Telling Choices: an exploration of the gender imbalance in participation in advanced mathematics courses in England

Heather Fiona Mendick

Goldsmiths College, University of London

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Abstract

In this thesis I address the research question: **how is it that people come to choose mathematics and in what ways is this process gendered?** This question arises out of the on-going gendered pattern of participation in mathematics beyond compulsory education in England and out of wider concerns about the ways in which inequalities are reproduced through individuals' choices. I draw on the findings of a qualitative research project, involving interviews with 43 young people (all but one aged between 16 and 19) and observations of their AS-level mathematics classes. The research participants are drawn from seven classes in three London institutions: a comprehensive school, a sixth form college and a further education college. Working within a framework drawing on feminism, post-structuralism and psychoanalysis, I argue that identity in general, and gender in particular, is a project and one that is achieved in interaction with others. By analysing the interviews as narratives of self, I examine in detail the ways in which choosing to do or to reject mathematics can become part of this project; that is how this choice can be read as a way of doing gender. I analyse the ways that students work the socio-cultural discourses about mathematics into their own identity work. The discourses that are most central to this process construct mathematics as 'hard', a proof of intelligence, certain, objective, associated with genius, and a signifier of social incompetence. I argue that these are oppositional and gendered. They inscribe mathematics as masculine. Thus they make it more problematic for girls and women to identify with the subject and so to succeed at and to choose it.

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My dad died during the first term of this PhD and this was a difficult time for my family. Thanks to my mum, Ruth, and my brother, Graham, for their constant support and belief in me. My family and friends have put up with me going on about gender and mathematics in an increasingly obsessive manner. I am indebted to them for their continued patience and understanding, and for lots of fun. I must mention at least Andrew, Anna and Gary, Farah, Rajko, and Susan.

A few months after starting this PhD I gave up fiction (with only occasional relapses) so that I could concentrate on the mountains of books and papers relating to my thesis. Since then I have turned to television and films to satisfy my appetite for stories. I doubt I would have made it to the end without *Buffy*, *The Sopranos*, *Six Feet Under*, *Oz*, and *Big Brother*, to name but a few.

Finally, I am inordinately grateful to Goldsmiths and to the Economic and Social Research Council for supplying the funding that made this research possible, and to the staff and students at Grafton, Westerburg and Sunnydale who allowed me into their classrooms and into their lives. I have learnt so much from watching, listening to, and talking with them, and I hope that comes through in this thesis. I also hope that they will be happy with the 'finished product'.

Table of Contents

List of Tables

List of figures

Chapter 1 Introduction

1.1 My name is Heather, and I'm a mathematician

While not a health endangering addiction, being a mathematician is a culturally and socially marked category of identity. It is something that is difficult to admit. It has the power to impress, intimidate and alienate others; its mention often evokes in them painful memories of their own experiences of school mathematics. However, in some ways it still feels a more secure label than that of educational researcher, and mathematics still more my academic home than any of the other disciplines with which I have flirted since returning to university study three and a half years ago. So, this doctorate is auto/biographical not only in that it is the outcome of my increasingly obsessive efforts during the last three years to find out **how it is that people come to choose mathematics and in what ways this process is gendered**[1], but also because it can be read as an attempt to understand my own identification with the subject. So to understand this you need to know a little about me. However, as Griffiths (1995, p.13) points out "using autobiographical material is not straightforward...There are epistemological problems." I begin with a few of these.

Recently I saw Roman Polanski interviewed about his filmmaking career. The interviewer, Mark Cousins, insisted on pursuing his rather facile theory of the way life experience relates to practice. So, for example, Cousins insisted that there must be some simple causal connection between the violent murder of Polanski's wife and friends and his next film *Macbeth*, and that *Tess* must have been the result of his exile from America, because of a pending conviction for underage sex, that immediately preceded it. Cousins continued to return to this theme despite Polanski's obvious annoyance; as the latter explained, influence is a complex dynamic, and everything has an effect on him and his work, including what he has for breakfast in the morning. In writing about how my own experiences have led me to do my research I am very wary of replicating the Cousins fallacy, by describing a series of events which seem to direct me-linearly, teleologically, inevitably-towards becoming a feminist, mathematics education researcher, with a penchant for psychoanalytic explanations and post-structuralist deconstruction. Like Usher (1998, p.22) I recognise the need to decentre time, for:

> How we understand ourselves is not just a matter of here and now present understandings of the past but a product of how we understood ourselves in

[1] Bold text is used at various points in this thesis with the aim of drawing the reader's attention to the emboldened words and phrases.

> the past and our anticipation of our future possibilities, how we will be in the future.

As well as pointing out the ways we all reconfigure our experiences to produce a self-justifying plot (see also Brown, 1997; Convery, 1999) Polanski's comments also suggest the way we cannot always unpick the tangled strands of influence, and motivations that are sometimes conscious, but more often are not. Underlying this research is my conviction that our choices, particularly about the way we live and our career paths, are expected to be rational but rarely are. Thus any attempt by me to describe my own choices is bound to rationalise them and so to underplay all the unconscious motivations-defences, fears, desires-that have brought me to this point:

> 'Being able to give reasons' for one's choice of action or definition of self-interest cannot be taken as unproblematic evidence of rationality or freedom from the unconscious either. A 'rational reconstruction' of the reasons for a choice or belief may on analysis turn out to be an elaborate rationalization of or reparation for an irrational wish or fear. (Flax, 1990, p.62)

However, the problems noted above, that is our human tendency to rationalise our past actions and the impossibility of discerning their unconscious motivations, are problematic for all forms of social research. Thus they should not rule out the use of the researcher's narrative of self within their work, especially given the powerful feminist arguments for the necessity of interrogating one's own identity in producing reflexive explorations of practice. Drawing on the feminist writings on methodology (these are explored in more detail in Chapter 2), it is clear that every researcher is present in their work:

> If nothing else, we would insist on the absolute reality of this: that being alive involves us in having emotions and involvements; and in doing research we cannot leave behind what it means to be a person alive in the world. (Stanley & Wise, 1993, p.161)

1.2 Choices, identities and labels

Identity may be a fiction but it is clearly an important and influential one (see section 3.5). People construct narratives of self by taking on labels. The perspective of situated cognition suggests a close relationship between this process and learning. Within this framework, learning happens in a way analogous to apprenticeship, via legitimate peripheral participation in a community of practice. This community may be that of mathematicians, teachers or adult males, and the learner becomes inducted into the community; thus "learning and a sense of identity are inseparable" (Lave & Wenger, 1991, p.115, and see the discussion in Chapter 4). I have organised the auto/biographical material

below around labels that feel important to me: mathematician, woman/feminist, and teacher. All are communities of practice within which I have served an apprenticeship.

1.3 All that David Copperfield kind of crap[2]

1.3.1 Becoming a mathematician

It is interesting that, while I am researching the process of becoming a mathematician, and the role of choice within that, I do not feel I ever made such a choice. For as long as I can remember I have seen myself as a mathematician. I even watched Open University mathematics programmes on Sunday mornings during my lower sixth and was the only person in my school ever to do A-level Further Mathematics. As a pre-school child I loved to write out long sums occupying a whole page, involving brackets, as well as the four basic operations.

I have always enjoyed puzzles. When we were given the rule for the divisibility of a number by 11, I set about proving it and then generalised it. I remember, when I was about 14 a friend said that there was a temperature at which Celsius and Fahrenheit scales give the same numerical value but that she could not recall what it was. I immediately wrote down an equation for this temperature and solved it. My friend was visibly impressed. She could follow the mathematics, she just would not have thought of doing it. This incident probably sticks in my head because of the reaction to it, which suggested that my response to mathematics identified me as different from other people. However, it was not until university that I read this difference in terms of power.

I do not remember having trouble maintaining a concept of real mathematics separate from, but connected to, school mathematics (see Burton, 1999c); alongside my O-level mathematics work I read Raymond Smullyan's *The Lady or the Tiger* (a book on mathematical logic), while at A-level I moved on to books by, among others, Ian Stewart and Douglas Hofstadter. These two types of mathematics were distinguished by valuing different things: discovery, understanding and beauty, as against getting all the answers correct, laying them out in the prescribed manner, and presenting them neatly (similar distinctions are found in the talk in this study of the participants who most strongly identified with mathematics, discussed in section 5.2). I think that I experienced mathematics as very powerful then; I definitely do now. As a result I view mathematics as a

[2] This sub-title is taken from the opening of the novel *Catcher in the Rye*: "If you really want to hear about it, the first thing you'll probably want to know is where I was born, and what my lousy childhood was like, and how my parents were occupied and all before they had me, and all that David Copperfield kind of crap, but I don't feel like going into it, if you want to know the truth." (Salinger, 1994, p.1)

very special subject (in a positive sense), whilst being aware that few other people share this sentiment.

However, the power and safety that the label of mathematician brought me was threatened when I began studying the subject at university. The difficulty of the material combined with other (male) students' lack of honesty/over-confidence about how they were coping with the course, led me to experience a sense of failure. Although the agony of struggling with what seemed impossible questions for hours on end was ultimately useful, in allowing me to empathise with my future students, it was not fun at the time. The following incident exemplifies the competitive nature of the Cambridge educational experience that seemed to feed the dynamic process through which my sense of failure was constructed. The night before the first year examinations began, a friend of mine (now a mathematics lecturer) came round and made a list of all the thirteen first year undergraduate mathematicians at King's College detailing how many questions he thought each of us was going to complete over the twelve hours of assessment. He put me at the bottom with eight and him at the top with eighteen (actually I got ten and he got fourteen). He later said he had intended it to improve my motivation. Of course, there is competitiveness, not only in his actions, but also in my recounting of them here.

1.3.2 Becoming a woman/feminist

In constructing an understanding of the problems I had becoming a mathematician at Cambridge I have come to see them as being inextricably connected to gender. Indeed I believe it is through these experiences that I first came to define myself as female, for as Wittig (1992, p.3) says before conflict "there are no categories of opposition but only of difference". It was at university that I realised the importance of gender in constructing social life, and that male-female relationships are characterised by inequalities of power. Thus my identities as a woman and as a feminist are inseparable.

This sudden awakening to the salience of gender was perhaps brought on by the transition from an all-girls school to King's College, where I was the only woman among the thirteen mathematicians in the first year. In lectures the ratio was a little better being assisted by the two all-female colleges; among lecturers the ratio was much worse. There was little blatant sexism (although I doubt that the friend who asked how my then boyfriend was taking it when I got a first to his second would have felt the need to inquire had things been the other way round). However, I did feel that, because I was a woman, I had to do more to prove myself academically with some of my peers. Perhaps this is simply due to the impression I gave of not being able to cope with the work, something I now view as a gendered response, a performance of femininity. Examination results proved

important, both to building my own confidence, and to my gaining respect as a mathematician within the group.

At Cambridge I also became aware of another form of prejudice: against scientists and mathematicians, called natscis and mathmos respectively. One friend got a T-shirt printed with the phrase "mathmos are nice people". Subject stereotypes were (surreally) real there, and having never read *The Hobbit*, any science fiction or even played *Dungeons and Dragons*, it probably was more difficult for me to continue to identify as a mathematician when I first arrived.

On reflection, at Cambridge I became a female mathematician. As Damarin (2000) describes, this is a difficult identity to adopt, carrying a double marking of cultural deviance (see section 5.4.2). The tensions involved in occupying such a subject position are one of the main themes of this thesis and are the particular focus of Chapter 6. By the end of my three-year degree course, while I had reaffirmed my identity as a mathematician (after a turning point in the second year when I decided not to switch to a B.Ed course but to complete my mathematics degree), I had no desire to become a professional mathematician. Thus although I cannot locate my choice to opt into mathematics, I did choose to opt out at this stage. This was an informed decision and I do not feel that, simply because I was capable of continuing with mathematics, I owed it, to myself, to my gender, or to society, to do so.

1.3.3 Becoming a teacher

After graduating, I trained as a teacher, something that I had been enthusiastic about since I was fourteen. I saw this as a job through which I could reconnect with the world after the previous three years' academic isolation, a way of 'keeping it real' as my brother (and Ali G) would say.

Becoming a teacher was also a political act because of my belief in the power of education to effect social change. However, there is a gap (or a chasm) between this goal, and the liberatory practices consonant with it, and what actually goes on in classrooms. For example, during my PGCE course I investigated gendered patterns in mathematics learning. My long essay looked at the role played by gender differences in affective variables, such as enjoyment of the subject, beliefs about its utility and attributions of successes and failures. While within it I clearly located myself in the 'we need to change the classroom mathematics and not the girls' camp, I feel that I did not carry this through effectively in my subsequent teaching. Although I did try to be anti-competitive and to encourage a critical approach to the curriculum, there were other pressures, external and internal, that affected the way I taught. These pressures included assessment regimes, the

requirement to secure good examination results, the impositions of senior management, the need to keep control of the class, and a desire to be seen as a 'good teacher'[3] by colleagues, by students, and by myself. I continue to struggle with these and to be frustrated by my apparent inability to move beyond them, perhaps my mathematical training has not helped leading me to expect and desire universal and unambiguous solutions. These contradictions contributed to my decision to leave teaching, giving me a space to reflect.

