the social practice.

Another way of thinking about this issue is that when we respond to a question we will be less anxious if we know what is going to be done with our response. One principle that I urged Jill to adopt when seeking to alter the way in which Seven Blue interacted in whole class situations (and more generally) was to be explicit about the social practice that was expected and the reasons for it. More generally in descriptions of the development of mathematics 'communities of inquiry' we find a similar emphasis on the importance of explicitly addressing and 'teaching' preferred forms of social interaction (Cobb et al 1992; Roth 1996, van Zee et al 2001; Wood 1994).

300

Studies in science classrooms[9] in which student inquiry and learning through discussion are valued also reveal aspects of alternative questioning practices that encourage student participation. Wolf-Michael Roth studied an expert teacher in an "open-inquiry learning environment" (Roth 1996). Questions were often opening and invited an extended response. In addition questions were asked about investigatory procedures, this type of questions are referred to as meta-questions by John Mason who considers them to be an important way of changing the relationship to questioning in the classroom (Mason 2002). The teacher also asked a significant number of questions about emotional issues. These encouraged individuals, groups, or the class to reflect on their feelings about the learning process. Such questions can be read as implicitly recognising the inseparability of emotional, cognitive, and social process. They also help to develop and maintain the sense of the class as a learning community. This emphasis on weaving a concern for the emotional into cognitive tasks is reminiscent of Corinne Angier and Hilary Povey's account of a 'spacious mathematics classroom' (Angier and Povey 1999) and also an important aspect of some techniques to facilitate participation in other situations (ICA:UK 2002).

Roth recorded the virtual absence of evaluation by the teacher. The lack of evaluation did not affect the basic power relationship between the teacher and students, which was still clearly asymmetric. For example, when talking to groups, the teacher exercised her authority to interrupt students to seek further justification or require rephrasing. Overall the teacher's questioning strategies seemed aimed at scaffolding the students' discursive activities to lead to independent accounts and articulate student centred discussion.

A group of educators working in a variety of settings aiming to encourage students to discuss their ideas and to formulate insightful questions of their own report the success of similar strategies (van Zee et al 2001). This group stresses the importance of developing 'discourse structures' that invite students' contributions and the importance of a respectful and attentive response to these and the creation of a comfortable environment. Taking a pragmatic approach to different structures of interaction, they report a process in which teacher centred guided discussion can be transformed into what they term 'student-generated inquiry discussion':

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[9] Neither of the two studies that I discuss particularly distinguish between teacher questions in interactions with the whole class and groups of students, as group work was a prevalent feature in both settings (see Roth 1996, Van Zee et al 2001).

> During student-generated inquiry discussions, teacher questions are rare but student questions occur frequently and spontaneously. The students may erupt in a "cacophony" (Gallas, 1995, p37) in which they vociferously share their thinking (van Zee et al 2001 page 163)

In Seven Blue, one of the factors that inhibited students' learning was the frequency of other less productive cacophonies caused by the students who 'shouted out'. Earlier, on in our work together I noticed that Jill would sometimes accept students' contributions when they were not invited but sometimes she would insist on them only speaking when invited to after putting their hands up. When I pointed out this apparent inconsistency she said that she accepted spontaneous contributions if they were 'helpful'. What Jill points to here is the relative complexity of some of the unspoken 'rules' that learners (and teachers) have to negotiate in classrooms to participate legitimately; it is not easy to define or describe when interruptions are helpful and when they are not before they are made. After discussion Jill attempted to clearly delineate and tell the students when they could only speak when invited to and when it was okay to 'shout out'. Generally, even the limited lifeworld analysis in Seven Blue indicates that we cannot assume that the meaning of a social practice is the same for participants just because they all participate in it. The reasons for and meanings of social practices require discussion if shared meaning is to be generated.

During our work together I came to refer to this as 'making the social practices explicit'. Essentially this means to report on what you are doing and why. This has implication for how the teacher models mathematical practices as well as the more classroom procedural practices. Making the practices explicit is also important with regard to engaged or transformative practice. Given the context of schooling sometimes an engaged teacher has to act in ways that do not accord with the sort of democratic social relationships that they are attempting to foster, for example when implementing assessment arrangements. Or indeed, the need in Seven Blue, to use 'surveillance' and 'discipline' productively to create conditions in which greater experiences of participation could be developed. Teaching is a mirror of life in the way in which often our choices are between actions which engaged teachers can be more or less uncomfortable with rather than enthusiastic about. Partly this is due to the situations we find ourselves in current educational contexts but also partly because of the nature of the human condition with its real physical limits and boundaries. In such situations at the very least integrity demands we give an account to the students of why we are doing what we are doing and our best understanding of why such practices exist.

Forms of response

One of the key methods I employed to prompt discussions about teacher questioning practices was to ask students to consider forms and means of responding to questions. Students' views across different locations are naturally diverse. However, in the last chapter I emphasised the extent to which concern with self-worth coloured students' experiences and was important in the strategies they chose to adopt. More concretely, most students indicated that they would like interactions to move away from responding individually to having an opportunity to discuss before answering. However, as some students in Seven Blue pointed out, there is only any point in discussing before answering if there is something worthwhile to discuss.

Asking students to discuss before answering is very easy to arrange in any classroom. I suggest that this is rare in school mathematics classrooms. This is supported by informal surveys with student teachers visiting many different schools and is supported by my experience in teaching as a supply teacher working in a wide range of schools. John Mason points out that asking students to discuss in pairs risks the "loss of immediate control" (Mason 1997, page 375). When I discussed this practice with Jill she responded that she was "afraid that I won't get them back".

Perhaps a reluctance to use this simple technique is understandable given the current constructions of the competent teacher as a person 'in control' and connected to this pervasive managerial ideology coupled with the existential anxiety and fear of loss of self-worth identified in the last chapter. As John Mason puts it, it requires a certain degree of "being" to "bear" this loss (Mason 1997). It is uncomfortable for the teacher, you do not know what the students are discussing although of course it is always the case that you do not, when they are silent, generally know what they are thinking. However, this discomfort does lessen the more times the technique is used.

The practice of discussing with the person next to you as a routine feature of classroom practice could potentially be a catalytic practice. In part this is because it calls for meaningful, genuine inquiry questions to be asked and such questions are likely to create a diversity of responses that would require reflecting on. It gives each individual moments of participative and shared learning and a sense of not being alone in an individual struggle with mathematics and against each other (see Chapter Four and Seven). The teacher explicitly signals that mathematical participation is more important than their 'control' of discussion. It encourages students to discuss mathematics at

other times during lessons. Less speculatively, a concrete example of practical knowledge arising form the research is that when discussion before answering is part of the students' experience they welcome it.

In most (school) classrooms, most of the time, if a student wishes to speak they raise their hand. At the end of this project I continue to have ambivalent feelings about this. 'Put your hands up' is an important technique of control in classrooms. It signifies and typifies the power of the teacher in relation to the students; the teacher does not have to put their hand up in order to speak. In addition, as seen in the previous Chapter, when a student puts their hand up it can have all sorts of meanings as well as or instead of those connected to participation in mathematical discussion. Part of my work with both Peter (Chapter Three) and Jill (Chapters Six and Seven) was to explore alternatives to 'hands up'. I note again how in student generated discussion science lessons some of the most productive periods were when a cacophony erupted and, presumably, the hands up convention abandoned (van Zee et al 2001).

However, my experience as a facilitator suggests that conversation or discussion in social groupings of more than approximately eight people requires some sort of mechanism or agreed practice of how people speak in turn and generally a person or people to facilitate the discussion. Sometimes for ease of flow of discussion I have been in groups that have, for short periods, dropped the facilitator role and 'self-facilitated': however this only works if everyone gives attention to facilitation (see Seeds for Change 2003 for a discussion of facilitation). If adults find turn taking difficult in group discussions that it is not surprising that children do too. As we have seen in Seven Blue, where 'hands up' was not enforced the discussion was unsatisfactory for all and some students were marginalised.

In group discussions in non-school contexts, indicating that one wishes to speak by raising one's hand is useful and as good as any other. We do it because it is easy and it works. I believe the issue is to find ways for the practice and meaning of raising one's hand in a classroom context to be more akin to that in other situations. In non-school contexts[10] when a hand is raised it indicates that the person wants to speak. Unless the facilitator asks and is given agreement by the group to curtail discussion, it is accepted that if one wishes to speak then one has the right to. Moreover, people are not generally expected to keep their hands raised whilst others speak but rather their desire is

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[10] In this discussion I refer to discussion that take place in participative and consensual groups; the practices of 'chaired' meetings both differ and overlap these.

acknowledged and recorded or remembered by the facilitator. If we wish to foster participation in classroom discussion then we need to find means to change the social practices of the classroom to be more like this.

One significant difficulty in doing this and more generally in fostering discussions in school mathematics contexts is that the teacher is both the manager of the discussion and a significant contributor to it. Generally speaking in non-school contexts a facilitator will only take on that role if she does not have a lot to say about yhe content of the discussion. In the study by Wolf-Michael Roth described above, the teacher was able to step out of this dual role at times. When interacting with the whole class in discussions the teacher's participation was similar to the students, for example waiting her turn to be invited to speak by the student who was presenting ideas to the class (Roth 1996). Of course this practice is a consequence and part of a particularly participative classroom ecology. However, if we wish to create such ecologies then one way to do this is to adopt their practices. One possibility is to give the role of facilitating discussion to a student so that the teacher can focus on their role as mathematical expert. Such skills like the skills of participating in discussion more generally need to be learnt.

In our early work with Seven Blue, Jill and I experimented with using hand signals to support discussion. Here I drew particularly on my experience of group discussion and decision-making in the ecological direct action movement[11]. The use of a small number of signals such as indicating agreement through silent applause can help the flow of discussion and consensual decision-making. In Seven Blue, silent applause was introduced to allow students who were not chosen to answer a question to show agreement with the person who did; this effectively allows more than one person to speak at once. Many students enthusiastically greeted the use of the hand signals and there were early indications that the class was beginning to develop its own indigenous practices. The use of hand signals in this way has an element of play in it and helps to create space for embodiment of social practices in the mathematics classroom. This is an area where I believe that there is much potential for further development and research.

The interviews with students in Seven Blue also indicated that some like being able to answer simultaneously. Simultaneous response might appear to run counter to the

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[11] My understanding is that the use of hand signals in the direct action movement originates in the peace movement in the US, though I have no evidence for this.

desire for discussion; however, both lessen the risk of potential individual censure or embarrassment. Currently, in the UK, particularly in primary schools, there is a growth in the use of choral participation and simultaneous response to questions that relies on various tools such as individual whiteboards. Yet the social meaning of such forms of response and how they change the nature of interactions in the classroom is under researched. Earlier in the thesis I referred to an example reported of how an individual whiteboard was used by one student in a sophisticated way to author a particular identity in the classroom by avoiding mathematical engagement (Denvir et al 2001). It is remarkable, though perhaps unsurprising, that significant changes in classroom practice warranted and encouraged by what is near statutory policy (Boylan 2000) are relatively under researched (Brown et al 2000).

Anne Watson has undertaken preliminary research on "unison" response by examining classroom interactions in South African classrooms, which for cultural/historical reasons and economic reasons (lack of resources and class size), use unison response frequently (Watson 2003). In this context unison response refers to an oral response. In these classrooms frequently unison response was in the context of teacher recitation and rote learning that did not develop understanding[12]. However, she also points to the way in which unison response may serve important social functions in terms of creating a sense of shared purpose and practice. Choral response might appear the antithesis of individual expression that a respect for diversity and the individual lifeworld implies. Moreover, they are forms of interaction which are 'traditional' in appearance. However, chorusing (though not necessarily in response to questions) means that a spirit of play can be introduced into the classroom. Further it can allow students a sense of being part of a collective who are together engaged in a learning process. Unison responses also introduce an element of ritual into the social practices of the classroom that is generally a feature of community life[13].

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[12] However, Watson also points to the way repetition may be a necessary requirement for abstraction and the complex relationship between factual knowledge and understanding in mathematical problem solving (Watson 2003).
[13] I do not have space to explore it here but there is an important distinction to be made between ritual and routine; usual school mathematics classrooms have too much routine and not enough ritual in my opinion.

FIFTH PIECE: QUESTIONING SCHOOL MATHEMATICS

> I have argued that the current conceptions of mathematics, of education, of learning, and – perhaps most of all – of teaching are violent, where "violent" is intended to provoke a sense of thoughtless transgression in addition to its more familiar sense of furious destruction. It is violence that is deaf to (and ultimately silencing of) the voices of its victims – ourselves. Moreover mathematics teaching is, in my opinion – and I speak here as a teacher who has been complicit in the project – not amoral, as it claims, but indisputably immoral. In allowing itself to forget that its subject matter is a humanity, it has become an inhumanity. It is thus that we have created a system that values compliance over creativity, that spawns destructive behaviour by destroying our experience, and that conditions learners to reach for the formulaic ahead of the imaginative. (Davis 1996, page 281)

Finding spaces to dance where none can be seen

There is apocryphal story about a traveller, who stops and asks the way to get to their destination, at which point the local replies "If I were you I wouldn't start from here". I feel similarly about school mathematics. I believe that the material presented in this thesis adds to a growing body of work, which questions the value of the practices of usual school mathematics by focussing on the socio-cultural experience of the learner (Angier and Povey 1999; Bartholomew 2002; Boaler 1997,2000; Boaler and Greeno 2000, Boaler, Wiliam and Brown 2000; Breen 2000; Burton and Povey 1999; Mendick 2002; Povey and Boylan 1998; Nardi and Steward 2003). In Chapter One I discussed or pointed to various reconceptualisations of what mathematics teaching and learning can be and indeed alternative practices that have been enacted in current school classrooms.

I do not intend to add to these here[14] but rather to consider how we can find 'find spaces to dance where none can be seen'. That is, given the pervasive ideologies of schooling, the pressured reality for teachers and children, and all the other multiple factors that constrain our space for creative action, to offer some answers to the question what can be done in today's school mathematics classrooms. One of the outcomes of the thesis is the belief that we do need to pay close attention to the very specific nature of the ecologies of practice we find ourselves in, therefore general prescriptions are unlikely to be universally applicable.

In the thesis I have focussed on the experience of the learner, but central to the premises of the thesis and to the methodology is the belief that the teacher can be an actor for

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[14] However, the extracts from a document co-authored with Jill in Appendix V does make a contribution towards this.

change. I believe we actually do know a great deal about the sort of social and mathematical practices that create a more meaningful and pleasurable experience for learners (and indeed teachers). What we know less about is how to bring these practices into existence and to sustain them in what are often infertile and difficult situations where not only the general context of schooling but indeed the sedimentation of student alienation and resistance can be barriers to more participative practices (see Goos et al 1998; Quicke 1994). There are many potential starting points for practitioner research in this area not least on the nature of the sort of social practices that teachers who foster participative classrooms enact and correspondingly the subjectivities and identities that they author for themselves and by so doing potentially for others. In the context of mathematics education Hilary Povey has begun to address this issue in her study of beginning teachers "working for change" (Povey 1995). Brent Davis' focus on teacher as listener is also an important contribution (Davis 1996).

At the same time, I believe that my discussion of democratic practice with respect to Seven Blue, in the previous chapter, alerts us to the way that in opening up spaces for greater autonomy requires the awareness and creation of boundaries to practices. Moreover, if we are to explore unknown mathematical territories with our students then we must recognise that this is a challenging and potentially fearful task. To use Louise's terms we are asking learners to step into "the fog" for sometime: they need assurance that it won't trip them up.

I believe that teacher education is inadequate in terms of preparing teachers to enter into and develop into the sort of more personable relationships that students call for in mathematics classrooms (Nardi and Steward 2003) or indeed in developing the quality of being, as John Mason puts it above, to sustain silence or developing mathematical discussion in the classroom. Teacher education to foster this would not foreground atomised competencies of even subject knowledge, but would rather spend time developing skills to foster awareness of self and others. Given, as I think this and other socio-cultural research shows, that learning is in part concerned with the authoring of identity student, and indeed existing, teachers would benefit greatly from participating in practices that make identity and authoring their foci. Such practices include psychotherapy and the performing arts; I am serious in stating that I believe all teachers would benefit from a short or indeed long course at clown school. However, given that even empiricist psychology is marginalised in the teacher training curriculum I do not have much hope of any policy changes in this direction in the immediate term.

However, just because it is difficult to see the spaces to dance in the current context of schooling it does not mean we cannot find them. To find spaces to dance where none can be seen we need some techniques that may help us to open up or get into such spaces. Sometimes if we find ourselves constricted without room to move, seemingly caught and trapped in routines of our or others' making, then it can be enough to find, metaphorically, one body part that can find a little movement. From here all can eventually come into movement. So more than a little ironically, in the spirit of the post-modern sound bite and "little books of...." I offer some aphorisms or short suggestions, about ways of that teachers can be and act in the classroom, ways of interrogating their practice and also some of the support they need both in terms of teacher education and later. The attentive reader will see how these are grounded in the thesis are echoes and responses to earlier discussions[15].

Pieces

Mathematics teachers would be better being sent to clown school than to higher education institutions to learn how to teach. But it's never to later too fill in this missing part of one's education (though getting it funded out of the INSET budget might be hard).

Be ruthlessly patient about insisting that students listen to other people in the classroom.

Accept that the students may be ruthless in insisting when it is time for you to stop speaking.

An engaged teacher recognises the limitations of school mathematics and may be deeply critical of it, yet none the less this is the 'game' in which her community is engaged with and against which her community will be judged and more importantly against which the students will judge themselves. The students and teacher need to take part in this game is space for play is to be found. It may help to be honest that it is a game.

If the situation is becoming hopeless mathematically or otherwise do something unexpected.

'Poor' behaviour is a sign of alienation. Look at those areas of the curriculum where there is less student disaffection, for example Design Technology is an example (in most schools). Ask the question how could a mathematics classroom be more like a DT classroom.

Students like teacher's have to learn how to come and use a board effectively.

When a student is working at the board, try sitting in a student's seat and putting your hand up.

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[15] And a particularly attentive reader may notice that the inclusion of these "Pieces" in this form is consistent with some of the advice they offer; I believe I have created enough space through my earlier conventionality in this thesis for a slightly more playful dance than more choreographed styles.

When you have to do things you do not agree with at least tell the students that is the case.

The ecological hermeneutic teacher is essentially a pragmatist who is aware that one of the purposes of their practice and identity is to introduce the students into the practices of school mathematics. Whilst she encourages her students to develop their own structures and enthusiastically enters into them she brings the agreed reified practices of school and other mathematics into play when appropriate.

Remember it's not your fault and it's not theirs either. Guilt does not help.

Don't do it alone, find your allies.

Play games.

Students can't exercise agency and author/ity unless they have choices. At the very least if they have to use a textbook exercise allow them to choose a question.

Lack of order is something that generally culturally we fear or avoid. This is particularly true in schooling and within schooling particularly true in secondary schools. Yet the essential rhythm of adolescence is chaos. A creative chaos that, if nurtured, supported and held in appropriate boundaries rather than denied or stifled can allow young people to begin to fashion the stories they wish to tell the world about themselves through their actions and ways of being in the world. It is a tremendous irony, that mathematics, which tells us that all complex systems are inherently mathematically chaotic, is experienced in school as a site where order is paramount. Accept chaos but make sure you have established the boundaries needed to contain it.

Make sure you make mathematical mistakes.

Ask questions you do not know the answer to.

To listen hermeneutically and to support student autonomy requires self-awareness and an ability to rest in the fear that arises when one lets go of control. So teachers need to find ways to increase their self-awareness and their ability to rest in such anxiety. Inservice training courses do not generally support this at least the one's mathematics teachers go to. Try going on a course for drama teachers and see if that helps.

The secret of resistance is joy.

Don't put the easiest question first and the hardest question last. Try putting the questions in a circle.

We ask children to pay attention, perhaps we ought to model this. If we pay attention to others they change, if we pay attention to the practice we are engaged in then it changes the nature of the practice: when does breathing become meditation? How much *attention* do we pay to the children.

If you see that a student is bored say "you're bored" and see what happens next?

If you find that you are bored then do something about it.

An engaged teacher accepts that they have to carry out the practice in the way that the ecology of practice they find themselves in demands and can even do so diligently but

310

attempts to do so consciously and so will look for the opportunities to do something which turns the situation on its head.

Ask the students.

SIXTH PIECE: AND SO?

Not knowing

> Now one rather annoying thing about scholars is that are always using Big Words that some of us can't understand ...
>
> "Well the customary procedure in such cases is as follows."
>
> "What does Crustimoney Proceedcake mean?" said Pooh. "For I am a Bear of Very Little Brain, and long words Bother me."
>
> "It means the Thing to Do."
>
> "As long as it means that, I don't mind" said Pooh humbly.
>
> ...and one sometimes gets the impression that those intimidating words are there to *keep* us from understanding. That way the scholars can appear Superior, and will not likely to be suspected of Not Knowing Something. After all, from the scholarly point of view it is practically a crime not to know everything. (Hoff 1982, page 28)
>
> Nobody has all the answers. Knowing that you do not know everything is far wiser than thinking that you know a lot when you really don't....Anyway, it's a relief to be able to say I don't know (Heider 1985, page 141)

In the Preface to the thesis, I stated that:

> The notion of claim is one that I am suspicious of. Making a claim has a resonance of securing territory or property. There is something competitive, definite, and fixed about it. Yet I do not feel this way about the contribution that I am making. 'Claiming' fits with a notion of knowledge that does not sit easily with the methodology I use, the methods employed, nor with the theoretical positions I argue for. In particular it is counter to a sense of knowing as a process.

At the same time, I argued that as part of the process of knowing, definite statements ought to be made and position taken. As the thesis comes to an end I wish to reassert the provisionality of the claims made in it. This is not because I think that the statements made are particularly tenuous, or that they do not arise from a credible approach to research, but rather because they are a means to gain greater understanding than final positions. And more important then this "to say I don't know" about many of the issues and questions that are unresolved and indeed in many ways unasked in this thesis. And to an extent I am happy to rest in the acceptance of the mystery of the complexity of human life. However,...

Is it good enough?

> Story telling is always quietly subversive. It is a double-sided axe. You think it faces one way but it also faces you. You think it cuts in only one direction but it also cuts you. You think it applies to others only, when it applies mainly to you. When you think it is harmless that is when it springs its hidden truths, its uncomfortable truths on you (Okri 1998, page 43)

...I also ask myself the question of whether my research is good enough. Peter Reason and Judi Marshall believe that the choices we make of the subjects of our research are not arbitrary but reflect unresolved or unconscious issues for participants (Reason and Marshall 1993). Such a perspective would also flow from a hermeneutic understanding of the research process. In my own case I certainly concur. I have chosen not to foreground the personal nature of my research but I am aware of how my 'story' is intimately bound up with the choices I have made, the questions asked and the direction of the research. In Appendix II I include some autobiographical material and an insightful reader will be able to make connections between this and my research process. However, this autobiographical account like the thesis as whole is an act of presentation and, as in any situation, when something is 'revealed' something else necessarily is obscured. Moreover, I have not chosen to share more intimate aspects of my history; I too, like my research participants, fear the gaze of the other.

However, as Ben Okri puts it, story telling is double-headed axe and the story I have told in this thesis about self-worth also applies to me. I believe that for all participants in classroom practices the issue of self-worth is important. I further believe that culturally, as part of our collective lifeworld, we all have moments, perhaps everyday, where we feel ourselves to be, in some way, not good enough. The fact that this is so is a terrible indictment of our system of schooling. However, I do not think we all feel this to the same extent. Self-reflexively one central part of my research process has been to ask myself the question, in different ways, "is it good enough?".

In the dream that was The Prelude to the research, students in the classroom are caught in a process of measuring and being measured. This is then contrasted with a situation in which each unique person can make his or her distinct and changing contribution to the whole. If I was to be congruent with this latter vision then perhaps I ought not seek to measure my research against some external criteria (regardless of the fact that it is intrinsic to the social practice of awarding PhDs that this is done). However, one aspect of engagement is to engage in social practices as they are but to do so with conscious

attention, to act them out (Kornfield 2002). So and with some humour, I ask myself the question does this research 'measure up'?

For what it's worth?