As part of that reflection, for the course *Social Divisions and Inequalities* on my MA in Gender Studies at Newcastle University, I wrote an essay about Worcester Sixth Form College's Equal Opportunities Policy and ended the essay by recounting some experiences I had while I was Equal Opportunities Co-ordinator there, a role within which I came into conflict with the Principal:

> We differed in our interpretation and our views concerning the significance of the Policy, the Principal seeing it mainly as a document necessary to fulfil FEFC inspection requirements. Two examples of our disagreements on interpretation illustrate how they were aided by the contradictions between liberal and radical discourses within the Policy and by the vagueness of the language that enabled liberal or radical readings of statements in it. I felt that to disseminate "awareness of equal opportunities through...staff induction and other training activities" (lines 72-3) it was necessary to have some equal opportunities training. With the support of the member of the senior management team with responsibility for professional development, half a day's training with an outside speaker was organised. Although this was the first equal opportunities training ever held at WSFC only one person out of a seven strong senior management team attended the full afternoon. The Principal did not even welcome the speaker. The second example concerns the Policy's requirement that the criteria for application for posts of responsibility be bias free (lines 74-5) which I felt was broken by the system of relying solely on line manager's recommendations. The Principal was staunch in his defence of this system. He saw it as requiring people to prove they deserved an allowance, he did not feel that there were any equal opportunities implications.

This passage illustrates how I was able to use the reading I had done to make sense of my own practice, something I see as a central purpose of research.

When I returned to full-time study and began my MA in Gender Studies I had dreams of pursuing some radical new direction. I even had to be persuaded by my tutor to take the option in Education. In retrospect this seems bizarre. It now seems obvious to me that I should use my experiences, some of which I have described here, of doing mathematics and of teaching, directly in my academic work. They both equip me with a

[3] I use inverted comments around this and other phrases as a reminder that they represent socially constructed positions with complexes of practices and meanings attached to them. Of course there are many more phrases that, on these criteria, should be so marked and are not. I have chosen to label only the ones that are most central to my argument.

unique and valuable perspective on my research and provide a powerful motivation to pursue it. Continuing to work as a teacher at Goldsmiths College, Westminster University and Grafton School[4] during my research has provided me with a great deal of material to contribute to my thinking.

1.3.4 My so-called life[5]

> Trained in algebra and analysis, I identify professionally as a teacher of mathematics. I have applied for a visa for an extended stay in the permeable territories of sociology-as a resident alien or a cross-specific hybrid, naturally. But my real home is the ferociously material and imaginary zones of popular culture, into which I and hundreds of others have been interpellated. (personalised from Haraway, 1997, p.49)

This process of writing my life was something I began during the first term of my research; it has been riddled with difficulties and insecurities. First, it forced me to consider the way I feel about writing. At the start of my PhD I was always surprised when anyone complimented me on my writing, as opposed to my ideas, and was unable to believe that I could write in anything beyond a functional way. I was particularly terrified of creative writing, whilst paradoxically wanting very much to be able to express myself in this mode. I suspect that this fear connects with the way that mathematics is socially constructed as opposed to writing (the epistemological implications of this are discussed in Morgan, 1998, and in Chapter 5 of this thesis). I have come to understand that writing is something that can be learnt and worked at and that a necessary first step, as with learning mathematics, is to confront the fear head on. I have also come to understand the process of writing as inseparable from developing my ideas so that even the simple linguistic act of inserting inverted commas or a hyphen becomes a theoretical and thought-provoking performance.[6] For example:

> The slash between the two elements in the term auto/biography is a useful reminder that the words we use are problematic. Shared meanings and understandings are not easily come by...The place of the slash in using the term auto/biography stops the flow of the word which might have the effect of making the reader pause to consider issues of authorship and voice. (Parker, 1998, p.116-117)

[4] Since I also conducted some of my research here a pseudonym is used.

[5] This was the title of a U.S. high-school angst drama that was cancelled after its, now legendary, first series. The current explosion of US teen shows, such as *Dawson's Creek* and *Buffy the Vampire Slayer*, owe it a great debt.

[6] This practice of inserting / and otherwise re-writing words to disrupt their normal meanings was popularised by early feminists. Daly (1987) is famous for "the/rapist" and "gyn/ecology" among other linguistic re-appropriations, and drew on an earlier essay by Wittig (in Wittig, 1992) in which the latter draws attention to the masculine subject assumed in the French word for I writing it as "j/e".

Auto/biography also acts to blur the binary opposition between writing about the self and writing about others. Instead of the former being irredeemably subjective and the latter potentially objective we have a glorious tangle of intersubjectivity and reflexivity.

Writing this has also made me think about how I come to know things, and was a key moment on my journey to non-foundational epistemologies (see section 2.2). I do see myself as thinking through fiction, with 'real' events mediated through an imaginary filter provided by everything from *Howard's End* to *Ally McBeal.*

> Life-transforming ideas have always come to me through books. Even when profound experiences alter my sense of reality, those lived moments usually return me to ideas I have read or lead me to further reading. (hooks, 1994, p.91)

Ultimately I consider the most successful attempts to capture the contradictory nature of self and life, are fictional; the form of a text is implicated in the material it is able to convey. Along with Acker et al. (1991, p.149) I wonder whether:

> Virginia Woolf, among other novelists, may give a better account of the conscious experiencing of life in all its episodic and unorganized ways than we sociologists can achieve.

While presenting the auto/biographical material, as I have here, under the three headings, mathematician, woman/feminist and teacher, does suggest something of the way I experience my-self, it is marked by omissions. As well as ignoring many other possible labels (Jewish, middle-class, heterosexual, Londoner and short, to name but a few) and the potent influence on me of fiction, in books and on big and small screens, it tends to paper over the contradictions that fiction voices.

Of the three labels it is my experience of being a woman and a feminist that feels the most contradictory, conflicted and confused and yet it is experience or "moments of shared ontological recognition" (Skeggs, 1997, p.25) that are at the base of the feminist movement. I am alternately drawn to the power of post-structuralist theorisations of gender and to everyday polarisations, of the 'all men are bastards' variety. Snitow (1990, p.38) gets closest to expressing my sentiments on the issue of gender equality and difference that threads through this thesis:

> From moment to moment we perform subtle psychological and social negotiations about just how gendered we choose to be…One can be recalled to 'woman' anytime-by things as terrible as rape, as trivial as a rude shout in the street-but one can never stay inside 'woman' because it keeps moving. We constantly find ourselves beyond its familiar cover.

1.4 Knowing experience

Returning to Griffiths' point about the contested epistemological status of auto/biography, what can I expect you to know from reading this? As Griffiths (1995, p.15) highlights, when writers "assume too much, communication breaks down". I hope that you now know enough about me to make sense of the arguments that I will make in this thesis. Some feminists (for example, Harding, 1998) have claimed more for experience, attempting to elevate it to the level of an epistemology, however the connection between ontology and epistemology is more complex than this standpoint position suggests (see section 2.2.2). The latter "reduces knowledge to a formula of being=knowing" (Skeggs, 1997, p.26) and disappears the contested nature of experience and the discursive constitution of the subject. I agree with Skeggs (1997, p.27) when she advocates using "experience as a way of understanding how women occupy the category 'woman'" and not "as a foundation for knowledge, a way of revealing or locating true and authentic 'woman'".

Ultimately interrogating our identity **is** important because it reminds us how contingent are the stories we tell about our experiences of research; others will tell other stories:

> But at least let us not operate under the illusion that the next protagonist has scientific right on their side, to demonstrate the truth about what happens to human beings without a flicker of intruding emotion, without a shadow of a doubt. (Walkerdine, 1997a, p.89)

This thesis is my meta-story constructed from the stories the students told me, the stories we tell ourselves and each other about mathematics, gender, our choices, who we are, and many other things. It is also an attempt to re-write these stories (Davies, 1993). However, before telling new stories it is important to pay attention to the silences in the current ones. The rest of this chapter begins this process by looking at the hegemonic stories about gender and choice in contemporary political and feminist thinking. It provides the wider context in which I am working to find methods to explore the gendering of mathematics, discussed in Chapter 2, and in which sit the academic stories of gender, mathematics and subject choice, discussed in Chapter 3, as well as a feel for the literatures through which I have approached this area.

1.5 The educational politics of choice

Currently the dominant media and political discourse[7] about gender and education concerns the 'underachieving' boy who was to be found "'strutting and fretting' at the centre of the gender reform stage in the mid-1990s" (Kenway et al., 1998, p.47) and who remains there in the new millennium. This figure has emerged for a number of reasons including changing patterns of male and female employment (O'Donnell & Sharpe, 2000) and a backlash against feminism (Faludi, 1992; Lingard & Douglas, 1999). However, his emergence is also tied to the Thatcherite extension of the private sector market economy into the public sector, including education. This shift has created a class of new managerialists, propounding a version of school effectiveness that is:

> Undertheorized in relation to issues of inequalities, they are technicist and managerialist in their approaches to schooling; their primary reference point is competitiveness in the global economy; and their primary method is constant testing, often associated with league tables of successful and unsuccessful schools. (Epstein et al., 1998 p.8)

The increasing importance of examinations and the reification of results is an inevitable backdrop to this thesis. However, by posing my main research questions around an attempt to understand gender differences in choice rather than in achievement, I am explicitly working with a broader understanding of the aims of education and of educational success than discourses of school effectiveness[8] allow. I also move beyond the oppositional framing of both the current debate and of some 1980s feminist positions; "at the moment we seem to be locked into a dichotomised, confrontational model of the girls' disadvantage discourse versus the boys' disadvantage discourse" (Jackson, 1998, p.82).

As a result of the marketisation of learning, 'choice' is now a powerful signifier within current debates about education (Gewirtz et al., 1995). The media and politicians speak of parental and student choice as **the** way of guaranteeing that each individual gets the most out of what our educational system has to offer and importantly contributes the

[7] The post-structuralist term discourse is discussed in more detail in section 3.5.1. Although similar to the concept of ideology, "the substitution of the term 'discourse' for 'ideology' signals an important shift" (Davies, 1993, p.14) away from the ideas of ideologies as distorting the 'truth' of social reality and subjects making mistaken commitments to them, towards ideas of a range of alternative discourses and subjects constituted through multiple recognitions.

[8] The pernicious effects of performativity/school effectiveness are evident in Benjamin's (2001) attempt to intervene in the production of masculinities in her class of 10-12 year-old boys in a special school. Benjamin (2001, p.53) notes: "if there is an average it follows that many must be below it". She argues that the boys' stress on macho forms of masculinity is a psychic defence against an untenable reality and concludes that New Labour's upward spiral of educational targets "is daily becoming more of a dystopic nightmare" (p.53). Ball (1995) also looks at the problematic impact of performativity on schools and of the 'discourses of derision' (originally discussed in Kenway, 1987) directed at schools as a result.

most that they can to the country. The hope invested in education is clear in Blair's speech after securing victory in the 2001 General Election:

> We need to start building the economy of the future based on skills and talents and education and the application of technology, knowing that for this country in the future the forces of global competition and technological change mean that we can only compete on the basis of skill and ability. (Blair, 2001, *online*)[9]

This quote demonstrates the way that New Labour's stories of educational choice are drawn from the liberal political paradigm in which choices are seen as individual acts, the route to personal autonomy and self-realisation, and as deriving from people's 'natural' talents and abilities. Therefore little regard is given to the structures and systems within which these choices are embedded. While conducting the interviews for this study I was struck by students' responses when asked to explain why boys and girls tend to choose different subjects to study within the sixth-form. Many told me that they had not noticed this part of their daily life until I had mentioned it and then were either unable to come up with a convincing explanation or ascribed the difference to a combination of chance and individual interest, despite my informing them that their choices fitted a recurring, nationwide pattern. "The young people see themselves as individuals in a meritocratic society, not as classed or gendered members of an unequal society." (Ball et al., 2000, p.4) It seems that these young people do not have a language in which to speak about the constraints, conscious and unconscious, on choice. My study aims to show that discourses of 'free choice' are unconvincing and to move to a new understanding of choice as "a matter of individuals interpreting the cultural knowledge available to them and playing the game of life according to the known rules" (Shaw, 1995, p.107). I am concerned to look at the way in which choices can perpetuate inequalities:

> Social regulation can function, not only in a sense through overt oppression, but rather through defining the parameters and content of choice, fixing how we come to want what we want. (Henriques et al., 1984, p.219)

The contradictions within liberal notions of choice are very apparent in Renton's account of his choice to become a heroin addict in *Trainspotting* (the film version of this sits on my bedroom wall):

> Society invents a spurious convoluted logic tae absorb and change people whae's behaviour is outside its mainstream. Suppose that ah ken aw the pros and cons, know that ah'm gunnae huv a short life, am ay sound mind etcetera, etcetera, but still want tae use smack? They won't let ye dae it. They won't let

[9] I am following Mann and Stewart (Mann & Stewart, 2000, p.16) here: "The online world is a new field-not least in terms of referencing online journals and websites...When references for online sources refer to a direct quote the italicized word *online* will stand in place of a printed page reference."

> ye dae it, because it's a sign ay thir ain failure. The fact that ye jist simply choose tae reject whit they huv tae offer. Choose us. Choose life. Choose mortgage payments; choose washing machines; choose cars; choose sitting oan a couch watching mind-numbing and spirit-crushing game shows, stuffing fuckin junk food intae yir mooth. Choose rotting away, pishing and shiteing yersel in a home, a total fuckin embarrassment tae the selfish fucked-up brats ye've produced. Choose life.
>
> Well, ah choose no tae choose life. If the cunts cannae handle that, it's thair fuckin problem. (Welsh, 1993, p.187-188)

These contradictions are also central to feminist imaginings.