> All good research is *for me, for us,* and *for them*: it speaks to three audiences....It is *for them* to the extent that it produces some kind of generalizable ideas and outcomes....It is *for us* to the extent that it responds to concerns for praxis, is relevant and timely...[for] those who are struggling with problems in their field of action. It is *for me* to the extent that the process and outcomes respond directly to the individual researcher's being-in-the-world. (William and Reason 1993 quoted in Reason and Torbert 2001, page 9)

This research has been 'for them'; in that I believe that I have contributed to theorising about the nature of learning through and in social practice, the social formations that arise with such practices and about the nature of participation and purposes of the participants. Moreover, I believe I have made a small contribution to lifeworld research. However, even though these social theoretical claims are some of the most substantial, they are not, for me, the most important. I agree with John Mason when he writes that that "the most significant products are the transformations in the being of the researchers" and that "second most significant products are stimuli to other researchers and teachers to test out conjectures for themselves in their own context" (Mason 1997, page 357). This, in Reason and Marshall's terms, is the "us" and the "me"[16].

I cannot articulate the extent to which my being has changed as a result of the research nor the extent to which this change in being is a consequence of my research experiences or of the freedom the research gave me to pursue other routes for self-development. The current ideologies that are hegemonic in mathematics education are those of bureaucratic managerialism (Boylan 2000) and technological rationalism (Ashworth 1998). The same ideologies and forces are found in higher education and influence the process of social research. I was given the privilege of conducting a piece of freethinking, exploratory research and to be supported in my desire to do that, not least financially. Crucially, people in my institution have *trusted* me as a novice researcher and the research process. They have, if in only a small way, defended educational values that are being attacked in all areas of learning. For this I am very grateful. I know from talking to my peers that others have often had much greater constraints.

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[16]This 'them/us/me' distinction ought to be used cautiously; I am, for example, one of them as well as one of us and a me.

I do not know whether my future lies in the academy, in the classroom, in schooling, or in other contexts, or indeed in a combination of any or all of these. But I do know that I am more able to be with others in ways that create and foster genuine embodied participation – so yes in answer to my own question, it measures up, and by extension so do I.

With regard to the extent that this research might be a stimuli for others not only the thesis but also all the other reports, seminars, presentations, conversations, and discussions that I have had formally and informally with others ought to be considered. Therefore, this question is one of those areas that I have to say "I do not know" and in any case perhaps can only be answered in the future. However, for one of 'us', it has certainly been worthwhile, both from her own account and from what I see. Jill, the person with whom I had my closest research relationship, was certainly influenced positively by the research. She continues to teach, is now, from a somewhat ambivalent earlier position, committed to mixed ability teaching, is a reflexive teacher involved in practitioner research and is making a contribution beyond her own classroom by involvement in professional gatherings. She is committed to the classroom and recently encouraged me to return to classroom teaching full time. Of course she is mainly responsible for her own development and it is impossible to identify in any detail exactly how our research contributed to this. In any case all credit is due to her for having the courage (or craziness) to be willing to work with me. At various places in the thesis I have pointed to but not discussed the issue of the fact that Jill was new to teaching at the time of our work together. However, she says that she believes that one particular value of our collaboration is that it gave her the opportunity to "think beyond the narrow blinkers of being an NQT".

However, part of my research stance was to extend the meaning of "us" to include learners of mathematics themselves. In this regard, I am much less certain that the actual practice of the research improved in any dramatic way the experience of mathematics of the students involved. This is not say that the involvement in the research was not valuable for them or appreciated in other ways. At the end of the year a number of students in Seven Blue, including some of the more disaffected ones, indicated that taking part in the research was one of the most enjoyable parts of the year. There is something valuable about having the opportunity to say what we feel[17]. Nevertheless, the situation remains that the experience of school mathematics and

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[17] Louise directly spoke of the cathartic nature of our interview.

teacher questioning for many, perhaps the overwhelming majority, continues to be alienating and soulless. The challenge that remains for mathematics educationalists was well put by one of the students at East High School, who, when asked if had anything to add said:

Will any of the stuff we've discussed today change any of the teaching?

EPILOGUE

This thesis began with a prelude describing a dream that occurred immediately before starting my studentship. On the day that I submitted the thesis I returned home to a letter sent by a friend who had asked to read some of my writing. I include the extract from her letter below not least because in this thesis I have emphasised some of the negative aspects and experiences of 'school mathematics' and such experiences are not universal. Though in reading Ros's short story of her experience of mathematics, I still feel a sense of pathos for missed opportunities. For some mathematics in school is something to be endured, for others fairly irrelevant, rarely is it an exciting exploration into the diverse worlds that people have created and which somehow, mysteriously and magically reflect and describe the universe we live in. Rarely too is school mathematics a means to experience moments of being part of a learning community which is a shame because mathematics has a particular contribution to make to providing such experiences and to developing our ability to participate in learning communities.

> My maths GCSE always felt a bit silly. My class was only allowed to do the middle paper (up to C grade). Everyone got a C. I remember feeling how silly that was. But my memories of it are all light. I remember how lovely I thought Algebra looked on the page, how neat and beautiful - what a great antidote/respite from a turbulent adolescence. (Ros, Letter, March 2004)

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APPENDIX I

RECORD OF RESEARCH ACTIVITIES

AND SAMPLE OF RESEARCH MATERIALS

1. RECORD OF RESEARCH ACTIVITIES

This record should be read in conjunction with the Third Piece of the Preface.

WHEN	ACTIVITIES	MATERIALS GENERATED
Autumn 1999	Reading and methodology training	Not applicable
Spring 2000	Observations in West Secondary school (3 lessons) and interviews with group of girls and group of boys	Observation notes including record of critical incidents Interview tapes & transcripts x 2
	Observation in two primary schools both of Numeracy lessons and other lessons (3x2 days)	Observation notes
	Meeting with three ITT students x 2	Notes made from tape recording of the meetings x 2
	Interviews with students on Primary Mathematics Education BSC 2 individual interviews and 2 group interviews	Tapes & transcripts of interviews x 4
Summer 2000	Participant observation with three ITT students (2x3 lessons) Whole class research activity for one lesson at East High School 4 focus group interviews (two conducted by Peter)	Observation notes Whole class letter "I'd be more likely to talk in class if…" Interview transcripts x 4
	Interview with Louise	Interview transcript
Autumn 2000	(All activities that follow are at North High School) 12 days in school 6 of Seven Blue's lessons observed/participated. Whole class survey One group interview (Seven Blue Girls A) 12 other of Jill's lessons observed/participated in.	Lesson observations/notes x 13 Seven Blue whole class survey Interview transcript, Seven Blue x 1 Email and other correspondence with Jill

WHEN	ACTIVITIES	MATERIALS GENERATED
Spring 2001	11 days in school 5 of Seven Blue's lesson observed/participated in 8 other lessons observed 4 group interviews (Seven Blue Girls B, Seven Blue Boys B) Survey of two Y9 classes Interviews with 4 Year Nine focus groups from Jill's class	Lesson observation/notes x 13 Interview transcript Seven Blue x 4 Interview transcripts, Y9 x 4 Email and other correspondence with Jill
Summer 2002	9 days in school 4 of Seven Blue's lessons observed/participated in End of year survey of Seven Blue 6 Jill's Y9 lessons & 2 other Y9 lessons	Lesson observation notes x 13 Learning together mathematics lesson project – draft Email and other correspondence with Jill Learning together mathematics project – first draft
Autumn 2003	6 days in School Learning together mathematics project	Learning together mathematics project final draft and resource collection

2. PROTOCOL FOR SCHOOL BASED RESEARCH 1999-2000[1]

This protocol outlines the ethical principles governing the collection of research data in schools as part of the research titled 'Changing Ways of Knowing. Children's experience of mistake making in mathematics classrooms'. It is intended to guide the method of data collection and the purposes for which it can be used.

The school-based research forms a part of a preliminary investigation into children's attitudes to mistake making in mathematics in different learning situations. The aim of the research is to contribute to improving children's learning experience. Therefore any collection of data will be done in such a way as to support children's learning.

Data will be collected by participation in lessons. This will generally be done by adopting the role of a support teacher and acting in an appropriate, professional manner. Data will be recorded as unobtrusively as possible. Any formal observation or other means of data collection that might cause greater disruption to the normal classroom situation will only be done with the agreement of the class teacher. Records of normal classroom interactions will be confidential to the participants in those interactions,

It is likely that additional data will be collected through interviews. These interviews will focus on children's learning experience. Such interviews will be confidential to the researcher and interviewee(s). However, in the unlikely circumstance that the researcher becomes aware of a situation that might be damaging to a student, the normal limits to confidentiality that apply in teachers' pastoral roles will be followed.

The identity of participants and schools will be protected in any research reports or papers written on the basis of the data unless specific agreement is given for disclosure.

Mark Boylan
25th November 1999
(revised June 2000)

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[1] This protocol applied to all observations in schools and interviews during the first year of the research.

3. INTERVIEW SCHEDULE EAST HIGH SCHOOL[2]

Introduction: Purposes of the interview. Confidentiality.

1. First I want to ask you about some of your responses on the questionnaire. Can you remember how you answered these questions, (about answering in different subjects)

People in the class generally indicated that they answered less questions in maths than other subjects. Is that because there are less questions asked or because people are less likely to answer when questions are asked

2. We asked a question about what might make you feel like you wanted to contribute more to class discussion. We looked at your answers and many people said similar things. I want to ask you about some of the responses. I realise that you may not have put these things down but I would like to here your opinions on why others might have.

We have written up your responses in the form of a letter to your teachers, I'd like you to read it and say whether you think that it's a fair reflection of what you think do you think we have understood the classes point of view

a) Quite a few people said that they would answer more if they could be sure that they were correct. Others talked about not standing out not being the centre of attention particularly in form of friends. Do you have anything to say about this

I'd like to say what a teacher might say about this. A teacher might say that its important to ask questions that are difficult and that people might get wrong because we can learn from not being right, what would you say to that?

What could be done to make you feel better about getting it wrong so it didn't matter so much.

b) A number of people said that you had concerns about being in Set A, was this something that you wanted to be able to say anyway or does it relate to answering questions or contributing to discussion

Respond again as a teacher, why tests and so on a re harder in set A, the reasons people give for having sets and invite comments

c) A number of people said they wanted better explanations or topics explaining better

What is a good explanation?

d) A number of you said that you would like to discuss with someone before you answered. Mr Lawton has/ I have done this with you sometimes, does this happen with other teachers

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[2] This schedule was used for the semi-structured interviews at East High School and was written in co-operation with Peter who conducted two of the interviews.

3. There was difference between boys and girls when it came to discussion in you answers on the questionnaire. Girls felt less involved in discussion but later the girls indicated that they did want to discuss things more.

Why do you think it's a good thing to do?

Now I would like to have a look at the exercise we did with cards, we want to look at what makes you nervous and what you think is the most helpful to your learning. Not everyone had a time to finish it but the two groups who did when they thought about "What is most helpful to learning" put these four A, D, E, and I and the most helpful, what do you think? Why

(Nervousness
These three BGH up at the top when it came to nervousness, do you agree?
A and F were at the bottom)

4. (What about this question about the parts of the lesson you feel most involved in. 20 people in the group said puzzles. What do you mean by puzzles, can you give an example, why are people more involved.)

5. I want to ask you now to use your imaginations. If you could imagine your maths teaching to be different how would you make it different, what would be maths like in you ideal world?

6. Is there anything else that you might like to add that I might learn from hearing you say?

7. I wonder if you could comment on the usefulness of this as an exercise, for example have you been asked before a teacher to feedback on how they teach you?

341

4. FOCUS GROUP SORTING EXERCISE[3]

A	B
The teacher asks a question and then gives time to think about an answer before people can put their hands up	We don't put our hands up and then the teacher asks someone by name for the answer
C	**D**
Someone calls out the answer. The teacher listens to the first person that calls out	The teacher asks people to discuss the answer with someone else and then asks for hands up
E	**F**
The teacher asks people to discuss the answer with someone else and then asks a pair to give an answer by name	Everyone answers the question together, for example by writing the answer down and then showing the answer
G	**H**
Everyone takes it in turns to answer	The teacher asks a question and people put their hand up straight away
I	**J**
The pupils ask the questions	The teacher does not ask questions

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[3] This sorting exercise was used at East High School and at North High School. Students' were given the statements on cards and invited to rank them three times according to the following criteria: How often the practice happened in lessons, how nervous each practice made them, and which they thought was more 'helpful to learning'.

5. LETTER FOR ADULT INTERVIEWEES
Information regarding interviews about the experience of mistake making

Thank you for your interest in my research into the experience of learning mathematics. Here is some additional information that will, hopefully, allow you to decide if you wish to participate. The information presented here is detailed because I see the interviewees in the research as co-researchers rather than objects of study and it is important that they understand the reasons for and context of the interviews.

I hope after reading it you will decide to participate. If you do so you will be contributing to developing a greater understanding of a much experienced but little discussed phenomena. I also believe that participation in research of this type can lead to greater personal insight into ones own relationship with learning.

About me
My background is in secondary mathematics teaching. I am currently a research student working on an Mphil/Phd. I also teach part time on Primary and Secondary mathematics education units.

About the research project
The working title of my research is 'Changing ways of knowing: making sense of people's experience of mistake making in mathematics.' There has been very little research done in this area and the project is exploratory. I do not approach this research as a detached observer but rather from a belief that this is an important aspect of learning and there are aspects of the experience of making mistakes which could be changed for the better. The project has two complementary strands. One part consists of observation in classroom situations. The second part consists of interviews with children and adults about their experience of learning mathematics.

The interviews
I would expect the interview to last about one hour. The purpose of the interview is to help develop a description of the experience of mistake making and situations of not understanding when learning mathematics. I see the participants as co-researchers in the attempt to develop this description.
I will ask you to provide as rich a description as you feel able about your general experiences of learning mathematics both at school and as an adult. A particular focus would be on times that you have made a mistake, been corrected by another person or experienced not understanding. Your description might include thoughts, emotions and physical sensations. I wish to stress that I am not seeking your opinions about learning mathematics but your personal experience of it.
The intention of the interview is to describe your remembered experience of learning mathematics, in order to prompt this I may show you some examples of mathematics. I will not ask you to do any mathematics. My role as interviewer will be to attempt to facilitate and record your description.

The purpose of each individual interview is to arrive at a description of your individual experience. Whatever your personal experience is, it is my belief that it is as valid as any other. However, at a later stage in my research I will attempt to interpret the descriptions drawn from the interviews as a series.

After the interview

Later I would like to send you a transcript of the interview for your comments to check that you feel that it does properly reflect your experience and to ask for additional biographical data that may be relevant. I would also seek your comments on any analysis that arises from the interview.

The individual interview tape and transcript would be confidential to my research supervisors, possibly a transcriber and to us. It is likely that extracts from the transcript would be quoted in papers prepared for my research thesis and possibly for conferences and/or journals. I would seek to preserve your anonymity in such papers. I will ask you to sign an 'interview release form' at the end of the interview giving permission for such quotation.

What if you are still interested in being a co-researcher?
I hope that you are still interested in being interviewed. Before deciding I believe that it would be useful to have an informal chat during which we could discuss a time and place that is convenient to you

My phone number is XXXX XXXXX (home) and XXXXX XXXXXXX (work) or ext XXXX if internal to SHU.

Regardless of whether you decide to take part, thank you for the time you have given this matter.

Mark Boylan

7. SCHEDULE FOR INTERVIEW'S WITH ADULTS[4]

Interview Schedule – 4th April 2000

Preamble – Purpose of the interview – part of research into mistake making and situations of not understanding, not my intention to transcribe the interview but may quote selectively. After the interview I will summarise under a number of headings and key quotes and I will send these to you. Anonymity – choice

Reminder – reflect emotion words, how does it feel, physical sensation

1. I would like you to tell me your story of learning mathematics

Prompts – primary secondary, A level, university

Strong memories, attitudes, choices

2. Tell me about a time you enjoyed doing mathematics – from each or at least two of those times

Tell me about a time you didn't enjoy doing mathematics

3. If you described yourself as mathematician how would you describe yourself – successful, good, fast

4. Let's talk about mathematics some more – can you describe what you think mathematics is?

How does it feel when you are doing mathematics

5, Let's talk about other people involved in your maths history

Tell me about any strong memories you have of teachers

What about other learners, people you have learned with

What about family views of mathematics

5. Social views of mathematics – maths is a core subject, is it important

6. Mistake making/situations of not understanding

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[4] This schedule was used with Primary Bed students. With Louise, I internalised the central issues and did not have a schedule present, choosing to follow the process of conversation.

Tell me about a time

    how did you feel about yourself and about mathematics

    Public mistake making,
    Mistake making
    Time of not understanding

6. Anything else that stands out

7. Imagination/future

Imagine that you were going to learn mathematics again, imagine you were about to be born again, how would you make your experience of learning mathematics different

8. SEVEN BLUE AUTUMN SURVEY

Name...   Boy/Girl

The way I feel about maths is..........

I think maths is..........

I like maths when..........

I do no like maths when ....

I do not like maths when..........

I maths I am a person who..........

Maths would be better if..........

8. SEVEN BLUE INTERVIEW SCHEDULE

1. Nature of interview, purpose, confidentiality issues

2. Read through summary of responses to survey "The way I feel about maths is" "how do you feel about maths?"

3. "I like maths when" read survey responses as prompts

4. I don't like maths when
read survey responses as prompts

5. Different practices
− read and show list of different types of practices that can happen in a lesson

6. Answering questions: When the teacher ask a question in class how often do you put your hand up? Do you sometimes know the answer and not put your hand up?
How do you feel if you get an answer wrong

7. Discussion of 'timetable competition', 'fog' and 'aha' vignette

8. What do you need to do to be good at maths

9. Different ways of responding sorting exercise

10. How could mathematics lessons be better

11. Discussion of different sorts of mathematics lessons - prompts

Activities in maths lessons

We do a 'starter' written on the board

I practice lots of similar questions

I work from a textbook

The teacher asks questions which have a short one or two word answer

I work in a group on questions or problems

The whole class works on a longer problem together

The teacher shows us how to do something

A student explains their ideas or method to the whole class

The teacher asks questions which have a longer answer

We do puzzles

I have some choice about what to do

I discuss my work with someone else

APPENDIX II

BEFORE THE RESEARCH - A PERSONAL HISTORY

Mark had not planned on becoming a mathematics teacher. At school he had been academically successful and had good personal relationships with most of his teachers, though on a number of occasions he experienced violent punishments from some, both at Primary and Secondary school.

At the age of seven he moved to Leicester and attended a small Catholic Primary school. When he arrived at the school the class he should have been in according to his age, was full. He was placed with children a year older. The classroom was organised by children sitting in groups of four. The tables were organised hierarchically with the "slower" children at the back of the room and the "brightest" at the front. Mark was placed at the back of the class. He liked the other children at his table. After a while the teacher decided that in spite of Mark's age he should be placed with the "brightest" and was moved. The reasons for moving were not explained to him. Mark liked the children on his new table too but missed his previous companions.

He entered a boy's comprehensive secondary school in 1977. Mark was part of the first year in the city that did not take the Eleven Plus exam. His school was organised into sets and he was placed in Set One for all his subjects based on tests completed during his first week. At the end of the first year he was put down into Set Two for English, his strict teacher told him that this was due to his poor handwriting and grammar. He remembers his mother's disappointment at this and he felt embarrassed and ashamed. However, his new English teacher was much more relaxed than the previous one. He had long hair and organised his room into groups of desks rather than rows. He emphasised creative expression and used drama in his teaching. The following year Mark went back up to Set One.

At the school social relationships formed mainly through the sets children were put in for lessons. The setting correlated to social class. However, Mark had strong friendships in his local neighbourhood which he carried over into school life and so he had a range of friends who were not in the same sets as him or in the same year group. At fourteen he was allowed to choose some of his examination subjects and opted to do P.E. CSE rather than an O level in French[5]. The school resisted his choice, as the subject was not 'academic'. Mark insisted and as a result, studied PE in a class with students from a wide range of social backgrounds and levels of academic success. He now sees this as in only real experience of comprehensive secondary education.

In his early teens, influenced by the punk sub-culture and a political environment of social conflict, he identified himself as an anarchist. In spite of his personal success in the classroom he was alienated from schooling and saw it as a form by which 'the state' created subservience; he saw teachers as 'agents of the state'. During this time, he was involved in a school students' strike.

Mark studied A levels at a Sixth Form College. When he began he studied English Literature, Physics and two Mathematics A Levels. After the first year he stopped studying the further Mathematics A level. Mark did this for a number of reasons. His social life had become very important and it was often in conflict with studying. This was also a time of intense spiritual exploration. In addition, though this was not a reason he discussed with his tutors, he had found topics in the Further Mathematics course difficult. Before this he had always found mathematics in school very easy; once he was shown what to do he would be able to do it.

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[5] At that time there were two separate examination systems in the UK: 'O levels' studied by only approximately 20% of the children and CSE, which the rest of the children were entered for. The CSE had less status than O Levels

On leaving college Mark went to a redbrick University, and began studying Physics and Philosophy. He realised, with disappointment, that the two elements of his degree were not going to be integrated and he was the only one studying that combination; he was told by his physics tutor "I don't want you bringing any philosophy over here". He also realised that he would reduce his workload by opting for philosophy alone.

In College and at University Mark continued to identify and argue for anarchist ideas and explored a range of spiritual beliefs. Through a University occupation he became a student activist and was involved in anti-apartheid and anti-fascist direct action as part of small groups and networks. In his third year at university he became attracted by Marxist ideas and was recruited to a Trotskyist party. He remained a member of this party for the next ten years. On joining the party Mark abandoned his anarchist beliefs. The culture of the party was hostile to spirituality and this became a less open part of his life.

He had began work doing casual piece rate employment in a factory and then a mailing company. Later, he obtained part-time work, in adult education working with the long term unemployed. When his contract ended he worked for the Employment Service, in relatively low paid administrative work. During this time he became a trade-union activist.

His initial decision to become a teacher was largely pragmatic. He desired more autonomy in his work and he resented working under the gaze of a supervisor. In addition, he believed that teaching was a job that would allow him to continue his political and trade union activism in the work place. As an anarchist, he had viewed teachers as tools of the state, now as a Marxist he saw teachers as potentially militant trade unionists. In addition, the government was offering substantial financial inducements train as mathematics teachers to people without mathematics degrees but who had mathematics in their academic background. This was a response to the shortage of teachers training as mathematics teachers.

A less pragmatic reason was the excitement he felt when he visited the mathematics education centre at a university offering conversion courses. He remembers the beauty of the mathematics on the walls, the learner's accounts of what they had done and the displays of mathematics from other cultures. He was reminded of his enjoyment of mathematics during his own schooling but also saw that he was glimpsing a different approach to learning mathematics.

Mark's two-year teacher training course was intellectually rich and stimulating time. He was introduced to new ways of seeing mathematics, was encouraged to reflect on himself as a learner, and emphasis was placed on the beauty of mathematics. Issues of equity were included in his course both implicitly and explicitly. Mark came to believe that schooling should be challenged in each classroom as well as at the structural level. He found that he enjoyed working with children.

He came to the end of his course in 1992 at a time of significant change following the 1988 Education Reform Act. He expressed his hopes and fears about the start of his teaching career in the following way:

> There is a sense in which all teachers committed in some way to putting children at the centre of the educational process, may find themselves increasingly the outsiders in the education system, even if they are in a majority. Thus all teachers may have to learn to create a space for good practice in the Brave New World of over-assessment, league tables and selection. Whilst it is important for me to be realistic about the way educational policies are developing and the need to bend a little in the present wind, in the long term I have a much more optimistic perspective. I

believe there will be opportunities in the future to influence change in a positive way. I hope to be able to play some sort of role in that. Therefore whilst [I am] intellectually quite pessimistic about the future of education, I am emotionally very optimistic.

Mark chose to take up his first teaching job in a school on a large, predominantly white, working class estate. Many of the children were alienated, disaffected and did not like mathematics. The type of teaching approaches favoured by other members of the department varied with many teachers adopting a traditional approach. However, there was freedom to explore different approaches and to contribute to the department's teaching materials.

Mark found it difficult to develop and maintain a humane classroom practice. Keeping order in the classroom was a priority and conflict with students was frequent. His teaching style incorporated both traditional and more progressive approaches. The latter were more in keeping with his expressed values and beliefs. However, he experienced disappointment that these progressive approaches did not generally impact on the children's alienation from school and mathematics. However, there were occasions and particular classes when more sociable relationships developed and the students had opportunities to explore mathematics. His commitment to anti-racist and anti-sexist mathematics could be seen in particular lessons rather than informing daily practice. Mark's identity as form tutor was important to him. He was an enthusiastic participant in the schools' residential programme for the children.

He continued to be reflective about his practice. He undertook some Masters Units and collaborated on a small-scale research project.