1.6 The feminist politics of choice

Liberal feminism[10], based on liberal political philosophies, which concentrates on removing discrimination against women within the public realm, finds it difficult to explain why there remain so few female mathematicians, politicians, engineers and so on, now that the overt barriers to their participation in these fields have been removed. It seems that women simply do not want to do these things, we perversely insist on making the wrong choices. This difficulty is manifest not only in the issues of employment[11] and subject choice, but also in arenas as varied as eating disorders[12], plastic surgery[13], rape and abortion.

I focus on just one key example: 'choice' is the rallying cry for the second wave feminist movement's continuing campaign for abortion on demand, and the legal treatment of the issue in North America is illustrative of the paradoxes contained therein. The Roe v. Wade case was an historic Supreme Court judgement guaranteeing a 'woman's right to choose' on grounds of privacy, in the sense of bodily integrity, the right of an individual to self-expression and self-determination (Schneider, 1994). However, as Rothman (1999) warns, there are problems with superimposing this freedom onto a social structure characterised by inequality. She acknowledges that 'choice' offers an effective starting point for political action, but an ultimately limited one that leaves the status quo unchallenged. This was made apparent by the second key judgement on abortion, the Harris case, where

[10] See Tong (1993) for an overview of the different feminist perspectives, such as liberal feminism and radical feminism, that are referred to in this section.

[11] A paradigmatic example of this from the United States is the case where the Equal Employment and Opportunity Commission (EEOC) took Sears to court arguing that "Sears had discriminated against women in hiring policies for commission sales jobs and by inequitable pay scales for managerial positions" (Farganis, 1994, p.55). Sears argued that women did not want to work in the competitive field of commission sales and **chose** other jobs. Feminists argued on both sides of the case with Rosenberg speaking for Sears and Kessler-Harris for the EEOC. The judgement in 1986 went in favour of Sears. As the various feminist discussions of this case demonstrate (for example, Faludi, 1992; Farganis, 1994; Milkman, 1986; Scott, 1990), it raises issues of choice versus coercion and equality versus difference and of how far it makes sense to say that people whose interests and aspirations are formed in a climate of oppression can be said to have freely chosen their situation.

[12] See Orbach's (1986) reading of anorexia as a protest against patriarchy, a hunger strike.

[13] See discussions in the work of Bordo (1993a; 1993b) and the recent trends for 'designer vaginas' and for having breast implants at ever younger ages (Chaudhuri & Mahey, 2001).

the Supreme Court ruled against the requirement to provide state funding for abortions. MacKinnon (1987, p.101), writing from a radical feminist perspective, is clear about the failings of the liberal argument that grants a theoretical right to abortion without providing the resources necessary to make this 'right' a reality:

> The logic of the Court's response resembles the logic by which women are supposed to consent to sex. Preclude the alternatives, then call the sole remaining option 'her choice'. The point is that the alternatives are precluded by conditions of sex, race, and class-the very conditions the privacy frame not only leaves tacit but exists to guarantee.

While my main aim in this and the preceding section is to spotlight some of the silences in the hegemonic liberal approaches to choice, there are also silences in the radical feminist responses. Radical feminists like MacKinnon (1987) and Dworkin (1981; 1983) produce powerful and necessary arguments. However, within such texts there is a tendency to see all the breast-implant obsessed 17-year-olds, women who stay with men who hit them, and girls who choose literature over physics as victims of 'false consciousness'. The resulting strategies, from banning pornography to scare campaigns to choose mathematics, are often counter-productive (Kenway et al., 1998). In this thesis I take seriously the choices that girls and women (and boys and men) make and see them as making sense in the spaces where they are. It is useful here to compare the perspective on sex and consent within MacKinnon's quote above with that contained in this more ambiguous statement by Wurtzel (1998, p.117) on adolescent female sexuality:

> [We] need to understand that when girls misuse or abuse the term 'date rape' it is only because the taxonomy of women's sexual experience has not yet classified all the different perfectly legal and easily available ways that these women-in-training feel themselves being violated-they have no language to express how they had no idea what they wanted until they got what they didn't want.

I develop these arguments in Chapters 2 and 3. In Chapter 2 I look at what the discussions in this chapter, about choices, politics and the self, mean for the processes by which we come to know and what the implications of these are for doing research. In Chapter 3 I deconstruct the failure of earlier feminist approaches to the gender and mathematics issue. I argue that the problems lie in their not moving beyond the individual/social dualism and having too simplistic a notion of power, as that possessed by dominant groups and used to oppress others. The model of choice that I introduce there, and that I develop throughout the thesis, is a post-structuralist one. It understands power as existing on the micro as well as the macro-level, as something implicated in and through all our actions. In Chapters 4 to 7, I apply this model to an analysis of observations of and

interviews with AS-level mathematics students. In these chapters I use the model to move beyond the opposition between the individual and the social to build more complex ways of narrating choices and the relationship between **individual** decisions and **social** structures, and to find ways of thinking how gender constructs mathematics and mathematics constructs gender.

Chapter 2 Knowing and doing research

2.1 Introduction

Underlying any attempt to explore the social world is methodology, it is "the archaeological foundation from which theories are constructed" (Skeggs, 1997, p.38), without it "we cannot *think*, indeed we cannot *be*; beyond methodology there is death, silence, the end" (Stanley, 1997, p.218, original emphasis). Doing research involves interlinked considerations of epistemology, methodology and method (Harding, 1987). In this chapter I begin with epistemology because:

- Writing a thesis requires the making of a claim to knowing. I do not think that I can get very far without elaborating what I mean by this, and by the phrase 'an original contribution to knowledge'.
- While some research questions suggest different methods or methodologies there is no simple implication from the first to the second and decisions about how to answer a particular question involve assumptions, implicit or explicit, about what it means to know.

In the first section of this chapter I use feminist critiques of traditional epistemologies to argue that neither knowledge itself, nor the ways in which it is produced, are outside of relations of power.[1] Thus I argue that epistemologies that are founded on a notion of reality (and of knowledge's relation to it) are untenable. Instead I advocate a position based in postmodern and post-structuralist[2] work that understands knowledge by starting from everyday practices of knowing. In the second section I discuss the implications of this 'progressive antifoundationalist' (Berube, 2000) approach for the methodologies and methods of the research that I used to find out **how it is that people**

[1] These arguments are not exclusive to feminist work on methodologies. Many intellectual developments have contributed to the move away from foundationalism and the death of the subject (Hall, 1991, highlights the parts played by the work of Marx, Freud and Sassure). I have chosen to draw largely on feminist work in this chapter because of the consistent political stance taken by feminists and because it is through these writings that I came to know about methodology (although I am inevitably influenced by my reading of other texts such as: Gouldner, 1973; Polanyi, 1959).

[2] While accepting that the conflation of the terms postmodernism and post-structuralism is "a fact of contemporary...debate" (Weedon, 1997, p. 180). I, along with other feminist post-structuralists (see for example, Butler, 1995; Weedon, 1997), find this problematic. Postmodernism is vaguer and broader, being used to signify everything from new styles of architecture to a contemporary postmodern era where globalisation has brought about shifts in identity, and "hardly a week goes by without a casual and often imprecise synaesthesia of 'postmodern' with 'progress' and 'pleasure'" (Humm, 1997, p.145). I prefer the label post-structuralist because, although far from uniformly used, it has come to refer to a collection of ideas about power, knowledge, truth and identity deriving from the work of Foucault, that I find productive and that I use/am used by in this thesis. However, I retain the term postmodern here because for some writers (for example Flax) this is their chosen label.

come to choose mathematics and in what ways this process is gendered. A central focus of the discussions is the way in which different approaches conceptualise the human subject. This connects with the material on my own identity explored in the introduction and to the more explicit treatment of identity, in relation to mathematics and subject choice, which is developed in the rest of the thesis. From now on I will put the word 'identity' in inverted commas to indicate that it is a problematic (but probably unavoidable) term, with its associations with an inner stable essence of the person, which is unpacked in section 3.5.1 where a fluid and performative understanding of the self is elaborated.

2.2 Epistemology[3]

2.2.1 Feminist empiricism: gendering knowledge

Second-wave feminists highlighted the ways women were missing from social research and the implicit 'identity' of the researched was male. For example, Paul Willis' (1977) influential study *How Working Class Kids Get Working Class Jobs* actually discussed how working class **boys** get working class jobs (and is now read as a text on masculinity for example in: Abraham, 1989; Foster et al., 2001). It was typical of social research at that time in falsely generalising from all male samples and was part of a misogynistic strain of ethnographic research in education in the 1960s and 1970s that was "focused on anti-heroes: the portrayal of the rebellion or resistance of the hooligans" (Delamont, 2000, p.96; see also McRobbie, 2000). This research, at best left uncritiqued, and at worst romanticised, the rampant sexism (and racism) of the boys studied. The feminist project rushed to fill the gaps in malestream social investigations; the first sociological studies of housework (Oakley, 1974), girls' subcultures (collected in McRobbie, 2000) and domestic violence (Dobash & Dobash, 1979) were done. Feminist empiricism reflected this early enthusiasm. It argued that while the assumed object of social research had been male, the basic progressive Enlightenment project remained valid. It had been misused, but non-sexist social science, the rational pursuit of knowledge, was both possible and the solution (for example, Eichler, 1988).

Feminist empiricism advocated a purely additive approach to the absence of women. However, it was "a curious hybrid" (Code, 1995, p.178) and had the radical

[3] Harding (1987) suggests a teleological progression in feminist epistemologies, from a rehabilitation of science in empiricism, through a valorisation of marginal experience in standpoint, to a more postmodernist stance. However, all three positions have been present since the start of second wave feminism and all three appear to some extent, intermingled in all the varied epistemological positions adopted by feminists since then (Stanley, 1993). Thus although Harding's threefold epistemological typology is used to structure this section, this is for convenience and is done with an awareness that each of these positions is plural and overlapping.

potential to demonstrate the gendering of epistemology itself. This potential is demonstrated in the now classic work of Gilligan (1993/1982)[4]. Gilligan, noting the absence of women from the research done by Kohlberg to establish his scale of moral development, decided to explore the way women make moral judgements. She found that males often reasoned from abstract points of justice, in a way seen by Kohlberg as the highest ethical state, treating a moral dilemma as "sort of like a math problem with humans" (p.26). She labelled this a 'separated' approach to moral reasoning, and contrasted it with the more 'connected' approach favoured by women. Connected reasoning starts from the relationships between people. Belenky et al. (1986) described *Women's Ways of Knowing* developing Gilligan's separated/connected distinction beyond knowing about morality to knowing more generally. This body of work reveals that traditional epistemologies are based on a model of the human subject as individualistic and rational, and essentially unchanged by the process of knowing. So the assumed maleness of the researcher as well as of the researched is more central to the process of knowing than empiricism had suggested initially (I return to this work and the ways that it has been taken up in mathematics education in section 3.3.2).

Thus, the feminist project shifted from inserting women into the samples and questions addressed by otherwise unchanged methods, to critiquing epistemology itself and, in particular, the relationship between knower and known:

> In the conventional model, the knower is separable from what is known, and the purpose of knowledge is knowledge. From the feminist perspective, the person who knows, what they know and what is to be known are joined in a nicely heretical confusion. (Oakley, 1993, p.208)

The goal of knowledge is replaced by the process of knowing; individualistic or separated understandings of the people involved in research are replaced by relational or connected ones; the rational human subject is replaced by one whose actions are influenced by conscious and unconscious factors. At the centre of feminist critiques are the need to acknowledge the situated-ness of the researcher and to reject the goal of objectivity, that the knower should detach themselves as far as possible from the situation they are studying, should perform what Haraway (1991, p.189) calls the "god-trick" of being everywhere and nowhere at the same time. To be objective in this sense one must conceive of one's self in a particular way. Braidotti (1994, p.28) explicitly connects the quest for objectivity "to the fantasy of self-generation, of being father/mother of oneself, thus denying the specific debt to the maternal"; objectivity is a denial of connectedness and

[4] A lot of classic texts are now available in second revised editions. Where their earlier publication date is significant I have included it, as here, after a /.

more specifically a flight from the feminine[5]. That objectivity and disembodied knowledge, and the psychic investment in these, have a role in perpetuating female exclusion is a central argument of this thesis and one that I focus on in Chapter 5. So, before developing my own position on knowing, it is productive to look at attempts to reclaim objectivity for the purposes of feminist political struggle.

2.2.2 Feminist standpoint: situating objectivity

Standpoint epistemologies' versions of objectivity are based in claims regarding the impact of the knower's social location on what they can know. This situated objectivity derives from reworking the Marxist idea that material life sets limits on our understanding of society. Specifically, the structuring of society through relations of domination and oppression means that the vision of the dominant will always be partial since it is they who occupy a position from which real social relations cannot be seen, while that of the oppressed offers the potential for a more complete social knowledge (Collins, 1998; Hartsock, 1987). However, it is not naively essentialist[6], recognising that marginal experience does not confer automatic epistemic privilege, since "standpoints are critically and theoretically constructed discursive positions, not merely perspectives or views that flow from their authors unwittingly because of their biology or location in geographical or other such social relations" (Harding, 1998, p.17). Harding (1998) proposes that this can form the basis for a 'strong objectivity'. However, since she argues that men can think from a feminist standpoint and Europeans can cultivate the standpoint of the women and men their countries have colonised, she offers nothing more than a rough guide as to how to adjudicate truth claims, rather than an explicit way of deciding between two differently situated and contradictory knowledges. As I argued in section 1.4, despite Harding's claims to the contrary, there is a confusion of epistemology and ontology here. Pure experience unmediated by the linguistic and discursive practices of the social world is impossible, and so experience, even used in a reflexive manner can never be the universal foundation of truth that Harding craves[7]. Within this thesis: "Experience is...not the origin of our explanation, but that which we want to explain." (Scott, 1992, p.38)

[5] Feminine here refers to those historically contingent and shifting discursive practices that are constituted as feminine in opposition to practices that are constituted as masculine. Both men and women can engage in both feminine and masculine practices. This model of gender is borrowed from the work of Connell (1995; 1987) and is elaborated using data in Chapter 6.