Mark mainly expressed his political views on schooling outside the classroom. There was a significant level of resistance amongst teachers to the introduction of National Tests and widespread disillusionment with the first version of the National Curriculum. This led to a localised parental boycott and later industrial action by the teaching unions. As a trade union activist he was involved in these campaigns.

After four years teaching he moved to another post in which he remained in for three years. His freedom to decide on the curriculum materials he used increased and he had a responsibility for one part of the department's curriculum. He acted as a mentor to students in initial teacher education. He later was given whole school responsibility for 'Equal Opportunities and Raising Achievement'. He had the opportunity to affect change beyond his classroom and influence others. However, he found that the time his new responsibilities took, meant there was less time to focus on his own classroom. His new role and the developing culture of assessment meant that a substantial proportion of his time was given to the preparation of tests. He was also involved in the process of setting children, though he did raise arguments for minimising the amount of setting and in favour of mixed ability teaching.

Enacting alternative approaches to mathematics became less important to him then enacting different social relationships in the classroom. He began to see himself as someone who "Happened to teach mathematics".

His political beliefs changed during this period. After being a loyal and energetic member of the party he had joined in his early twenties, he began to become critical of the organisations practices and began to openly disagree with its hierarchical structure. He came to feel a deep political and spiritual connection with the earth. In his personal life he sought and developed ways of relating to others more openly. These changes were co-emergent with beginning to spend much of his free time climbing and dancing. The death of a close friend acted as a catalyst to resign from the political organisation he

was a member of and a return to a more open and explorative spirituality particularly through a movement meditation dance form called 5 Rhythms Dance. Subsequently, he started to direct his political energies towards ecological and creative direct action.

He was frequently disillusioned with his work. During one of these periods, he read Jo Boaler's *Experiencing School Mathematics*. He found in her research confirmation of his beliefs about teaching. He had maintained connections with the university where he had trained and began to attend termly meetings of a critical mathematics education group. He began to experiment more frequently with styles of learning, and in particular started to avoid the use of practice exercises in textbooks and worksheets. He tried to create greater opportunities for discussion and choice in his lessons. He remembers the first half term of his last year of teaching, as a time when teaching was enjoyable, congruent with his values, and more worthwhile for the children.

However, his worldview continued to change and move into greater flux. He believed that government policy would necessitate even more of the disciplining and coercing of children, which he found painful. He saw less scope for space to teach differently. He wanted time to reflect on his values and beliefs about schools and life more generally. He questioned whether it was possible for the positive effects of his actions as a teacher to outweigh the negative and whether it was possible to teach in a 'different way' in mathematics classrooms anymore. He decided to resign from his teaching post. He felt a measure of guilt about doing so.

The connections that he maintained with higher education, the experience of the way in which educational research literature had influence him and his desire to "have time to think", meant that after resigning it felt natural to apply when a bursary to do a research studentship was offered. His application was based on wanting to research 'motivation' in mathematics classrooms.

APPENDIX III

WORKING NOTES ON THE 'SOCIAL' IN
MATHEMATICS EDUCATION RESEARCH

During the last twenty years, a recognition that theoretical models of mathematics learning based on individualistic and positivistic psychology are inadequate to understand how mathematics is learnt has led to developing concern with the social aspects of mathematics learning.

Social constructivism

Alternative social psychologies have been offered with differing emphasis on the extent to which the social and cultural is seen as ontologically prior or is rather seen as a mediator and means of individual constructions. Symbolic interactionism and ethnomethodology have frequently provided theoretical foundations of such social psychologies and as a methodology for research (Bauersfeld 1988; Cobb and Yackel 1998).

A significant and influential strand of this approach has been the development of social constructivist perspectives (Cobb et al 1992; Cobb and Yackel 2000; Cobb, Wood and Yackel 1990; Wood 1994, 1999). These researchers propose three levels of analysis to understand the ongoing practices, and so learning, in school mathematics classrooms: classroom social norms (general social activity of the classroom), sociomathematical norms (social activity related to negotiating and creating meaning in mathematics), and classroom mathematical practices (the mathematical activities, algorithms, and procedures that are found in the classroom). These three levels of analysis are interdependent and interrelated. A consequence of this perspective is that the mathematical conceptions and activity are dependent on the type of social activity within the classroom.

One reason the social constructivist perspective is significant is because it has provided the theoretical basis for the 'reform movement' in the US discussed earlier. Indeed the earlier distinction I made between usual school mathematics and alternatives to school mathematics, draws on this perspective. Social constructivist researchers have posited the notion of "the school mathematics tradition" (Cobb et al 1992, Cobb and Yackel 2000; Gregg 1995). From the social constructivist perspective the essential feature of the school mathematics tradition is the learning of procedures and instructions to engage in symbol manipulation rather than to act mentally on "taken-as shared mathematical objects" (Cobb and Yackel 1998, page 162).

Social constructivism concerns itself primarily with the individual classroom micro-culture. Social constructivist proponents themselves recognise that an account needs to be given of the prevalence and persistence of particular forms of classroom micro-culture and interactions across different classrooms. This is particularly necessary given the reform agenda of these researchers. In part, the notion of the school mathematics tradition aims to do this. Explanations as to why this tradition is prevalent and persistent are given in terms of individual teachers (and to a lesser extent students) beliefs about their roles. The classroom tradition is changed by a process of the teacher initiating a renegotiation of the 'norms' of the classroom. The school mathematics tradition is thus seen predominantly as the consequence of (often unconscious) choices made by individual teachers in individual classrooms and is open to change on such a basis.

Socio-cultural approaches

Socio-cultural approaches to understanding mathematical learning and classroom practice offer alternatives to models of individual learning through social mediation and give ontological priority to the social. These approaches are diverse and represent the application to mathematics learning and schooling of different theoretical perspectives

(Lerman 1994; 1997). Some perspectives tend to be mutually supportive, whilst others are contradictory. However, empirically they make similar claims about mathematics and mathematics learning. The claims made by socio-cultural theorists are that:

- aspects of the experience of learning such as affect, cognition, identity, language, culture (both the micro-culture of the class room and the wider social culture) cannot be viewed as discrete, separate factors;

- some of these elements that have been seen as peripheral to the learning process, such as identity and social relationships are central to it;

- learning mathematics is not learning an 'objective' body of knowledge, mathematics is socially, culturally and historically located;

- further that learning mathematics is essentially learning to participate in particular forms of social interactions and practices such as mathematical discursive practices.

Socio-cultural theories have developed alternatives to the constructivist model to explain intellectual development and mathematical learning. The ideas of Vygotsky have been influential; see for example Confrey (1995), Lerman (1997), Waschesio (1998). Socio-cultural epistemologies of mathematics and mathematics education have challenged the idea of mathematics as an atemporal area of human knowledge (see for examples Bloor 1994; D'Ambrosio 1985; Ernest 1991; 1998; Hersch 1994; Powell and Franskenstein 1997; Restivo 1994; 1999). From this perspective mathematics is a social practice and so learning mathematics is learning to do mathematics rather than primarily learning a set of concepts or ideas.

It also suggests the need to talk of a multiplicity of mathematics rather than a single unified structure. Thus mathematics learnt in school is related to, but distinct from, other aspects of mathematics and school mathematics includes both procedures and concepts learnt and the social and cultural practices that are intrinsic to learning these procedures and concepts. Such analysis supports the idea of viewing the traditional approach to teaching and learning mathematics as being a distinct set of cultural and social practices that I refer to as Usual school mathematics.

Whilst the socio-constructivists 'school mathematics tradition' is taken as bounded within individual classrooms or at most the school mathematics community, socio-culturalists see school mathematics as embedded in wider social and political practices, formations, and ideas.

The nature of school mathematics practices and policy have been analysed in terms of their ideological content and political nature (Cabral and Baldino 1998; Chassapis 2000; Ernest 1991, 1999; Boylan 2000; Mellin Olsen 1987; Segarra 2000; Skovmose 1994; Skovsmose and Valero 2002). Others have applied Bourdieu's ideas of social practice and habitus to account for particular aspects of mathematics education (see for example Gates 2002, Zervenbergen 2002).

The analysis of school mathematics as socially constructed and ideological and supported and based on more general critiques of schooling in society (Apple 1979, 1995, 1996; Bernstein 1996, Giroux 1981, 1992).

These analyses help to explain why the historical and cultural practice school mathematics is the dominant and persistent practice when considering society as a whole. However, they are less helpful for understanding the ways in which the practices of school mathematics are recreated and sustained in individual classrooms. Nor at examining the type of knowledge produced by school mathematics, or how participants experience the practices of school mathematics.

One developing approach that helps to address these issues understands school mathematics as engagement in discursive practices. Such analysis are often informed by post-structuralist theory (see for examples of this approach Walkerdine 1988, 1997; Evans 2000; Evans and Tsatsaroni 1994; Dowling Cabral and Baldino 1998; Hardy and Cotton 2000; Hardy 2001; Morgan, Evans Tsatsoroni 2002).

These writers offer rich insights into mathematic learning, however, they privilege discourse as being the most important form of social practice. In Chapter Three, I position myself in relation to post-modernist thought. I discuss ways in which discourse (and text that arises from it), is one form of action in the world. It is unique in that it usually (though not always) a mediator of other forms of action. However, I take the view that metaphor of the world as text is limited and action is not always linguistic or discursive.

An alternative conception of mathematics as social practice that has the potential to account both for the generation of social practices in particular classrooms and account for mathematical learning is found in theories of learning as participation in communities of practice. In mathematics education the work of Jean Lave and Etienne Wenger have been influential (Lave 1988; Lave 1996; Lave 1997; Lave and Wenger 1991; Wenger 1998). For a discussion of this theory see Chapter One.

APPENDIX IV

WORKING NOTES ON:

CONCEPTUAL CANOPIES, PHILOSOPHICAL
THREADS, PARADIGMS AND ECOLOGICAL THINKING

Researchers ontological, epistemological, and methodological premises have been analysed as *paradigms* (Guba 1990, Guba and Lincoln 1998, Denzin and Lincoln 1998a). The notion of a paradigm can have many meanings but in its most generic sense it means "a basic set of beliefs that guides action" (Guba 1990, page 17).

Below I offer one way to characterise different research paradigms as described by Egon Guba and Yvonna Lincoln[6]. Each paradigm can be described in terms its ontological, epistemological and methodological commitments.

Basic beliefs (Metaphysics of Alternative Inquiry Paradigms)

Item	Positivism	Postpositivism	Critical theory et al	Constructivism
Ontology	naïve realism – "real" reality but apprehendable	critical realism – "real" reality but only imperfectly and probabilistically apprehendable	historical realism – virtual reality shaped by social, political, cultural, economic, ethnic, and gender values; crystallized over time	relativism – local and specific constructed realities
Epistemology	dualist/objectivist; findings true	modified dualist/objectivist; critical tradition/community; findings probably true	transactional/ subjectivist; value-mediated findings	transactional/ subjectivist; created findings
Methodology	experimental/ manipulative; verification of hypothesis; chiefly quantitative methods	modified experimental/manipulative; critical multiplism; falsification of hypotheses; may include qualitative methods	dialogic/ dialectical	hermeneutical /dialectical

(Guba and Lincoln 1998, page 203)

Different paradigms are reflections of and productive of seemingly incompatible philosophical standpoints; a researcher is expected to adopt one of the alternatives and research from within it. Perhaps the idea of incompatibility of paradigms has its origins in the anti-foundationalism of Kuhn who wrote of paradigms "speaking past each other" (Davis and Hersch 1981) and of paradigms replacing each other.

Anti-foundationalism is developed further in post-structuralist and deconstructionist thinking where the notion of any 'grand narrative' is disputed[7] (Lyotard 1992). Generally, post-modernism suggests the importance of scepticism about the claims made for all the different paradigms. Such scepticism can lead to nihilism in which the relativistic nature of truth is taken as meaning there is no truth. However, there is an alternative to this nihilism and that is to embrace the reality of multiple truths and therefore of the usefulness of different research paradigms.

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[6] The identification of a particular set of research with similar philosophy and methodology as a constituting a paradigm is itself an example of the way social researchers "write the world'" (Usher 1996). Therefore, different categorisations are possible and will be influenced by theorist own commitments. I quote Guba and Lincoln as one that has some currency in methodological theory and is presented in a popular research methods text. Peter Reason offers an analysis of competing worldviews that includes more spiritually orientated worldviews (Reason 2003).

[7] Although, as Lyotard points out, this itself is a grand narrative of sorts

I assert that different research traditions are reflections and refinements of different legitimate and valuable ways humans come to know/create the everyday world. Even the most ardent post-modernist acts in the world as if there is a positivistic reality as they maintain their daily lives. The existence of a 'real world' is paradoxically an essential feature of the taken for granted social and personal lifeworlds. We all do come to know/create the world by acting in it and manipulating it; life is like one ongoing experiment or workshop.

On the other hand, even the most ardent positivist exists at least, in a social world that they recognise is one that is interpreted and that others do not share their views. The existence of others whose lifeworlds are different to ours is a feature of 'reality'[8].

My appeal here is to step out of the positions we adopt and defend (and have interests of various sorts invested in) as academic researchers and consider the different ways we live in the world in and beyond that academic life. It is an appeal to foreground our experiential knowing (Heron 1992, Reason & Tobart 2001) and is an echo of a call "to commit to integrating inquiry and practice in everyday personal and professional settings" (Reason and Tobart 2001). In everyday and even professional settings we shift between different ways of knowing the world.

If we recognise this, we have the possibility that the deconstruction of grand narratives may allow us not to so much reject them but to re-inscribe them as useful and appropriate ways of knowing about the world in particular contexts and situations. To appropriate terms used by Thomas Kieren such narratives can be reinterpreted as part of a move to multiversal as distinct from universal truths (Kieren 2002).

Such a philosophical pragmatism, in part, recognises and is justified by a polyphrenic view of the self (the term polyphrenia appropriated from Russell 2001). Post-modernism has not only offered a critique of the possibility of grand narratives but also the view of the single, unitary self as either an experiencer or constructor of the world. Instead we can recognise a multiplicity of selves. Such a view is also found developing in anti-foundationalists within cognitive science (Thompson, Varela & Rosch 1993). I have more to say about the self (see Chapter Four) but for now I suggest that once we abandon the unitary notion of the self then I [sic] may have positivist, a critical realist, and constructivist selves, who live in/make different realities[9].

Others have put forward the idea that research paradigms may not be incompatible (Firestone 1990). William Firestone argues that if paradigms are seen as cultures, following Kuhn, rather than emphasising the philosophical basis, then they need not be incompatible but can build on and influence each other in a dialectical way. Firestone's attention to the practice of research points to the way in which historically, the analysis of the philosophy of a paradigm may often occur as a description and justification after it has developed. This emphasises the way in which 'paradigm' is actually a codification and/or reification of a research tradition. He also argues that operationally different paradigms have much in common. However, whilst I applaud Firestone's practical pragmatism I go further and assert a philosophical pragmatism as well.

To attempt a full philosophical justification of my assertion would be a thesis in itself; however, I offer two pieces of 'evidence' for this position. Firstly, Kuhn's identification of paradigms was an empirical 'finding' as well as a philosophical

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[8] There are, from a deconstructionist perspective, basic contradictions within my narrative throughout this section. For example the use of the term lifeworld supports a very particular paradigm or set of paradigms. I think it is unavoidable when discussing paradigms or philosophies to do so from within a paradigm or philosophy.
[9] Or rather there are selves, strands or identity and/or subpersonalities whose way of knowing the world (and action in it) correspond more to one paradigm or another.

position. His work rests on an interpretation of the history of science and philosophy in which different paradigms supplant each other in terms of shifts rather than evolution. From a critical or post-structuralist perspective we can recognise and inquire into the ideological nature of this history. However, we can also recognise that a paradigm shift is also a pragmatic event. If we consider recent history of the social sciences we can see such a paradigm shift from positivism to post-positivism as hegemonic. There has not been a similar shift in relation to newer alternative paradigms. Within the alternative paradigms themselves there is no single challenger to post-positivism's hegemony. This situation may change but the post-modernist context that makes alternative research paradigms possible also means that it is difficult to see a way in which anyone of them alone could hegemonically displace post-positivism.

Even if such a paradigm shift were to occur it is unlikely to mean that research based on a qualified realism would disappear because it is useful:

> Post-modernism tries to convince us that there is no global story, no objectivity, no truth to be found. Yet for many people, particularly those who have engaged in mathematical research, this flies in the face of experience. Some mathematical situations are not in rapid flux, and so some assertions are more appropriate, more valid than others; some 'truths' have at least a sense of permanence. (Mason 2000 page 316)

In advocating a philosophical pragmatism I invoke the spirit of Paul Feyeraband's scepticism that there is a universal most appropriate way of gaining knowledge (Feyeraband 1975). Ironically in the very physical sciences that co-arose with positivism that theoretical pragmatism is most accepted. In the first half of this century the idea that a phenomena such as light could be thought of (positivistically and experimentally) as both wave and particle was perturbing. Yet now it is accepted that sometimes it is better to consider light as a wave and as a particle. As Firestone points out the advent of Einsteinian physics did not replace Newtonian mechanics but added to it. In mathematics the pragmatism is more fully found in the philosophical perspectives of mathematicians. Where in spite of a recognition of the demolishing of the foundationalist project by Godel and Turing and compelling quasi-empiricism of Lakatos, mathematicians still continue to cling to Platonist ideas (Davis and Hersch 1981).

Maps

We can think of social research paradigms as means of knowing the world metaphorically as maps and the type of worlds that are known/created through them as terrain[10]. The metaphor of 'maps' is one that is most congruent with empirical positivism, where "the territory is primary and the map is secondary" (Reason & Tobart 2001 page 6). From the perspective of constructivism and post-modernism, this relationship is reversed; map is primary and the territory secondary, or even that there is only a map and no terrain that is distinct from it.

The perspective I am taking is not to synthesise or try to make compatible different terrains/maps; they cannot be merged. However as researchers we can move between the different terrains and adopt different maps. When we are located in a particular terrain we must be mindful to move within that landscape in a way that is appropriate to it and to use a map that is suitable for our purpose. Creating a map in the style of a climbing guide to explore city streets that are unknown to us, is not likely to help us on

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[10] I am drawing on Denzin and Lincoln's metaphor of research landscapes here (Denzin and Lincoln 1998)

our journey[11]. If a map is to be useful it must include information or at least indications of where and when it is best used and perhaps also how it connects and links to other maps.

The multiplicity of maps we create (and need) and as part of the Giles Deleuze and Felix Guattari (1987) develop this idea further, counter posing the concept of a 'tracing' to a 'map'. The maps created in a post-positivist paradigm are, in Deleuze and Guattari's terms, tracings. To make a tracing is to impose a static order that organises, stabilises and neutralises multiplicities (Deleuze and Guattari 1987, page 13). A tracing is separate and distinct from that which is traced. In contrast a map is:

> orientated toward an experimentation with the real...The map is open and
> connectable in all of its dimensions; it is detachable, reversible, susceptible
> to constant modification. It can be torn, reversed, adapted to any kind of
> mounting, reworked by an individual, group or social formation. It can be
> drawn on a wall conceived of as a work of art, constructed as a political
> action or as a meditation (Deleuze and Guattari 1987, page 12).

It is not my aim in this thesis to fully realise the production of such a map but overlaying different tracings at least points to the complexity of the social phenomena considered and that no single means of producing a tracing offers a complete or sufficient guide to action[12].

Philosophical threads

I do not claim that I have fully grounded or even enunciated the pragmatic and multiversal perspective I adopt. There is an implicit metadiscourse of an ecological existential pragmatism. What I am attempting to do is to clear some space between and within paradigms that justifies drawing on methodological traditions, which are usually seen as being in opposition or competition with each other. The claim that I make is that it is possible to receive the choice that the researcher is offered of different paradigms not as 'either/or' but 'this and that'.

I have asserted the legitimacy of moving between different meta-narratives and research paradigms. However, there are certain presuppositions about the nature of existence that make such a stance tenable. I have indicated that one of these is a multiple view of the self. There are other philosophical threads that may also be presupposed by such a perspective and certainly are important to the ways of understanding classroom interactions that I present here.

Consider again the metaphor of thesis as tent in which the cloth is woven from the fibres of the research material that includes the theory and methodology. I adopted this metaphor as a move away from the foundationalist implications of the more traditional building metaphor. Whilst a tent does not have foundations it does have key supporting poles to allow it to be raised and guy ropes of one sort or another to provide tension and to anchor it. Without these the cloth of the tent will remain more or less two-dimensional. Within this thesis you will find two interrelated principles that have the same function. These principles are an ecological perspective and the principle of co-emergence (Varela, Thompson Rosch 1993) of existence/phenomena.

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[11] Perhaps, this is only true if the city is one in the minority (rich) world that is relatively safe and ordered. A map akin to a climbing guide that indicated for example the crux, or most difficult or dangerous part of a route might be useful in more challenging environments.

[12] Later in Chapter Four, I refer to 'Mapping the lifeworld' in Deleuze and Guattari's terms this process is more of a tracing than a mapping.

An ecological perspective suggests the importance of considering each part in relation to the whole. The co-emergence of phenomena points to the irreducibility, in both explanatory and causal terms, of any existence to the environment in which it occurs and of an environment to the existences of which it is formed. Existence and environment must be understood here in their most general sense. A corollary of this is the unity of the knower and the known; that is the irreducibility of phenomena either to the 'world' or to the perceiver/interpreter of the world. The use of the terms emergent is indicative of the way in which ecologies, be it a biological ecology, an ecology of language, and ecology of mind, or a social ecology, display emergent properties. Self-organisation of existence creates qualitative differences which can be identified as emergent properties.

The development of these ideas can be found in existential phenomenology (Merleau-Ponty 1983/1963, cognitive science (Varela, Thompson and Rosch 1993 , mathematics education (Brent Davis 1996) and systems thinking (Flood 2001).

An ecological view steps out of the binary tension between structure and agency.

An ecological and co-emergent perspective gives a richer meaning to dialectic relationships that goes beyond that derived from Marx's reformulation of the Hegelian dialectic. The classic formulation of dialectic in terms of thesis, antithesis, and synthesis is refined as the unity of related phenomena in their co-dependent arising (Varela, Thompson Rosch 1993). Thesis, antithesis and synthesis co-emerge, thus, in Marxian terms, the anti-thesis and synthesis are already present and arise with the thesis. This is a development of the Marxist dialectic in that Marx wrote of the thesis containing the antithesis. The understanding of the dialectic as implicit in co-emergence (and thus existent in the natural world (Engels 1982/1925) is a further move away from the Hegelian dialectic. In more modern use dialectical relationship has not been used to point to thesis and antithesis but rather two phenomena which are mutually influencing and inseperable. It is this understanding of dialectics that is emphasised by the principle of co-emergence. However, when we introduce the notion of ecology we reintroduce the Hegelian spirit of movement and change but not as the move towards the Geist, but rather as an embodied reality of existence. For all phenomena exist within an ecology in which they arise and are part of, yet as they arise with that ecology, being part of it they must necessarily change it. Which is a rather complicated way of saying 'everything changes'. Dialectical thinking that seeks to grasp these changes rather than static pictures and may need to

> be metaphoric and poetic rather than literal (Bleakley, 1989); it is demonic and ironic rather than logical (Torbert, 1991). Dialectical thinking is "post-linguistic", to use Heron's term (1992), in that it self-reflexively draws attention to the distorting possibilities of its own categories: it is aware that the map is not the territory, that the map is not even the map.

(Reason 1993, page 9)

Ecological dialectics contends that any phenomena is understood in relation to the ecological whole and that the "unit of analysis" or what we take into account at any time will shift and change. In relation to my research in relation to this the individual classroom is understood in relation to the whole ecology and this replaces consideration of wider social structure with thinking about wider social ecology. The ecology is present within each part.

Existential pragmatism

The pragmatism that I advocate is not only philosophical but an existential pragmatism. A philosophical pragmatism suggests an appreciation of the power of different philosophical traditions as ways of knowing the world. An existential pragmatism points to the different ways of being and acting in the world that are open to us. This is similar to the *existential pragmatism* (McLaren 1994, Denzin 1992) that can be found in Lyotard in his celebration of multiplicity and diversity. However, as McLaren (following Denzin) points out the absence of any meta-narrative may ignore structures of oppression and a pragmatism based solely on local narratives and personal conscience allow space for "the very reign of terror he [Lyotard] …so vehemently opposes (Denzin 1992, page quoted in McLaren 1994).

A second challenge to existential pragmatism is the question of where, when and how movement is made through the different terrain of the research paradigms.