[6] Essentialist is often used to label those positions that are based in an understanding of difference as biological. However, I follow Bohan (1997) in using essentialist to label those positions that locate gender and/or other differences within the individual, regardless of whether the essence is seen as biological, social or anything else.

[7] Or as Hall (1991, p.58) put it: "There is absolutely no political guarantee already inscribed in an identity. There is no reason on God's earth why the film is good because a Black person made it. There is absolutely no guarantee that all the politics will be right because a woman does it."

Motivating Harding's attempt to construct a "successor science" is the paradox of feminism wanting simultaneously to claim that all knowledge is situated **and** that it has escaped relativism and found the route to unadulterated truth claims. These two positions Haraway (1991, p.188) calls "radical constructivism" and "feminist critical empiricism". I imagine them, as she does, as being two ends of a slippery pole. And:

> It is, of course, hard to climb when you are holding on to both ends of a pole. Simultaneously or alternately. It is, therefore, time to switch metaphors. (Haraway, 1991, p.188)

Haraway's own choice of metaphors is 'vision'. Her divergence from Harding is clear when she says that although "subjugation is not grounds for an ontology; it might be a visual clue" (p.193). Drawing on the imagery of technoscience she sees all vision as mediated by, "instruments of vision" (p.193); vision is never innocent. She asserts the situated and "embodied nature of all vision" in order to reclaim seeing from the distancing and conquering gazes "honed to perfection in the history of science tied to militarism, capitalism, colonialism and male supremacy" (p.188). Haraway's 'optics' is just one of many possible metaphors that see 'identity' and 'power' as more contradictory and fluid than in either empiricist or standpoint accounts. Such metaphors must ultimately be judged by their utility. This metaphor for knowing is a powerful one, encouraging us to use dialogue, empathy and imagination to locate ourselves and to think ourselves into different social locations. However, Haraway's purpose is a little different from mine and this is evident in the way that her sort of seeing must be learnt. Although seeing is something we all do, her emphasis on optical instruments perhaps suggests a scientific process of viewing qualitatively different from that which we engage in daily. Perhaps because of the centrality of learning to my project I want a theory of knowing that captures its everydayness rather than its utopian possibilities. The next section develops my own complementary approach that is more grounded in the routine social practice of knowing, "in a Wittgensteinean spirit I am arguing that we should look at what we do rather than what the philosophers say we do" (Hekman, 1999, p.105).

2.2.3 Knowledge as a social practice: learning as apprenticeship

In my research I proceed by a metaphor drawn from the field of situated cognition. Starting from seeing humans as social beings, learning (or coming to know) is seen as a social activity, taking place in a way analogous to apprenticeship. Knowing is omnipresent and always takes place within a community of practice, in which the knower/learner is a legitimate peripheral participant (Lave & Wenger, 1991; Wenger, 1998, see discussion in section 4.3). The nature of the community of practice, the access knowers/learners are

granted within it, and its structure and its mode of operation, thus become important epistemological issues. So, this is a model of knowing that foregrounds the relational. It suggests that we ask what kind of epistemic communities we should create to support the society that we want. It also foregrounds issues of power and avoids de-politicising decision-making (as Young, 1990, argues this is one of the most pernicious aspects of the liberal democratic approach to social justice).

Knowing conceived as social practice emphasises that it is not something that happens only in the ivory tower or the laboratory. Knowing is synonymous with engaging with the world and so we are constantly learning. It also recognises that, while we may venerate empiricism or rationalism, we rarely employ them in our daily lives (Code, 1995). The rationalistic paradigm for knowledge production "is at the same time hegemonic and aberrant" (Hekman, 1999, p.102) and has dubious utility for deciding the truth status of propositions once these get beyond the complexity of 'the cup is on the table'. And it further serves an ideological purpose, to "obscure the extent to which there are genuine choices about how to know the world and its inhabitants" (Code, 1995, p.3). Since knowing involves choices and since, as I argued in the last chapter, these are complex mixes of conscious and unconscious elements, this makes epistemology also a psychoanalytic project. A socially-grounded and psychoanalytically-aware epistemology sees how stories filled with anxiety and desire permeate our knowing. The knower is both rational and irrational, and is formed through the practices in which they engage.

Returning to the troubled matter of objectivity, while not using the word, in this thesis I am working with Code's (1995, p.178) 'storied objectivity', "one that produces stories about its own claims to objective status-and that recognizes the need for such stories, resisting any temptation to assume that its 'successes' are self-justifying". However, if all we have are stories, why should we believe one rather than another? I now address the issue of how to avoid such relativism.

2.2.4 Feminist postmodernism/post-structuralism: the descent into relativism?

The position introduced above and developed throughout this thesis is an antifoundationalist one that moves beyond the search for universal grounds for knowledge. Post-positivists and feminist modernists have attacked antifoundationalism arguing that in abandoning claims to represent reality and to posit a stable subject, we also give up the grounds for political action and are reduced to relativism. These are important challenges and in this section I look at each of the points they raise in more detail as a way of further elaborating my position.

In post-positivist accounts of research the quest to represent external reality is to preserve us from the intrusion of political biases. Hammersley (2001a, p.4) describes post-positivism as opposed to 'activism' and 'postmodernism', and seeks to secure the validity of research "in terms of truth-as-correspondence" and to achieve value-neutrality. For him the strongest argument against 'feminist' and 'postmodernist' methodologies is that political concerns should have no place in determining the goals or validity of research work (Hammersley, 1992, 2001a; see also the similar positions of Seale, 1999; Silverman, 1993). He argues that researchers produce facts that can then be applied using values and it is only in the second stage that politics are involved.

However, although the "promise of the existence of a neutral yet emancipatory reason" (Flax, 1993, p.30) in post-positivist accounts, is appealing, it is naive to believe that truth is ever separable from politics. This is clear from Foucault's work (see section 3.4.2):

> I have been trying to make visible the constant articulation I think there is of power on knowledge and of knowledge on power. We should not be content to say that power has a need for such-and-such a discovery, such-and-such a form of knowledge, but we should add that the exercise of power itself creates and causes to emerge new objects of knowledge and accumulates new bodies of information...The exercise of power perpetually creates knowledge and, conversely, knowledge constantly induces effects of power. (Foucault, 1980, p.51-2)

Those who support the exclusion of politics from research ignore the political stance of those they defend. Knowing is always a political act (Ramazanoglu, 1992). The rehabilitation of Enlightenment rationality is not just a waste of time but the attempt to create innocent knowledge is dangerous; "I believe that four of the greatest tragedies of modern Europe-slavery, the oppression of women, Nazism and Stalinism-were potentiated by our collective wish that innocent and universal positions are possible and desirable" (Flax, 1993, p.32; see also Connell, 1995).

For feminist modernists the intolerability of antifoundationalism derives from its nihilistic consequences. Here the abandonment of objective reality has been a secondary issue with the focus of critiques being on the consequences of the loss of the centred human subject. Feminism, they argue, is a truth discourse with emancipatory aims and so is incompatible with relativism; a feminist politics requires a stable subject existing within and producing knowledge about a unified category of 'women'. Hartsock (1990, p.163) provocatively asks:

> Why is it that just at the moment when so many of us who have been silenced begin to demand the right to name ourselves, to act as subjects rather than objects of history, that just then the concept of subjecthood becomes problematic?

Harding's (see section 2.2.2) is one of many voices (see also Francis, 1999; Fricker, 1994; Strickland, 1994) supporting Hartsock in reading post-structuralism as condemning us to political paralysis and as the latest ruse for maintaining male supremacy.

The irony in Hartsock's question comes from the fact that it is **not** a coincidence that the problematisation of subjecthood has come along at the same historic moment as the proliferation of the claims to occupy that position. Subjecthood could only remain unproblematic while it was the restricted province of a narrow group of people (white, male, heterosexual, Western, young, able-bodied...). It was always a partial position and it was through the differences that liberation politics forced inside its boundaries that this became evident. Trying to squash the embodied female subject, the post-colonial subject, and other Others into the straitjacket of the Enlightenment self has split it beyond all hope of resurrection. However, this does not condemn us to relativism:

> The alternative to relativism is not totalization and single vision, which is always finally the unmarked category whose power depends on systematic narrowing and obscuring. The alternative to relativism is partial, locatable, critical knowledges sustaining the possibility of webs of connections called solidarity in politics and shared conversations in epistemology. (Haraway, 1991, p.191)

Post-positivist and feminist modernist positions "work with a caricature of relativism that no self-declared, self-respecting relativist would endorse" (Code, 1995, p.186). The critics who argue that a relativist can never prove their case, ignore the fact that we do this all the time, and in ways which are only rarely based in science and logic. This is where the insights gained from seeing knowledge as a social practice are most valuable, reminding us that we decide between conflicting truth claims daily through interaction within communities of practice. A democratic epistemology enables us to escape being trapped between relativism and realism. That we ultimately decide what to believe within a community "is not to say that such acceptance makes those views true, or rejection makes them false, but rather to say these are the best methods available to us for making decisions which accord with reality" (Seller, 1988, p.175-176). We come to know through dialogue and the struggle to understand others' positions:

> What peace and equality are discovered to be will depend on the decision that various communities have taken. Through our decisions with a community, we decide how we want to belong to the world, how we want to set about understanding it, living in it and changing it, we have nothing else to rely upon except each other in taking these decisions. (Seller, 1988, p.181)

Looking at the social practice of post-structuralism (what post-structuralists actually do rather than what we or our critics say we do) it is clear that our work is not relativistic in

the way Hammersley suggests. It is concerned with issues of power and **can** be 'liberating', as Walkerdine (1990, p.70, original emphasis) argues, we are not obliged to accept any given truths and "showing the truth about girls to be a production in which there are no *simple* matters of fact is a central and strategic part of our struggle".

> But in order to recognize the effectivity that such investigations may have, it is necessary to discard the last vestiges of those nineteenth-century philosophical disputes between materialism and idealism. These oppositions, which grew out of highly politically charged but very specifically historically located disputes, have a lot to answer for. They have done much to constrain our ways of understanding of the materiality of ideas, and to recognize the embeddedness of thought in the most prosaic aspects of social and economic life. But if human being is always 'being thought' and if human practices are inescapably made up in thought, then thought itself can and does play a role in contesting them. To diagnose the historicity of our contemporary ways for thinking and acting is to enhance their contestability, to point to the need for new experiments in thought which can imagine new ways in which we can be and act. (Rose, 1999b, p.58-59)

This is the sense in which I hope to make 'an original contribution to knowledge' in this thesis. That is, to make visible some of the unquestioned commonsense assumptions within the ways in which we think, learn, teach and live, and so to enable new "experiments in thought".

Summarising this section: to do my research I need methodologies and methods that theorise the 'identities' of those involved in the research as fluid, contradictory, relational and combining the rational and the irrational, and that recognise that there is no knowledge beyond or outside of relations of power and so:

- Put gender and other social divisions at the centre of the research process and understand these divisions as inequalities of power relations.
- Theorise the role of the researcher in the process and see the need for them to take responsibility for the impacts of their research.
- Seek to generate knowledge by attending to silences in current research, seeing things differently, re-writing old stories and telling new ones. "It is a matter of introducing a kind of awkwardness into the fabric of one's experience, of interrupting the fluency of the narratives that encode that experience and making them stutter." (Rose, 1999b, p.20)

In the next sections I describe the process of doing my research under three headings: selecting the research sites, interviewing students, and observing lessons. These descriptions pay attention to the three points identified above and are concerned with how I made the methodological choices that I did. In following them it might be helpful to refer

to the 'time line' on the next page which is designed to show the pattern of my research across the three years of the PhD, focusing, in particular, on the way that the data collection and analysis fitted with other aspects of my work. I have chosen to include a column on the communication of my research because of the central role of discussion within communities of practice in my model of knowing.

Table 1: Time line[8]

Year:	*Autumn term:*	*Spring term:*	*Summer term:*	*Teaching/learning:*	*Communication of research:*
2000/2001 First year of national AS-levels	I gradually come to see my teaching at Goldsmiths and at Grafton as part of my research but do not collect data on this in any formal way	I do 11 interviews involving 12 Grafton students I change supervisors (from Dennis Atkinson, Rosalyn George and Lesley Jones to Dennis Atkinson, Debbie Epstein and Leone Burton)	I negotiate access to Westerburg and to Sunnydale and go on a preliminary visit to Westerburg I analyse the Grafton interviews	I teach an AS-level mathematics group for two terms at Grafton I start learning Spanish I teach on PGCE, BA(Ed) and MA courses at Goldsmiths as part of my departmental bursary	I present some findings to the Language and Culture research group in my department and then write this up and submit the paper to the conference Mathematics, Education and Society 3 (MES3)
2001/2002 First year of A2-modules (the scandal of OCR results being 'changed' hits the papers in August)	I observe two weeks of classes at Westerburg, Sunnydale and Grafton (3 AS groups, 2 AS groups, 1 AS and 1 A2 group respectively) I do 13 interviews involving 18 Westerburg students and 9 interviews involving 13 Sunnydale students	I observe half a week of classes at Westerburg, and Sunnydale and one week at Grafton (the same groups as before)	I observe half a week of classes at Westerburg, and Sunnydale I spend the summer analysing the data from Westerburg and Sunnydale I upgrade from MPhil to PhD	I teach a GCSE foundation mathematics group at Grafton for 6 months I attend a GCSE Spanish class at Sunnydale I change funding from a departmental bursary to an ESRC award but continue teaching on the PGCE and BA(Ed) courses at Goldsmiths	I present work at: The British Society for Research into Learning Mathematics (BSRLM) (Mendick, 2001); The Association of Teachers of Mathematics; MES3 (Mendick, 2002a); Psychology of Mathematics Education (PME26) (Mendick, 2002b); other research groups I submit a chapter for inclusion in a book (Mendick, 2003b)
2002/2003 Estelle Morris Education Minister resigns	I contact Sunnydale, Grafton and Westerburg to get an update on the students. I begin 'writing up' completing first drafts of chapters 1-3	I write first drafts of chapters 4-6	I complete the thesis	I attend an AS Spanish class at Sunnydale I continue teaching at Goldsmiths and in February start work in the Sociology Department of Westminster University	I present work at: BSRLM; Discourse, Power, Resistance (Mendick, 2003c); Gender and Education Conference (Mendick, 2003a); other research groups I submit a paper to the journal *Gender and Education*

[8] Adapted from an idea in Bibby (2001).