Various responses to Lyotard's personal existential pragmatism have been offered. (Murphy 1991) distinguishes between master discourse and metadiscourse and echoes Deleuze and Guattari's concept of mapping. Peter McLaren explains this distinction in this way:

> A master discourse tries to impose itself on all other discourses; it sets up binary tensions such as progressive/reactionary. On the other hand, a metadiscourse makes an effort to understand society as a totality by portraying the contradictory nature of society and the complex interactions between its different spheres (Mclaren 1994, page 11).

However, the adoption of such a metadiscourse, just like the adoption of the particular discourses of the research paradigms is not in the end, or even at the start, an epistemological or ontological act but an axiological act - one of value.
There is a question here of 'ought versus is' – is this a model of how knowledge is gained or how it ought to be, if it is then the task is to bring them into line, if it is ought then it is about making choices in our epistemology.

However, some paradigms more easily encompass or can include other paradigms whereas some a much more "univocal" (Jardine 2002) in their claims to be **the** truth. There is scope for discussion here in relation to intellectual development following Belencky et al (Belencky at al 1996) and Hilary Povey (1995) and possible Wilbur. In addition we may think of the way in which paradigms open and expand with more reflexive and encompassing paradigms being developed from more restrictive ones.

Using different paradigms is important because if not then is it legitimate to use or reference research developed in one paradigm in another. For example in discussing teacher questions I look at "wait time" and quote research based on an experientialist model.

APPENDIX V
LEARNING TOGETHER MATHEMATICS LESSONS

Learning together mathematics lessons: promoting community and group work in the Y9 classroom

by
"Jill"
& Mark Boylan

1. INTRODUCTION

This document is a product of a combination of research into Y9 students' experience of different teaching and learning styles, reflection on classroom practice and relevant literature and evaluation of classroom activities. It is very much intended as work in progress.

It serves a number of purposes. Firstly, it attempts to persuade of the benefits of attempting to develop a sense of community and shared purpose in the classroom. Secondly it discusses the nature of productive group work and raises questions about the formation of groups. Thirdly it describes a programme of specific activities that will support such an approach and constitute a programme of study in essential group work skills. This programme combines mathematically valuable activities with structured guidance for the students and opportunities for reflection on the group processes. It builds on the pair work skills and whole class discussion the students experience in Y7 and Y8 CAME lessons. This programme is based on a particular approach to teaching and learning that seeks to develop learning communities in the classroom. Some of the general principles of this approach are given in an appendix written by Mark

It has been written for and developed in the specific context of xxxxxxxxxx school. The quotes from the students and the references to their views refer to one particular Y9 class. A class survey was carried out and sixteen of the students were interviewed. The student's views are not put forward as representative of the year group as a whole but as some of the experiences present in Y9. The experiences and attitudes that we found are similar to those reported in other similar research. This Y9 class was a higher class. These were some of the more highly academically achieving students, yet for many confidence was an important issue. We believe that it is likely that students in other groups will have similar feelings about these issues.

The programme is based on the belief that the ability to learn together, whether in a pair, a group or a whole class is not an ability that necessarily arises naturally but is one that can be fostered, taught and learnt.

Some activities may be done at the same time as modules that their content relates to are being done, others may be done as individual activities before and links made later. In this case some of the activities might act as forms of formative assessment that gives an impression of the classes understanding before the main topic is explored. Alternatively the activities may be done later than the main module, which covers that content. In this case the activity might act as a form of more summative assessment. Our intention is that this project

is integrated into and provides a way of approaching the Y9 POS. Many of the activities will support the development of the using and applying mathematics aspects of the curriculum.

2. RATIONALE

The participation by learners in whole class, group and paired discussion is valuable for its effect on mathematics learning and as a social good. It is the basis for the development of communities of learners that promote achievement in and enjoyment of mathematics.

Concern for equity and social justice calls for the creation of an atmosphere where all students feel comfortable to speak in class. Such an atmosphere tends to support better motivation and positive attitudes towards mathematics.

Interviews with Y9 students suggest that some students (particularly some girls) feel less comfortable about contributing in their mathematics classes than in their form group. For example

"You get so used to your form groups…I feel like I don't know most people. I just don't feel comfortable putting my hand up" (Girl Year Nine)

Every mathematics set in Y9 is a unique combination of students that only meets together for their mathematics lessons. The development of a learning community from a collection of individuals is primarily the responsibility of the teacher. The new grouping in Y9 is an opportunity to create new learning communities and for students to step out of norms established in form groups.

Although a small number of students said they were happy with the balance between individual and group work, many asked for more work in groups and identified this as a positive aspect of other subjects in comparison with mathematics.

Nearly all students value the opportunity for discussion in lessons.

"You can't work on your own, you need to talk to someone else about your work" (Boy Y9)

However a few Y9 students also showed a mature awareness of the opportunity that working together offered for distraction, which could lead to "chatting to the person next to you about East Enders". However, others they felt that they had the maturity to focus on the mathematics. The impression the Y9 students gave was that they wanted more opportunity for structured discussion.

Regardless of the benefits for mathematics learning, the ability to co-operate and work with others to common ends is an important one to learn across the curriculum. Work with this particular Y9 group demonstrated that it is not enough to simply put children in groups or to ask them to work together for group work to develop. As with other difficult skills children learn they need support and guidance from the teacher and activities that allow their skills to be developed and practiced.

3. ROUTINE ACTIVITIES

The following activities are some of the means by which these general principles can be embodied in daily lessons. Many of these are already common practice or developing practice at Hampstead.

- Open or semi-open questions are used to encourage discussion. In order to discuss there needs to be something to discuss about.

- Asking questions which the teacher does genuinely not know the answer to.

369

- Opportunities are given for the whole class to answer questions together at certain times. For example, by the use of individual white boards, answer cards, hand signals or choral response.

- Students are sometimes given the opportunity to discuss answers before answering in teacher class-interactions. Interviews and surveys indicate that this is valued by many students and encourages more to speak but also that it is important that the type of questions posed in this situation require discussion to make it meaningful. So for example asking students to "turn to the person next to you and discuss at least three different ways of finding 12 ½ % of 160" and time given before contributions are invited may be appropriate. Less worthwhile are simple closed question such as what is 12 ½ % of 160.

- Students are routinely encouraged to use each as a first recourse when finding difficulties.

- When doing practice exercises, questions are routinely divided up amongst the students so as a whole all the questions are answered whilst individuals may only do some of the questions (allows sharing in a plenary).

- Students working in pairs may work on a different problem before sharing with their partner.

- Students are encouraged to ask questions of the teacher. Traditionally, asking questions has lowered students' mathematical status within groups. This needs to be reversed so that asking an appropriate or worthwhile question is valued,

- Students are encouraged to regularly express how they feel about activities and their understanding of particular topics. For example during a plenary to indicate by hand signals how confident then feel about what they have learned that lesson.

- Mistakes are valued as positive contributions to the groups learning and any critical comments made about other students are challenged

4. SOME GENERAL GUIDELINES

The activities are likely to be successful if the following are borne in mind:

- Developing a sense of community and group work skills takes time. Patience is important both with the students and by the teacher to the development of their own skills;

- It is extremely valuable to explain to the students reasons why they are being asked to work in the particular ways that they are. That is to make the reasons for the social practices explicit;

- Social stretch versus mathematical stretch. Where new groups are being formed or new social practices developed it is better to ensure the students feel reasonable comfortable with the mathematical content to begin with and they are not being stretched too far socially **and** mathematically. It is important to recognize that explaining your thinking to someone else is itself mathematically stretching

- Active learning, discussion and group work are noisy and the classroom will be noisy at times.

370

- Groups need time to get going. The level of 'busyness' in the class may not be, on the surface, as great as in a lesson where the students are working on exercises. Students have opportunities to be carried by others when working in groups. However, busyness does not necessarily equate with learning and there are plenty of ways for quite disaffection when individual tasks are set.

5. MAKING GROUP WORK SUCCESSFUL

5.1 Forming groups

The ideal is to arrive at a situation where all students are able to work successfully with all other students. However, this ideal is unlikely to be achieved and how groups are formed is an important issue. Experience withY9 has shown that how well members of groups work together has had a dramatic effect on outcome.

The issue of how to form groups is one where this document is definitely work in progress. There are many of factors to take into account. The following points are made as a starting point.

Firstly, the programme is based upon the centrality of pair work. Most of the time in lessons students will work in pairs and even when working in larger groups there maybe times when it is preferable to divide tasks up to be done by pairs. We think it may be helpful to distinguish between everyday pairs, who should be someone that the students feel comfortable working with and paired work created for specific purposes. Gwen has attempted to involve the students in the decision making process about the formation of pairs and groups with varying success.

An obvious starting point is to begin with friendship pairs and where students choice about who they are working with is taken away from them it needs to be justified.

Where larger groups are formed mixing students from different form groups, friendship groups and gender maybe useful as it can help to make a clear demarcation of the group as a mathematical learning group.

Gwen's experience with her Y9 group has highlighted the importance of being sensitive to the needs of students who have no obvious friendships within the class and also of strong but unproductive friendship pairs that may be resistant to being split up.

5.2 Home groups and jigsaw (rainbow) groups

The opportunity to and ability to explain mathematical ideas to others is associated with higher attainment and enjoyment of mathematics. For some students doing this in whole class situations can be daunting. Home and jigsaw groups are a means of providing opportunities to develop the confidence to do this and to work with unfamiliar students in a focused way.

The programme of activities works towards developing the social skills to be able to participate effectively in jigsaw groups by the end of the autumn term.

Students begin in their home groups and work on a problem together. They derive a solution or set of solutions or knowledge about a particular problem or problems. Individuals in each group then separate to go to form new jigsaw groups with three others from three different home groups. The students then share their knowledge or understanding. One of the advantages of this way of

working is that all students have to participate in both sorts of groups, with familiar work partners and the unfamiliar.

For example, different home groups might be given some text from one of four different newspapers. They are asked to analyze sentence and word length in the text and prepare statements about the newspaper they have examined. This work might be divided up within the home group; one looking at mode lengths, another at the mean and so on. What is important is that by the end of working in the home group each member must be confident about being able to explain their findings and how they were obtained. Jigsaw groups are then formed which have a representative who is now an expert on each paper. Results are shared and each Jigsaw group derives comparative conclusions about the four sets of data.

This way of working is challenging, however, it has been used successfully (and possibly developed) in primary settings. Secondary pupils do have the social skills to work in this way. Once they have had learnt this way of working it is a valuable learning style that can be used in the future. Jigsaw groups are sometimes known as rainbow groups. The home group is given a colour and the jigsaw group has one person of each colour, forming the rainbow.

5.3 Seating

There are disadvantages and advantages of different ways desks are arranged and we offer no suggestion as to what maybe an ideal permanent arrangement. However, successful groups larger than pairs will require particular seating arrangements which allow all members of the group to see each other easily. Research in primary classrooms has shown that children can learn how to quickly reorganise furniture according to purpose and we do suggest that desk arrangements do not have to be static.

6. PROGRAMME OUTLINE

The programme is not prescriptive and the approach and order of activities could be varied. However, there is a development through the activities of different social practices and so it can be seen as a cumulative programme of study. The aim is to develop comfortableness with different ways of working during the autumn term that can be further enhanced later.

Before the description of each activity a rationale is included as to its purpose and social objectives are included. These can be shared with the students. This is part of making the practices explicit. The section "What you might say" gives suggestions of how this rationale and objectives might be shared with students. It is not intended as a script and if the suggestions are very different from the way you speak to the class then you could use alternatives more in keeping with your own style.

Detailed lesson plans are not provided in every case, nor are the many possibilities for variation or extension included. Our aim has been to balance providing a structure without rigidity.

The suggested activities are particular examples and should be combined with some of the routine activities (above) that support the social objectives for the particular weeks.

7. ACTIVITIES

7.1 Week one and two: Learning names, meeting everybody,

Rationale

"When we are put into sets next year, we think it may be useful to play some games for the first couple of lessons so everyone can get acquainted with each other" (Y9 written response)

The basis of community is to know each other. The teacher's experience of a class of students as a 'a class' can lead to the impression that all students know each other. This is not the case. Name learning activities should continue after the first lesson. If the students get bored of doing them every lesson then agree that they can stop doing them when everyone shows they know everyone else's name

Social Objective: for all students to know the names of other students; for as many students as possible to know each other; for students to feel comfortable about saying how they feel in class

What you might say: "We are going to be learning mathematics together and we cannot do that if we don't know each other"

"You get to say your name a lot during the first week so you know you have as much right to be here and to learn here as anyone else – its about finding your place in this class and knowing that everyone has a contribution to make"

"These games only work if everyone cooperates. Everyone had a role to play"

Activity one –Stating names

Very simply go around the class and each student says my name is. In subsequent lessons this can be combined with, "my name is …and my favourite number is", or "…and what I like/don't like about maths is."

Comment: This allows students to be in the classroom as a 'whole person'. It gives space for the students to express their attitudes verbally and directly rather than indirectly and non-verbally. Mathematics learning is about attitude and feeling as much as about cognition.

Activity two – Passing names

A student states their name and then asks another student by name a short question and so on. Students are encouraged to ask a question that is reasonable. You do not 'lose' by not being able to answer, you lose by asking a question that cannot be answered. Add in some rules, you cannot ask a person of the same gender or in the same form.

Comment: This can be a risky activity but one that can building trust quickly, early on with the class it establishes that the students have authority as questioners.

Activity three – My name is chain game

Mathematical objectives/link to POS: Oral and mental activities, page 31[1]

Each student is given a card which has written on it "My answer is ", "My name is….." "My question is" the cards form a circle of question and answers

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[1] Page numbers refer to KS3 sample medium term plans

Support, core, extension available

Comment: Make it clear at the start that some have difficult answers and others easier, after a few seconds the teacher will give the answer or ask for anyone to give it. After being used once or twice it can be timed. The chain is completed by everyone's involvement; it helps to create a sense of unity. Everyone has to listen to everyone else and all are worth hearing. In observations of Y9 it was clear that some students commanded the class' attention more than others.

Activity four – Naming bingo

Mathematical objectives/link to POS: Oral and mental activities, page 31"

- Each student has a laminated bingo card and a non-permanent OHP pen. Each card has a number on the reverse.
- Students get up and move around the classroom to find a person with a number fitting each of the descriptions in their 8 squares. They must also ask the person's name and write it down.
- You are not allowed to use the same person more than once (may need to with smaller groups).
- When a student has filled all 8 squares they must total their numbers in the 9th square and they have won.
- Possible variations:
  - ➢ Winner is the person with the highest/lowest total
  - ➢ You can use a number more than once – who can fill their card with the least numbers?

Comment: This requires students to speak to students that they do not know. Sociability is rewarded.

7.2 Week three and four: Working as a pair

Rationale: The ability to listen to other members of the class is essential to work in community Between weeks two and three working pairs should be established which are likely to remain as everyday pairs for the remainder (at least) of the half term for most students. The activity below helps to promote good pair cooperation particularly if the pair are unfamiliar with working together

Social objective: Students to develop listening skills, ability to work in particular pairs; ability to listen to anybody in the group

What you might say: "There are potentially 30 (or whatever) teachers in this room if you listen to each other"

"Mathematics is about communication this activity is to practice communicating mathematically"

Activity five – Back to back

Mathematical objectives: space shape and measures1 page 33. In particular language associated with shape, construction skills

Resource: set of cards showing parts of tessellations. Cards to be chosen from the set according to complexity of the designs according to ability

    (i)   Whole class introduction: teacher describes one of the patterns to the class. The students in pairs attempt to draw the design on a large sheet of paper or an individual white board. One or two students might then take the teacher's role

    (ii)   Back to back. Students take two designs each in pairs and then attempt to describe the shape for the other to draw

    (iii)   Students in pairs attempt to draw accurately an enlargement of their design. Vary the equipment available depending on ability. Extension might include providing a detailed and accurate description or instructions for the construction

Comments: This activity could act as a formative assessment for Space, Shape and Measures one. Difficulty of (i) and (ii) can be varied by restricting the language available. Some of the tessellations invite discussion about angles in polygons

7.3 Week five and six: The whole class working on a problem together

Rationale: The success of each individual in a class is at least in part dependent of the success of the whole class. Developing the ability of the whole class to divide up a problem between them allows for more interesting problems to be examines and for a more efficient learning process.

Social objective: To share in the experience of all contributing to class success when solving a problem together

What you might say:

"If everyone worked individually on this problem we'd spend a longtime getting the results and not a lot of time understanding them. So if we split the task up we can move more quickly"

"we learning together and everyone's work counts"

Activity six: Decimal fraction patterns

Mathematical objectives: Number 1

Starting point. The whole class to find decimal equivalents of 1/7.,2/7/ 3/7, 4/7 etc. With or without calculators depending on ability.

Students to describe number patterns, Questions for core and extension what would the 25th digit of 1/7 be, 100[th]etc. nth digit of a/7

Main activity, other fraction series to be divided amongst the class, with pairs working on the problem together, exploring the patterns, generalizing.

All the results are collected for different fractions on OHP or board or large sheets of paper

Comparison and discussion in plenary

Comments: Differentiation within groups and between groups by the nature of the fraction series explored. Other questions that arise, which series give terminating decimals which single recurring, are their any patterns if we just look at the reciprocals

Activity seven – Consecutive sums

Mathematical objectives: Algebra 2, Sequences functions and graphs
Resource: Teachers notes

Structured investigation into sequences formed from sums of consecutive numbers. After initial discussion tasks are split up between groups and outcomes of the groups investigation are discussed.

Comment: The whole class contribution to the investigation should be stressed. As an alternative way of sharing work, particularly different ways of recording work, student could put their work out on their tables and others could go and look at others work. Alternatively, students could be given an OHT and a pen to prepare a slide to present to the other students.

7.4 Weeks seven and eight: Working in groups

Rationale

The ability to work effectively in a small group of four or five students is a difficult one to learn. These two activities require students to work together cooperatively to be successful

Social objectives

To experience solving a problem that requires cooperation and that cannot be solved individually. Also the give away game is a game for five players so there is the opportunity to work with unfamiliar partners.

What you might say

"What does frustration mean… Some people find working in groups frustrating, you may feel some frustration during this activity…that's ok, but I want you to see if you can overcome that, it's a chance to develop your patience."

"If you try to sort it out individually it won't work, be patient, cooperate"

"The only way to be a winner in these activities if you aim for everyone in you group to be a winner"

Activity eight – The give away game

Mathematical objectives – Using and applying mathematics. Resource cooperation squares pieces cut up in envelopes

Rules of the game (to be put up on OHT or board)

This is a game for five players. If you only have four then one person should be C and D.

Player A should have all the A pieces, Player B all the B pieces and so on. You will not start with an equal number of pieces.

The **rules** are that there should be no talking, no pointing and no non-verbal communication.

You may not take pieces or point to pieces or ask for pieces to be given to you in any way.

You may only **give** pieces.

The game finishes when each player has complete square

Comments: The rules are deliberately vague. This allows groups to develop strategies to solve the problem, but they have to do this non verbally. After the game has finished you may wish to suggest that the students write about how the game proceeded and how they felt during the game. If possible the teacher should join a group.

Activity nine – Making a cake

Mathematical objective/link to POS Number/algebra 1

Resources: Making cake cards and instruction sheet (based on article in MT 133 Dec 90)

Best done in the intended students 'home groups'. This activity requires students to share information with each other in order to develop a solution and to decide what information is relevant to solve the problem. This is a challenging activity and it is likely that intervention will be needed and a discussion of different strategies by the whole class will be useful as they proceed. A useful hint is for each person to read their cards and as a group for

them to decide which cards have information that is definitely irrelevant. If groups are finding the process very difficult then each person could put one card down to be read by the others.

Comments: As worthwhile as the activity, is discussing how it was completed. Give some time for reflection and possible writing about how they worked

7.5 Weeks nine, and ten: Organising your own home group

Additional resource: 'How well did we work as a group.' Sheet to encourage reflection on group work skills also helps to encourage reflection on what is important in group work.

Rationale: Good home groups allow the development of more adventurous ways of working. Students need support to develop the ability to organize their group.

Social objectives: To be confident and comfortable about working in a group of three or four where all are involved and all contribute

What you might say:

"You are going to be working together for a while on this project. At the end you will be asked about who contributed what, so try to find a way of working where everyone is doing an equal share

Activity ten – data handling

Mathematical objective: Handling data 1 page 34. Resource *How True* From SMILE plus Nice Ideas in one place

Students are to work in groups of four carrying out a statistical study, survey or experiment. Either with data provided or with data they have collected. The survey or study should be substantial enough to require a division of labour. Groups may need support on organizational skills, for example forming a work plan.

The *How True* resource gives some ideas for investigation if students find it difficult to generate their own.

There is scope here for students to do a substantial piece of work over an extended period of time. This might lead to a group report, presentation or poster.

Comments: The "How well did we work as a group" sheet is a prompt for reflection. Teacher feedback on group work skills as well on the mathematical outcomes is valuable.

7.6 Weeks eleven and twelve: Jigsaw groups

Rationale: Working with people that you know well is challenging, working with relative strangers more so and requires practice. Jigsaw grouping allow the class to be more than a collection of groups but makes links between groups. This generates stronger and more fluid communication within the class. The activities require students to present or talk about their ideas and to listen to three others. For some students this can be a bridge to contributing in the whole class or listening to others.

Social objectives: Students to experience the support of a home group to solve a problem and then to present that to others that they are less familiar of working with.

What you might say

"During this lesson you will work with some people you are not used to working with. You will be representing your homegroup"

Activity eleven: Who is best at maths

Mathematical objectives/link to POS: Number and Algbera 1

Core, extension and support versions available.

Extension: Brian, Ramesh, Nicki and Samantha

Core: Samaya, Morwenna, Jaap snf Jeremy

Support: Leon, Nelson, Rosa and Vaclav

Students are given the role of teachers. In their home groups they have a set of one student's answers to a series of problems, for example Brian. The home extension groups would be a Brian group, a Ramesh group, a Nicki group and a Samantha group. Their first task is to identify any errors that the student has made. They should be encouraged to split this task up within the home group. As a group they should aim to all be able to discuss their student's work with others.

When they have done this, Jigsaw groups are formed with one person who is an expert on each student. For example an extension Jigsaw group would have one person each from a Brian group, a Ramesh group and so on. In the jigsaw group each member presents what they know about the individual's answers that they have analysed. The aim in the Jigsaw groups is to compare the students' answers and formulate a short report. They then return to their home groups to share their reports.

Comments: *Whole class discussion about different methods can be generated. It is important that different parts of the activity are timed and students encouraged to keep to these times.*

8. Appendix

General principles

The particular activities suggested in the programme below are not a substitute for on-going practice that promotes discussion and a sense of a learning community.

To be successful the need to embedded in a daily practice which has the following general features, although not all feature will be apparent on a daily basis:

- Makes explicit the reasons why particular social practices are being promoted in terms of the desire to develop a sense of community and learning together. For example by referring to behavioural expectations in terms of the needs of the whole class rather than the individual;

- Establishes classroom norms that are based on the needs of the group not the status of the teacher. For example students are reminded of the need to listen to each other because they can learn from each other rather than because of an abstract need for quiet or because the teacher's status demands it;

- Attempts to develop a meta-cognitive awareness amongst student by sharing social objectives as well as mathematical ones. A meta-cognitive awareness would feature an ability to identify the ways that pairs, groups or the whole class can work together which have positive and negative effects on learning. Examples of appropriate social objectives to be shared might include that a particular activity aims to develop listening skills or putting forward a point of view or ensuring everyone can contribute;

- Mathematical discussion is encouraged between students whatever activity they are engaged in unless there are specific reasons why students should participate individually and if so these reasons should be explicitly stated;

- Talk about learning not work. Much talk in mathematics classrooms refers to individual students work. Lessons can easily become focused for the students about 'getting on with your work' or 'how much work have you done'. Talk about work can distract from a focus on learning and tends to individualise the learning process. This does not mean that it is wrong to ever mention work, learning can be and often is hard work but care needs to be exercise about the implicit messages that are contained in some of the talk about work in classrooms;

- Patience. Learning difficult social skills like difficult mathematical concepts takes time. Patience needs to be offered by the teacher to their own learning process, to the classes and to individuals. This programme values active learning and participation. It attempts to find ways of including all students in discussion within groups and in the whole class. The confidence to speak is an important in being able to participate fully in community and for equity. But for some students contributing in a whole class situation or speaking to a relative stranger can be painful and difficult and confidence may develop slowly. Interviews with less confident students have indicated that they can feel intimidated by loud and more vocal students;