2.3 Methods and methodologies: selecting research sites

Before deciding what data to collect and where to collect it I had to find a way of looking at subject choices. My starting point for exploring the gendering of the choice to study mathematics was to see choice as being centrally about 'identity'. I view subject choice as one of the key sites where young people make themselves:

> When we choose subjects we are obliged to redefine ourselves and make a public statement about what sort of person we are, or hope to be. It is perhaps the first significant choice of identity. (Shaw, 1995, p. 113)

In Chapter 3 I will extend the argument, introduced in the discussion of learning as apprenticeship (section 2.2.3) that 'identity' is not an essence of the person but is produced in and through the practices in which we engage.

Although choices do not happen at a single point, the end of compulsory schooling forces a crystallisation of young people's views about themselves, their futures, their education and mathematics, and provides a useful place to start exploring these. As a result I decided to focus on those students on AS-level courses who were still quite close to this structurally enforced moment of decision-making. There is little qualitative research in the mathematics education literature that informs "the evidential facts that girls choose mathematics less than boys and that gender disparities in achievement prevail at some levels" (Boaler, 2000, p.39), and still less that approaches this through an exploration of the identities of people doing mathematics. In addition, that which does exist has generally focused on compulsory or higher rather than further education (FE)[9]. There is also a great deal more known about the reasons why people reject mathematics and/or fail at it than about those who take it up and/or succeed. As a result I decided to look at those who had chosen to continue with mathematics into the sixth-form. This meant that I would be collecting data in the kind of environments that I had worked in for years and from the kind of young people with whom I had a great deal of professional experience. Given the

[9] The persistence of the emphasis on the quantitative in research on gender and mathematics is evident in all three of the papers dealing with this topic at the most recent meeting of the International Group for the Psychology of Mathematics Education (Forgasz, 2002; Neria & Amit, 2002; Soro, 2002). Examples of qualitative studies focused on gender and mathematics learning in secondary education are Barnes (2000a; 2001), Boaler (1997), and Nardi & Steward (2000); examples from higher education are Evans (1995; 2000), Macrae et al. (2001), and Mann (2003, although this is only a summary of the full unpublished report). Bibby (2001) looks at primary teachers' relationships with mathematics and Burton (1999a; 1999c) at those of professional mathematicians, although the explicit and implicit ideas about 'identity' in these studies are very different. Within further education, a generally under-researched field (Hughes et al., 1996), the small amount of work on gender and mathematics that I am aware of comes from Burton (2001), Landau (1994) and Walshaw (2001). While all of these studies influence my work only the work of Bibby, Evans and Walshaw uses a similar approach to mine to 'identity'. I locate my own approach within this and other studies of educational choice throughout this thesis.

anxieties that I had about doing research, familiar contexts helped me to feel more comfortable with the process.

I collected data from three educational institutions that I have called: Grafton Comprehensive School, Westerburg Sixth Form College and Sunnydale FE College. These three settings are described in detail in section 4.2. Here it is enough to know that Grafton was an ethnically diverse, largely working-class school that worked together in a consortium with three other local schools to provide a wide range of post-16 options for students; Sunnydale was a large FE college, within walking distance of Grafton, and catering mainly for adults doing part-time and/or vocational courses; and Westerburg was an oversubscribed highly academic college with an ethnically diverse, but largely middle-class, intake over an hour's underground journey from the other two.

My choice to do research in a range of different FE providers was **not** in order to get a 'representative sample' of students from which generalisations could be made. There is no simple relationship whereby increasing the sample size of a study necessarily makes it a more worthwhile piece of work (Potter & Wetherell, 1987). My epistemological position, outlined above, means that I was looking for research contexts which would enable me to collect data that I could use to create new stories that people would feel have application to their own settings. So representative-ness was important only in helping to stimulate the ideas for such stories and to make these stories convincing to others. Although in social research, representative data are often seen as necessary for producing findings that are generalisable to other contexts, in legal and clinical cases, the responsibility for deciding on the applicability of findings to new situations lies with the receiver and not with the giver of the information (Kvale, 1999). The latter needs only to provide sufficient evidence to allow such judgements to be made. Freud's case studies (for example, Freud, 1990) provide good examples of highly specific texts presented in such a way that people have taken from them a wide variety of meanings that they have then applied in their own ways in the situations where they live.

The process of gaining access was relatively straightforward at Grafton where I worked part-time and had good relationships with staff and students in the mathematics department. Aware that there are macro-social factors, deriving from recent, rapid educational changes that are making it increasingly difficult to find schools and colleges willing to participate in research projects (Troman, 1996), I designed the data collection so as to minimise the demands on teacher time. I also wrote the initial letter, sent to college principals (see appendix 4), so as to stress this and to describe the research in a way that would not be threatening to staff, who may have connected being observed with being judged via Office for Standards in Education (Ofsted) and Further Education Funding

Council (FEFC) inspections (the observations are discussed in section 2.5). I found two places that were willing for me to research there, and then came the decisions about how to collect data.

2.4 Methods and methodologies: interviewing students

With my emphasis on student 'identities', it seemed that interviews would be the most direct way to access these. I view "the processes of interviewing and of being interviewed [as] not simply about the giving and receiving of information but at least as much about speaking identities into being, solidifying them and constantly reconstituting them through the stories we tell ourselves and each other" (Epstein & Johnson, 1998, p.105). Unconscious factors form an important part of this process, "the elements of phantasy, the rush of desire and/or disgust, of who we desire and who we wish to be-in psychoanalytic terms, the cathexis of object choice and identification" (Epstein & Johnson, 1998, p.116; see also Hollway & Jefferson, 2000, and Walkerdine et al., 2001, for an exploration of the role of unconscious factors within the interview process). I read the interviews as performances of self in which language functions not to describe reality or inner states but constitutively (Fairclough, 1989; Potter & Wetherell, 1987) to do 'identity' work.

I interviewed forty-two mathematics students aged between sixteen and nineteen and one mature student (see appendix 1 for details of all research participants). The interviews varied widely in both length, ranging from fifteen minutes to forty minutes, and in formality. Students were asked:

- To describe a typical mathematics lesson, and what they had enjoyed most and least during the year.
- About the different learning styles used in their classes and about which of their subjects was most similar to mathematics and which most different from it.
- To give the reasons for their subject choices and for what they hope to do when they leave the sixth-form.
- About their feelings on gender.

Appendix 2 contains a copy of the interview schedules used in Grafton and in Westerburg and Sunnydale. These were slightly different due to the interviews being conducted at different points during the AS course (see the 'time line'). The interviews were semi-structured and started with a very open question to describe a 'typical mathematics lesson' to allow students some role in directing the interaction. In all except one case, where the interviewee did not give me permission, I taped them. The interviews are the main source

of data used in this thesis so here I explore in some detail the ways in which power played in these interactions.

2.4.1 Interview roles

As argued in section 2.2.1, the knowers and the known are not separated but are joined in a "nicely heretical confusion" (Oakley, 1993, p.208). Oakley (1981) applies this understanding to interviewing; she deconstructs the traditional text-book approach to interviews and challenges what she calls the "masculine paradigm" in which interviews are seen solely as ways of extracting information from respondents; respondents are objectified, and seen as passive and present only to help the interviewer; all communication is strictly one-way and the interviewer is prohibited from disclosing their personal views. Within this paradigm "getting involved with the people you interview is doubly bad: it jeopardises the hard-won status of sociology as a science and is indicative of a form of personal degeneracy" (p.41). She argues that this paradigm needs to be replaced by a less hierarchical relationship in which there is "no intimacy without reciprocity" (p.49). I was not concerned with detachment in my own interviews and anyway my class at Grafton, and some other respondents, already knew where I stood on the gender issues that I asked them about. In several cases students asked me about my own views and extensive discussions ensued. My own questions and comments in the interviews were often an instant reaction, expressing sympathy with or offering a challenge to what had just been said. In the cases where students chose to be interviewed in groups of two or three such sympathy and challenges, in addition to several of my prepared questions, were also provided by other students.

The model of detached interviewing is a myth that leaves the roles of the researchers untheorised beyond the implicit assumption that they are coherent rational subjects. Feminists have written a great deal in an attempt to theorise the role of the interviewer following Oakley's influential paper. A focus of this work has been power understood in terms of the relative positioning of the interviewer and the interviewee within social structures, notably those of gender, class, age and race/ethnicity. In a project focusing on gender it is significant that I am a woman. I interviewed young men and women, sometimes in single-gender or mixed-gender groups. The evidence on the effect of interviewers' and interviewees' genders on the interview itself is ambiguous. Perhaps since listening is often associated with femininity in society my gender was an advantage making it easier for students to talk to me (Neal, 1998). Finch (1993, p.170) argues that in woman-to-woman interviews, the fact that "both parties share a subordinate structural position by virtue of their gender" makes a special interview relationship possible. However, this view

of the gendering of interactions in interviews universalises and fixes gender difference and ignores differences between women and men.[10]

In my research, the most significant socio-structural difference between the participants and myself was that of age. David et al. (2001) argue that any adult in a school is inevitably identified by students with the teachers and benefits from this power. In Grafton I worked as a teacher, while in Westerburg and Sunnydale I occupied an in-between state (Morris-Roberts, 2002). In all classes, I sat with the students, obeyed instructions from the teacher, took notes (although of course very different ones from the other students), and was occasionally used by students to subvert the teacher's intentions. Sometimes when I talked to students about things other than mathematics I felt as if I was being naughty. I also adopted some teacher-like practices: assisting students with their work and even teaching a few lessons in Westerburg, hanging out in the mathematics staff office, and even though I encouraged students to call me 'Heather' I often found they addressed me as 'Miss'.

While I acknowledge David et al.'s point that in the age-stratified organisations where I researched I benefited from the way students identified me with their teachers, I think there were important differences in the ways that the students related to me compared to how they related to their teachers. For the interviewees at Grafton for whom I was their current mathematics teacher, the pedagogic discourses within which our dialogue is normally framed did intrude, particularly on the fraught issue of homework.

There is an example of this in my interview with Michael (his story is explored in detail in section 6.2.3), a student who had submitted very little homework. He tells me that the way he learns best is "do some exercise, normal questions that I get from the teacher, which is you."

"So it's actually just doing exercises at home by yourself?" I ask.

"Which I don't do," adds Michael.

Although I was not consciously aware of it at the time, my question, with its direct reference to work "at home", appears to me now to contain an implicit telling off which perhaps explains Michael's response. However, Michael's willingness to disclose to me the personal information that the parents he lives with are not his biological ones, something he rarely tells teachers, does suggest that he saw the interview as a different space from the classroom. It is also important to remember that the teacher/student division is constructed differently in each of the three locations and, even within a single place,

[10] There is much in the literature on this: see for example Luff (1999) who discusses the issues involved in interviewing anti-feminist women and Phoenix (1994) the way that gender interacts with other factors such as race/ethnicity.

different combinations of teachers and students also produce a range of constructions of this power relation.

Linguistic and cultural differences also had an obvious effect on the interactions. Several of the young people whom I interviewed were recent entrants to this country and did not speak English as their first language. I found the interviews with Ashley and Priya, from Hong Kong and Sri Lanka respectively, more difficult to conduct and to analyse due to language issues and perhaps also cultural ones. Their responses were often short and frequently laughter or the phrase "I don't know" was offered instead of the longer explanations that I wanted to provoke. In our contemporary culture interviews proliferate, from celebrity chat shows to high street market research, and so individual interviewees are pre-socialised to the technique. This is even more so now than when Benney and Hughes discussed it in 1977 (reprinted in 1984). However, I do not know to what extent this applies in other countries.

The discussion of research relationships above demonstrates clearly that power pervades the interviews and that power, although disproportionately on the side of the researcher, is not fixed there. I finish with one more example of this, the issue of informed consent. A letter was given to all interviewees explaining briefly the purpose of my research (see appendix 4). However, it is debatable how far their initial consent was genuinely 'informed' by an understanding of what I would do with their words. I would argue, with Hollway & Jefferson (2000, p.88), that "the decision to consent...cannot be reduced to a conscious, cognitive process but is a continuing emotional awareness that characterises every interaction". So although consent is given at the start it is constantly being re-negotiated in the participants' subsequent actions and interactions. These issues of consent then involved not just the initial decision as to whether or not to be interviewed but, for example, negotiations regarding with whom to be interviewed and when, the actions of not turning up for interview appointments (and for rearranged interview appointments), how students within the interview interpreted my interview questions, and what they chose to say to me and what to not say, and the refusal of Matthew to be taped. Additionally ethical considerations did not end with my obtaining 'informed consent' but were on-going throughout the process of analysing the data.

2.4.2 Analysing the interviews

I started my analysis by coding all of the first eleven interviews from Grafton using the computer program NVivo. The codes I used were a mixture of ones, such as 'enjoyment of mathematics', which arose from my interview questions and others, such as 'family', which arose from the students' answers. However, I then abandoned this approach

in favour of a more holistic approach that involved writing a story for each interview. I did this because when looking at all the responses on a particular topic, for example what makes mathematics similar to or different from other subjects, it was possible to understand these responses on different levels. They could be looked at in isolation, so that some people in drawing parallels to or distinctions from mathematics spoke of the curriculum, and some of the teaching methods, while others focused on the atmosphere in the class or on the teacher. However, they became more meaningful when looked at in the context of the interview as a whole. So for example, for Nazima, mathematics' similarity to English was about the teacher, but so too were the things she selected when asked about what she had enjoyed about mathematics lessons and about the difference between GCSE and A-level. In fact the role of the teacher permeated her account of school mathematics. It thus seemed that I could examine each interview more productively as an integral whole through one or more central strands that threaded through many of the responses. This would allow me to look at both consistencies and contradictions within the accounts. However, my hours spent coding were not wasted because I found that two of the original themes, students' reasons for choosing mathematics and their views on other people's image of mathematics, were useful starting points for developing the stories. These themes involved the students in defining themselves against other people and thus enabled me to focus on the ways the students spoke about 'who they are'.

Theoretically, using stories rather than codes better captured the way students, through a complex process of negotiation and identification, were positioning themselves relative to mathematics. Experience exists through our attempts to make sense of it by telling stories (Bruner, 1990). Stories impose order and structure and patterns of cause and effect; they attempt to explain why things happened as they did, and to decide what did happen.

> It's a way of explaining the universe while leaving the universe unexplained, it's a way of keeping it alive, not boxing it into time. Everyone who tells a story tells it differently, just to remind us that everybody sees it differently. Some people say there are true things to be found, some people say there are things to be proved. I don't believe them. The only thing for certain is how complicated it all is, like string full of knots. It's all there but hard to find the beginning and impossible to fathom the end. The best you can do is admire the cat's cradle, and maybe knot it up a bit more. (Winterson, 1985, p.93)

After completing the individual stories I developed connections between them and the substantive chapters of the thesis are "written around 'analytic sets' of young people" (Ball et al., 2000, p.17). This device:

> Blends fairly detailed narratives with a degree of conceptual focus...Each set addresses a range of issues via patterns of similarity and difference identified in the narratives elicited from young people. (Ball et al., 2000, p.17)

I sent to each student the story of their interview accompanied by a letter (see appendix 4). Most students did not provide me with any feedback, but that which I did get was positive regarding the ways in which I had read them from their interviews. For example, Peter e-mailed: "Thanks for the report :-) it made amusing reading. You've really got my personality down, it's scary." I got more feedback from students at Grafton because of my continuing contact with the school. These students' two main concerns were the names that I had given them and the way their words had been presented, repetitions, hesitations, deviations and all. The first was easily changed the second was not. "We tend to think we speak like characters in a play, but actual or natural verbatim speech is not at all like play dialogue." (Potter & Wetherell, 1987, p.13) This created an ethical dilemma for me. On the one hand there was my commitment to respond to interviewees' concerns, to present them in a way that they considered fair and not to exploit my power over their words. On the other hand there were considerations of how far I could edit their words free of the conversational features that were often central to my analysis. It was not that I felt that the original transcript contained within it the truth of what happened:

> The idea that transcription is 'simply putting the words down on paper' is very far from reality. Transcription is a constructive and conventional activity. The transcriber is struggling to make clear decisions about what exactly is said, and then to represent those words in a conventional orthographic system (Stubbs, 1983). (Potter & Wetherell, 1987, p.165)

However, aesthetic editing seemed unjustifiable. My partial resolution is to abandon the very long indented extracts from transcripts that were a feature of my initial stories in favour of using shorter extracts incorporated, like the speech in novels, into this thesis. This is an idea that I have borrowed from Billig (1992, p.29):

> The reconstructions use literary devices for representing dialogue: 'He said..., then she said..., then he said', and so forth. These devices are more usually found in fiction or journalism than in social scientific writing. There is a theoretical reason for using this style...each individual is unique...The conversations represent unique moments in their lives. The heavy theoretical categories, so commonly encountered in social psychological and sociological texts, can easily obscure this sense of individuality. It is necessary to use a style which conveys that the remarks made in this course of unfolding were moments occurring in the course of lives being led. Moreover, the participants often had very funny things to say. Social scientists should not plod along with their serious concepts, spoiling all the fun.

Billig aims to present accessible and populated social research, to write research that is readable and filled with the people who took part in it. So do I.

Writing about how I analysed the data is difficult because so often it seems that what I did and what happened were beyond words. In this section I have tried to give a flavour of what I did and I hope that the stories themselves in subsequent chapters will fill in the gaps. I end my discussion of analysing the interviews with what I think is the most serious limitation of my work. This derives from my decision to tape the interviews, rather than use notes. This decision had significant advantages:

> Full note taking is difficult at the speed of normal discourse, it can intrude upon the interviewees concentration and upon the flow of an interviewee's responses and-perhaps more seriously-leads to the collection of only a small fraction of the data possible to accrue from an interaction. (Powney & Watts, 1981, p.27)

As well as disadvantages:

> One may speculate that if the tape recorders had been available in Vienna at Freud's time, there might not have existed any powerful psychoanalytic theory or practice today; a small sect of psychoanalytic researchers might still have been reading and categorizing their transcripts, and discussing their reliability rather than emphatically listening to the many layers of meaning revealed in their embodied therapeutic interactions. (Kvale, 1999, p.105)

Taping interviews results in the over-reliance on linguistic information. This is especially so when, as in this project, I rarely had time to transcribe interviews straight after I did them. The tape itself records only a small fraction of what occurs in the interview and the transcript even less. Although I also listened to the tapes my analysis was largely reliant on the transcriptions. One place where I was more able to attend to embodied practices and layers of meaning was in the observations.

2.5 Methods and methodologies: observing lessons

I observed three weeks of lessons in each of the groups containing students whom I interviewed in Sunnydale and Westerburg. Because my research at Grafton was more opportunistic and because I taught there, by the time I embarked on observations four of my twelve participants had dropped mathematics while three were studying the subject at another school in the consortium that did not respond to a letter I sent concerning the possibility of observing there. I observed the other five participants in class. However, because I taught five of the students for two terms and worked with members of the parallel group containing the other seven I feel that I have a great deal more tacit knowledge about them (although less on paper) than for those at Westerburg and

Sunnydale. My 'insider' status at Grafton also meant that I was given all the documentation relating to the students-including registers, reviews and test marks.

Traditionally the combined use of interviews with observations and documentary data has been thought of in terms of triangulation:

> In the B movie, the exact position of the damaged bomber limping back from Germany is always found by triangulation. The direction of its radio signal is assessed by two geographically separated receivers, allowing an exact fix to be made on its position. In the same way, it is thought that the researcher can use discourse collected from different sources to 'home in' on the facts of the matter and thus show up some accounts as distorted or rhetorical. (Potter & Wetherell, 1987, p.63)

However, as Potter & Wetherell (1987, p.64) go on to point out, detailed study of data from a range of sources (and even re-listening to the 'same' data) or by a range of researchers increases rather than reduces the variability; "indeed, in the course of attempting to triangulate the result is more often than not 'homing out', resulting in the proliferation of more and more inconsistent versions". So, consistent with the epistemological discussion earlier, I was not using observations to get closer to the 'truth'. Instead my main aims were that observations would:

- Provide data to stand in productive tension to the interview data. By this I mean that the 'homing out' would enable more complex analyses of the students' accounts of self within the interview opening out multiple possible meanings.[11]
- Allow me to work with a notion of discourses as structures of practice rather than just as structures of language (Blackman & Walkerdine, 2001). As noted above, this is a major limitation of working predominantly with audiotapes and transcripts of interviews.
- Allow me to see 'identities' in practice in relation to others in the immediate context of their mathematics lessons. Boaler (2000, p.36) highlights the way that students', especially female students', responses to mathematics have often been viewed as maladaptive in the research literature and argues that this is only possible if "they are considered outside of the environment in which they are produced. An important limitation of many previous research studies investigating gender relations in mathematics is that they have not researched the teaching environments in which students were working."

[11] Involving more than one researcher in the data analysis can also contribute to this process of 'homing out'. Unfortunately I did not have the opportunity to do this.

- Provide an opportunity for students to get to know me and to get used to me before I asked to interview them and an opportunity for me to participate in the life of the colleges by working with them in their classes.

Appendix 3 contains the observation schedule that I used to take detailed field-notes that I wrote up within a day of the experience. It was useful to have basic information about each lesson such as a seating plan and timings but beyond that I simply focused on my research question concerning 'identity'. I looked at and described the practices that students and teachers engaged in collectively and individually. However, at any one time there is, of course, a great deal going on in any classroom and what I wrote down was inevitably highly selective and dependent not only on my research question but also on everything from my own 'identity' and experience (particularly as a teacher) to what I had for breakfast that morning, how I happened to be feeling that day, and of course on what else I was expected to do in the classroom and what I could see from where I was sitting. What I wrote down was also dependent on the theoretical stance I took and this is discussed in section 4.3. I then worked through my notes identifying and classifying incidents according to themes that emerged from the data. I do not see the process of these themes' emergence as one of my discovery of the intrinsic truth embedded within my data, as perhaps the Glaser & Strauss (1968) version of grounded theory would suggest, but as one of creative invention on my part. Although, as with the interviews, this was a process of invention that often surprised me.

Issues of power entered into my relationships with staff as well with students. I found negotiating my role in classes with nine teachers each with different expectations of me, some stated but mostly not, difficult and stressful. I felt comfortable in the groups in Grafton. I knew Matt and Trisha (the Grafton teachers whose classes I observed) well and both related to me as a teacher and often asked for my advice and help in class. In Westerburg, where I acted as a sort of sub-teacher/observer, my position felt less secure. Although access was agreed in advance, this was subject to some on-going negotiation. Twice I was excluded from sections of Veronica's lessons, once when she gave students a talk about the stress they were under, and again when she nagged them about their key skills assignments. In the first case she got Alan, the head of department, to tell me that she wanted to be alone with the group and in the second case she told me that this would be something that I would not be interested in because it was not related to mathematics. I suffered from an irrational terror that I would lose access to Westerburg and that my PhD would become impossible as a result. This was probably not helped by the one hour and forty minute journey I had to do to get to and from the college each day which meant both that I packed the observations there into shorter intervals than I did at either Sunnydale or

Grafton and that I spent these brief but intense periods constantly tired. In Sunnydale, where classes were more like lectures, I had a more passive role, often spending the entire ninety minutes sitting at the back taking notes, although even during such periods the students nearby often used me as a mathematical resource.

When Veronica excluded me from a section of her lesson on the grounds that I would not be interested this made me aware of the gap between what she thought I was doing and what I thought I was doing. This gap was not unique to her and raised some ethical issues for me. I tried to be honest about what I was doing with all those into whose classes I went; I answered many questions and gave out writing from the project to staff that expressed an interest. However, there were a couple of deliberate exceptions to this. First, I have not shown Veronica the paper (Mendick, 2002b) that I wrote about her class. While I had not promised to do this it does feel dishonest keeping it from her, something I do because of how uncertain I am about what her response to it would be. Second, from the beginning, the story that the head of department, Alan, told about what I was doing at Westerburg was that I was observing the students **not** the teachers. Although I felt that this gave the incorrect impression that I was not recording anything about the teachers in my notes, due to my fear of losing access I did not contradict this statement when I heard it. Then on my last day of observations at the end of break, another teacher Andy asked me point blank: "Do you write down what we talk about in the staff room as well?" This took me by surprise and I replied, "yes, sometimes, it depends what it's about." Although several other members of staff were present no-one else said anything. I later told Andy that the only thing that I wrote down about that break was his question and my response. It felt like I had finally come clean.

2.6 Conclusions

In this chapter I have introduced the ways in which I have been collecting, analysing and presenting my data linking these to my epistemological commitments while highlighting some of the methodological absences in the literature on gender and mathematics. Throughout my account of how I did the interviews and observations I have paid attention to the issues of power, both the power of the researcher and the need for them to take responsibility for this, and the fluidity of power within the practices that make up research. I have also been concerned with the conceptions of the human self, whether as 'subject' or 'object' of research, which different methodologies presuppose. In particular, I have wanted to disrupt the standard presumptions of a rational, detached and coherent individual collecting data about the actions of other rational, detached, coherent individuals (see also the critique in Hollway & Jefferson, 2000).

Although this is the 'methodology' chapter, methodology cannot be contained within its boundaries as literature cannot be contained within the one that follows, and data cannot be contained within chapters 4 to 7. All of these are 'layered' throughout my writing (Kenway & Willis, 1993). Ideas and data are drip fed into the thesis, occurring in many places in slightly or radically different forms, in more or less detail, and in a variety of contexts. I hope both that everything is present from the start and that each new page adds something to the mix.

This chapter has mapped out the project of this thesis to produce knowledge based in social practice that accepts the **Background** of facts, beliefs and language games (Wittgenstein, 1953) within which we operate and construct meaning without accepting that these are universal truths. It thus moves beyond the nihilism/absolutism binary "by asserting a non-foundational foundation" (Hekman, 1999, p.121) for knowledge. This connects the search for foundations to our everyday ways of knowing, since the former is part of the Background within and against which we work. Feminist strategies must be ones of both connection to and transformation of this Background:

> The fundamental beliefs that constitute the Background give us our world; we cannot step outside them and create new worlds out of nothing. What we can do is to work with those beliefs shifting them in a direction more to our liking (Hekman, 1999, p.146)

In the next chapter I explore the Background of beliefs about gender, mathematics and subject choice and some of the directions in which I would like to shift them.

Prelude to Chapter 3: The trouble with literature reviews

At this point in my thesis I feel a certain obligation to provide a literature review. However, I have a few problems with this. The first problem is deciding in which literature to locate my work and myself. In researching this thesis my approach "involve[d] recourse to some disciplinary and theoretical promiscuity" as Kenway & Bullen (2001, p.3) describe it. I have drawn on writings from literatures in sociology, cultural studies, post-structuralism, psychoanalysis, psychology, feminisms, theorisations of gender, class, race/ethnicity and sexuality, the philosophies of mathematics and of social justice, feminist epistemologies, gender and mathematics education, and many more; I have 'read' quantitative and qualitative studies, ethnographies and genealogies, fact, fiction, films, television, music and journalism.

A second, more serious problem is the atheoreticism of conventional literature reviews. My thoughts on this were focused when I read Evans and Benefield (2001), a recent article that is a contribution to the debate around evidence-based teaching and the relationship between theory and practice (see also section 8.2). They (p.529, emphasis added) argue that a "**systematic** review" of the literature should:

- Define an "**explicit** research question".
- Through "**transparent** methods" and "**exhaustive** searches", aim to find all research, published and otherwise, that addresses this question.
- Evaluate the relevance and value of the research studies to the enquiry using "**clear** criteria for including and excluding studies" and "joint reviewing to **reduce bias**".
- Provide "a **clear** statement of the findings of the review".

While accepting their first point (with the proviso that they understate the way even "explicit" questions are liable to multiple readings), I reject their second. This suggests that they have a very narrow view of relevance, defining as relevant only those studies that directly address the question in hand, in their case the effects of interventions on Educationally and Behaviourally Disturbed children. Interestingly, although Evans and Benefeld dismiss the matter of theoretical approach as irrelevant, it resurfaces when their "exhaustive" literature search produces eleven studies. These are (unsurprisingly) mostly ones conducted in America, although they do not consider the application of studies conducted in one national context to another as problematic, and from a psychological perspective. Thus their approach implicitly selects by theory and, as Hammersley (2001b)

argues in a response to this piece, they assume a positivist model of both the research reviewed and the review process itself. In this passage they imagine a very limited role for theoretical work, as offering explanations for the social phenomena 'discovered' by experimentation.

> Sound studies do not necessarily only include RCTs [Randomized Control Trials], but if one is wanting to say something about the effects of a particular intervention, one would have to be able to judge that against the effects of doing nothing, or of doing something different. Other studies, which might have an explanatory or theoretical role, can be included in a 'best evidence synthesis' to provide possible explanations for the effects of interventions. (Evans and Benefield, 2001, p.539)

This ignores the way in which I see theoretical work functioning, not to produce explanations for what we already know but to construct things anew. Throughout my research I have found that the theoretical approach adopted is a more important criteria for deciding whether to include a piece of research in my 'literature search' than the topic itself, and that new knowledge is generated by an alchemical process where ideas are taken from one area into another, so opening up a subject in unusual and unpredictable ways.

Further differences between their and my approach to theory are evident in the third point that holds out the hope of an Archimedean point beyond conflicting theories, outside of power, from which research can be viewed objectively and clarity can be produced. While Evans and Benefield (2001, p.530) acknowledge both that the political context does impinge on the research and relatedly, that "policy-making is rarely a rational process" they do not feel that this need affect the conduct of systematic reviews (contrary to the position I argued in the previous chapters that objectivity is a dangerous illusion and anyway not usually the most effective way of bringing about change).

Finally, the importance of theoretical perspectives and the impossibility of clarity were brought home to me when I watched *Raw Deal: A Question of Consent* (Corben, 2001). This is a documentary about a controversial American rape case. In brief the story runs as follows: a woman is hired as an 'exotic dancer' for a fraternity party, after finishing her work she returns to the party, she then leaves the next morning and accuses one of the men at the party of raping her, the police arrest the accused man, and at this point it emerges that there are two amateur videos of the events at the party, the police watch one of these, they decide that the sexual acts on the video are consensual and they release the man they had arrested. Instead they arrest the woman for bringing false testimony. This case got a lot of publicity in America; the National Organisation of Women organised regular pickets of the campus, and it became a political football in subsequent local electoral races. However, what I found disturbing and fascinating was the way the film

interwove footage from the video of the party with interviews with the woman involved and with a friend of the accused man who was an eyewitness to the night's events. It becomes evident by the end of the film that it is possible to have two completely opposed interpretations of the same images and that these interpretations will be intimately tied to one's sense of self. Normally, while rape is a very ambiguous crime, we proceed under the assumption that if there were a record of the events then we would know 'what happened'. The film illustrates that this is not so, the answers that we produce to the questions we are asked about an event, and even the questions we are able to ask, depend entirely on the discursive frameworks through which we can look at it and on the positions that we are able to occupy relative to it.

> Evidence, however, only counts as evidence when it is recognized as such in relation to a potential narrative or theoretical construction so that the narrative/construction can be said to determine the evidence as much as the evidence determines the narrative construction. (Skeggs, 1997, p.26)

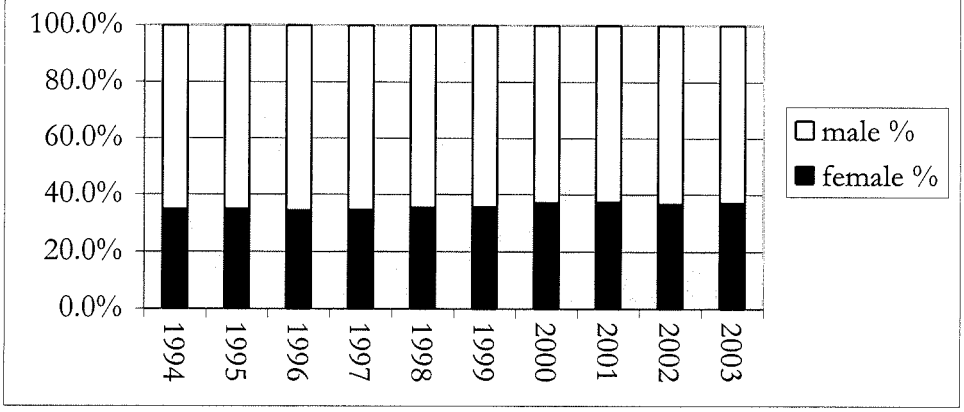
Butler (1993b, p.15) makes a related argument in her discussion of how, in the Rodney King trial, the defence used the amateur video footage of him "being brutally beaten, repeatedly, and without visible resistance" by police officers as evidence that Rodney King constituted a source of danger to the police. She argues that the defence case required seeing the footage:

> As evidence that the body being beaten...bore an intention to injure precisely those police who either wielded the baton against him or stood encircling him...That it *was* achieved is not the consequence of ignoring the video, but, rather, of reproducing the video within a racially saturated field of visibility...This is a seeing which is a reading, that is, a *contestable* construal, but one which nevertheless passes itself off as 'seeing,' a reading which became for that white community, and for countless others, the same as seeing. (p.15-16, original emphasis)

Chapter 3 Differing lenses on gender, mathematics and subject choice

3.1 Introduction

Figure 1: Participation in A-level mathematics by gender



The unchanging gendered patterns of participation in non-compulsory mathematics (illustrated in Figure 1) need to be juxtaposed with the evolving gendered patterns of attainment in the subject. There are very few remaining differences between the attainment of male and female students in either GCSE or A-level mathematics examinations (Gorard et al., 2001; Guardian, 2002a, 2002b, 2003a, 2003b). Although boys are still more likely to secure the top A* and A grades at GCSE and A-level respectively, the differences are small and getting smaller[1]. However, as discussed in section 1.5, the current government and media focus of thinking on gender and education, and indeed on education generally, is on results in examinations. It is in part a wish to help to shift this focus that is behind my concentration on choices.

In contrast to the shifting patterns of attainment at school level, the decision to continue with advanced mathematics remains a highly gendered one. This polarisation persists despite decades of feminist intervention; as Shaw (1995, p.107) says, "the most striking feature of subject choice is that the freer it is, the more gendered it is". In fact, as

[1] In 2003 11,341 boys (3.2% of those entered) and 11,111 girls (3.1% of those entered) were awarded an A* grade for GCSE mathematics. At A-level in 2003, girls got 8,574 and boys 13,167 grade A's although for the second time in the history of A-levels, the first time being in the previous year, this represented a slightly higher proportion of the total female entry than the total male entry, 41.4% as against 37.4%. Additionally, value added statistics, that compare actual A-level performance with that predicted on the basis of average GCSE score, have consistently shown that boys make about one quarter of a grade more progress during their sixth-form mathematical studies than do girls (Curriculum Evaluation and Management Centre, 1997, 1998, 1999, 2000, 2001, 2002).

the graph above (Figure 1) shows, in the nine years from 1994 to 2002 inclusive, the proportion of the total number of 17 and 18 year-olds entered for A-level mathematics in England who are male showed very little change, dropping only slightly from 65% to 63% (Government Statistical Service, 1995, 1996, 1997, 1998, 1999, 2000, 2001, 2002; Guardian, 2002b, 2003b). This greater participation of males in mathematics courses becomes more pronounced as you go up the levels from A-level, to undergraduate, and then to postgraduate, and is also reflected in the larger number of men than women working in mathematically-oriented fields. There is a similar pattern of gendered participation in mathematical activities in other countries (Blattel-Mink, 2002; Boaler, 2000, have recent statistics on the situation in Germany and America respectively; while Hanna, 1996, contains slightly older data from a range of countries).

Since mathematics acts as a 'critical filter' (Sells, 1980) controlling entry to high status areas of academia and the labour market, for those concerned with the reproduction of gender inequality it becomes pertinent to ask why girls are disproportionately opting out of such a powerful part of the curriculum. Hence my research question: **how is it that people come to choose mathematics and in what ways is this process gendered?** In this chapter I will be looking at some other researchers' attempts to tackle this question. At its heart are the classic sociological oppositions between structure and agency, and relatedly, between the social and the individual. It is one version of the oft-asked question of why members of oppressed groups appear 'freely to choose' educational paths and behaviours that ultimately serve to reproduce their oppression.

This chapter provides the theoretical context for my research. It builds on the epistemological discussion in the last chapter on ways of subverting the gendered binary opposition:

OBJECTIVE/SUBJECTIVE

In this chapter I use literature but this is not a 'literature review' (see *Prelude to Chapter 3: The trouble with literature reviews*). I begin with a brief survey of research on the gendering of mathematics since the 1970s, the point at which second wave feminisms began to have an impact on thinking about gender[2]. My aim is genealogical, in the Foucauldian sense, "to historicize the present" (Kenway & Bullen, 2001, p.9), rather than to do the job of an historian. In this section I look first at biological and then at sociological explanations for

[2] The words sex and gender were originally used to distinguish between the biological and the sociological aspects of being female respectively. However, more recent work, such as Butler (1999), has shown that the distinction between sex and gender is no longer helpful since even 'sex' and the body are 'gendered'. Thus throughout the thesis I use gender to subsume all the meanings that were previously divided between the two terms. The construction and the deconstruction of the sex/gender distinction are discussed in more detail later in this chapter in sections 3.3 and 3.4.2 respectively.

the gendering of participation and attainment in mathematics[3]. Although in this thesis I have rejected a focus on attainment in favour of one on participation, here it would be unhelpful to maintain any such distinction. This is because arguments about them are interlinked in the literatures, in complex and often contradictory ways. For example, while some researchers argued that gender differences in cognitive abilities, evidenced in the lower scores of girls in mathematics assessments, were the cause of gender differences in participation, others argued that girls relative under-participation in mathematics was the cause of their lower test scores (see Fennema, 1996, for a discussion of her 'differential course taking hypothesis').

Thus, one aim of this chapter is to present something of the range of academic stories about gender, mathematics and subject choice. However, my presentation of these stories is necessarily selective. I have made my selection in such a way as to set the theoretical scene, to explain why I have arrived at the framework that I have, and to introduce key elements of this framework. The argument is constructed in stages: in presenting and critiquing the biological case, I explain the reasons why I think a socio-cultural account is necessary; in presenting and critiquing the modernist sociological case, I explain why I think that a different conception of the individual and the relationship between the individual and the social is necessary; and then, in reflecting on the connections between biological and sociological explanations, I explain why I think that there are ontological problems with how they imagine both gender and mathematics. I then introduce the main ideas I am drawing on in my feminist post-structuralist, psychoanalytically-infused framework. The overall argument is thus concerned with re-thinking the relationship between the poles of the dichotomies:

INDIVIDUAL/SOCIAL

AGENCY/STRUCTURE

And so it is about ways of thinking about who we are. Questions about 'identity' run through all the discussions here, and within these one further opposition is important:

SOCIAL/BIOLOGICAL

This division functions as a way of organising the material here but, perhaps contradictorily, I also want to deconstruct the dichotomy by showing the role of the social in explanations that are usually labelled biological and the role of the biological within explanations usually labelled social.

[3] Much research has been concerned with explaining gender differences in terms of psychology. However, within psychology there are important differences between those who see psychology as deriving inevitably from one's anatomy and those who see it as produced within the social arena. It is these distinctions that are central to the discussion here.

3.2 Biological explanations for gender differences

Biology has a long history of being used to exclude women from education:

> Scientific and medical authority have provided the ongoing justification to naturalize and pathologize women's emotions, particularly through the growth of psychiatry. An early version of eugenics, "hysteria" was diagnosed as a female disease whose symptoms included hyper-emotionality and absence of reason. Scientists argued that hysteria was caused by education. The stress of using her mind caused her womb to tear free from its moorings and float about the body. Education thus rendered women useless for childbirth. The fear of hysteria thus justified excluding her from education and enforcing her place as wife and mother. (Boler, 1999, p.44)

Boler's (1999) research on education and emotions traces the way that biology has been, and still is, mobilised within oppositional discourses, that tie femininity to what is natural and bodily and masculinity to what is cultural and cerebral, in order to construct women as beyond education (see also the historical studies: Cohen, 1998, 2003). A famous example is Rousseau advocating two different educations, one for his "rational man", Emile, and another for his "emotional woman", Sophie (a position critiqued in Wollstonecraft, 1988/1792). My purpose in this opening is to foreground the ways that nature and biology are never innocent and beyond power. In what follows I demonstrate the ways in which this applies to current biological explanations for gender differences, focusing first on research on 'abilities' and then on attitudes. Here, I use this as evidence for the need to explore sociological approaches; and later in the chapter, the implications for developing alternative ways of understanding biology, and its relations to the social, are discussed.

3.2.1 Evolutionary psychology and gender differences in 'abilities'

Maccoby & Jacklin (1974) in their review of prior research on gender differences influentially argued that amongst all the various differences claimed between men and women, most were unfounded, some remained open questions, but four were fairly well established. These were gender differences in mathematical, verbal and spatial 'abilities' (all assumed to be singular and unproblematic objects), and in aggression. Hyde & McKinley (1997), in their discussion of meta-analyses of studies of cognitive abilities, refer to the former three as "the holy trinity" of gender differences in 'abilities' due to the persistence of the belief in their reality, despite methodological problems with the supporting studies. All these differences, and not just those on measured mathematical 'ability', have been related to the gendering of mathematical fields of education and employment. For example, it is argued that mathematical performances and preferences are enhanced by both spatial skills and by competitive and aggressive instincts. As well as differences in average scores on

mathematics tests, researchers have found differences in the distributions of male and female scores with the former showing greater variability (this latter research is discussed in Wiliam, 2003). This research on 'abilities' contains implicit or explicit assumptions about the reasons for the gender differences found. Caplan & Caplan (1997) point out two key assumptions behind much of this work: that gender differences in a particular measured 'ability' imply that all men do one thing while all women do another, and that measured gender differences are biologically based and so are both inevitable and unalterable. I argue against these assumptions in what follows, but first I outline their theoretical foundation.

Moir and Jessel (1989) present empirical evidence for the influence of chromosomes, brain lateralisation and hormones in determining intellectual 'abilities'. However, the theoretical basis of this and other current biological arguments is evolution's assertion that the genes in today's human beings are those that were most successful at getting themselves transmitted to future generations, Dawkins' (1976) anthropomorphised 'selfish genes'. It is argued that since, as humans, we have spent over 99% of our evolutionary time as hunter-gatherers, so our minds have evolved adaptations in response to the selection pressures of that environment. Gender differences in the hunter-gatherer environment, together with men and women's different investments in their offspring, have meant that successful genes were often ones that have different phenotypic effects in men and women. Ridley (1993, p.7) claims epistemic authority for evolutionary psychology; he argues that while "almost all social science proceeds as if 1859, the year of publication of *The Origin of the Species*, had never happened", in contrast, evolutionary psychology is "informed by the fact that the inherited architecture of the human mind is the product of the evolutionary process" (Barkow et al., 1992, p.7) of natural selection.

However, many evolutionary biologists dispute the way in which their ideas have been translated into the social realm and the way that, within this framework, genes are viewed as causing, often complex, social behaviours. Dawkins (1982, p.13) argues that the notion of super-deterministic genes is a myth:

> If a child has had bad teaching in mathematics, it is accepted that the resulting deficiency can be remedied by extra good teaching the following year. But any suggestion that the child's mathematical deficiency might have a genetic origin is likely to be greeted with something approaching despair: if it is in the genes 'it is written', it is 'determined' and nothing can be done about it; you might as well give up teaching the child mathematics. This is pernicious rubbish on an almost astrological scale. Genetic causes and environmental causes are in principle no different from each other.

Dawkins' comments draw attention to the social context in which the meanings of biological research on gender differences are produced, a social context that assigns priority

to "genetic causes" over "environmental causes". This social context is something that is ignored by most researchers seeking to explain gender in biological terms. As highlighted in the opening of this section, people make sense of this research "in the context of a pre-existing system of meanings in which sex difference is both polarised (men and women are 'opposite' sexes) and hierarchically ordered (women are 'inferior')" (Crawford & Chaffin, 1997, p.82). These meanings persist even though it has been shown that biology does not fit a binary model and that there are no necessary connections between the genetic, hormonal and genital definitions of gender (Davies, 1989; Fausto-Sterling, 1985; Paechter, 1998).

As a result of this context, and of publication bias, studies that show no gender differences in response to testing are disproportionately absent from the literature; we have a literature of 'gender differences' but not one of 'gender similarities'. Richardson (1997) labels this the 'file drawer problem'. Additionally those studies that produce differences are problematic. Seeing gender difference as natural and oppositional not only gives meanings to completed research that might be otherwise, but can also result in the researcher attaching different labels and ascribing different motivations to what could be seen as matching behaviour. Fausto-Sterling (1985) cites a useful example here, the study *Eye of the Beholder*, in which researchers showed videotape of a baby reacting to different stimuli, to male and female college students. In one sequence a baby becomes startled, then agitated and then starts to cry when confronted by a jack-in-the-box:

> Those students who thought the baby to be a boy described the baby's tears and screams as anger. In contrast, those who thought the baby to be a girl said 'she' responded fearfully. In other words, the behaviour, crying took on the emotional significance of anger or fear depending only upon the observer's belief about the baby's sex. (p.151)

This suggests that findings on gender differences from non-'blind' studies are suspect. That much of scientific research has historically been ideologically motivated is generally accepted (see for example Gould's, 1996, survey of research on biology and 'race'). The epistemological consequences of this are wide-ranging; as the critique of empiricism in section 2.2.1 indicates, it is not enough to say that this was 'bad' science.

> We can smugly laugh at this, attributing the obviousness of their motives to their having lived more than 100 years before research sophisticates such as ourselves, or we can honestly assess the extent to which we have or have not progressed beyond the motives and the sloppy science that characterized so much 19th-century research into sex differences. (Caplan & Caplan, 1997, p.55)

Meta-analyses, that apply a particular statistical technique in order to aggregate results across the available studies, have shown that measured gender differences are decreasing and are small (Hyde & McKinley, 1997). So knowing the gender of a child tells us nothing about their actual mathematical, verbal, spatial, or any other functioning; differences based on averages of large samples can result in statistically significant, but educationally insignificant, results (Fausto-Sterling, 1985; Walkerdine, 1998). The dominant pattern is one of overlap between men and women and differences between men and between women are more important than differences between all men and all women. As Wiliam (2003) points out, these meta-analyses also highlight the variability in measured gender differences in both the size and the spread of results (this is very apparent in the thorough collation of studies in Maccoby & Jacklin, 1974). Since some tests favour girls, some produce no differences and others favour boys, all that a higher overall average for boys implies is that more of the latter have been used within this research field. In other words, males' higher average scores and the greater variability of these scores on tests of mathematical 'ability' are an artefact of the instruments used and a product of the ways in which they have defined mathematics.

I find unconvincing biological explanations for the different choices and results girls and women make and achieve regarding mathematics. This is for the reasons already discussed above of all the multitude of ways in which the biological is always mediated by socio-cultural influences, and because biologically reductive arguments cannot account for the significant geographical (Ernest, 1998; Hanna et al., 1990) and historical (Shuard, 1982) variations in the gendered patterns of participation and attainment within education. Spender (1980b) identifies that men were much better at languages when Latin was compulsory for university entrance. Historical and geographical variations evidence the much greater significance of socio-cultural over biological factors, while Spender's example also highlights the role of power and of the social valuation of what men and women are 'found' to be good at.

> We habitually think of the social as less real than the biological, what changes as less real than what stays the same. But there is a colossal reality to history. It is the modality of human life, precisely what defines us as human. No other species produces and lives in history, replacing organic evolution with radically new determinants of change. (Connell, 1987, p.81)

The centrality of social factors is also the theme of the next section, which critiques the psychological literature on attitudes[4].

[4] Arguments from evolutionary psychology usually deal with attitudes as well as 'abilities'. In such cases all the previous critiques apply. The distinction I maintain here, and the distinctions that I make throughout this

3.2.2 Gender differences in self-esteem, confidence and anxiety

There is a great deal of research evidence that girls have less confidence and greater anxiety than boys when faced with mathematics problems (Sutherland, 1983). Relatedly, for example in Licht & Dweck (1983), girls have been found to have what are labelled 'maladaptive' patterns of attribution. That is, when they succeed at a mathematics problem they tend to see this as being due to luck, task ease, effort on their part, or other external and/or unstable factors; conversely, when they fail at a task they explain this in terms of their own inability, or of the difficulty of the problem, that is to internal and/or stable factors. This pattern is 'maladaptive', it is argued, because it makes future successes less likely, it produces 'learned helplessness'. Boys, in general have been found to have the opposite patterns of attribution of success and failure. Dweck (1986) developed her earlier work by speaking about goal orientations. She found that boys are more likely to be oriented towards learning goals "in which individuals seek to increase their competence, to understand or master something new" while girls are oriented towards performance goals "in which individuals seek to gain favourable judgements of their competence or avoid negative judgements" (p.1040). Dweck argued that the female pattern of goal orientation leads to challenge avoidance and low self-esteem and so is detrimental to learning. Moreover, since it is found disproportionately among high-achieving girls, Dweck concludes her work explains why so many of the highest performing girls opt out of mathematics.

This field of research launched a thousand interventions to raise girls' confidence and self-esteem. Since this research and these initiatives were "inspired by a blend of certain American psychological theories with certain feminist theories" (Kenway & Willis, 1990, p.1), I need to explain why I am including them here, under biological explanations, rather than in the section on sociological ones. This is because, after observing the pattern of girls' maladaptive responses to anxiety and goal orientations, researchers such as Dweck "had 'no idea' how this might arise-these characteristics were, it seems, a corollary to being born female" (Willis, 1995, p.189). Thus the problem was firmly located within the girls and **not** within social structures. With this rejection of the social in favour of the individual, the biological inevitably follows through the back door. (There was other research into mathematics anxiety that strongly rejected biology and looked instead to the context in which mathematics was learnt, notably Buxton (1981) and Tobias (1978), and I discuss this is section 3.3.2.)

chapter, are useful in allowing me to organise a vast amount of material, without, I hope, constructing too many false caricatures of different theoretical positions.

This body of research has been widely challenged on its own terms. Boekaerts & Segers (1996) collected data on attributions and goal orientations at what they called the 'momentary' level (while conducting a task) as well as at the customary 'middle' level (after completing a task). They found that at the middle level boys were more likely than girls to ascribe successes to 'ability', although no other gender differences were found in patterns of attributions. However, even "this tendency no longer exists when attributions are measured in actual task situations" (p.235), that is at the momentary level, where attributions are most likely to influence test performance. Additionally, Renshaw (1990) reviewed the research literature to show that it overstates its case regarding the strength of gender differences in affective variables and to question the assumed causal relationship between self-esteem and achievement (see also Chetcuti & Griffiths, 2002). This work provides further evidence that if we look in different places and with different prejudices we will find different things in our data.

Other critiques of the field are more sociological, drawing attention to an important absence from the original research: the social context in which such gendered patterns of confidence, anxiety and self-esteem arise and in which the meanings of this research are constructed. Boaler (1997), spotlighting the classroom context, found no significant gender differences in the attitude to and confidence in mathematics when students were taught using a project approach rather than the traditional 'chalk and talk' one. As she later commented:

> My main concern with Dweck's analysis is that she attributes certain motivational patterns to girls as though such patterns exist outside the settings in which the girls are taught. This seems to me a fundamental flaw as motivations must surely be highly situated. (Boaler, 2000, p.32; see also Burton, 2001)

Jones & Smart (1995, p.164) drew on their experiences of working with sixth-form mathematics students to suggest: "it may be that the signs we read as lack of confidence do not tell the whole story". They question the implications of teachers making wide-ranging decisions about students mathematical futures based on what they take to be confidence or lack thereof (Elwood, 1998, contains evidence that teachers' decisions about entry level for GCSE mathematics are often based on ideas about students' levels of confidence).

Broadening 'context' to beyond the school gates, Chetcuti & Griffiths (1990) and Kenway et al. (1990) draw attention to the ideological aspects of the self-esteem discourse, pointing out that it is individualistic and rooted in liberal understandings of the self (understandings that I discussed in section 1.5). These Enlightenment understandings of the self are falsely universalising. Many studies draw attention to the non-culturally specific

nature of the female self-esteem discourse. In ignoring the role of racism, access to the English language, respect for mother tongue and teacher stereotyping in determining self-esteem "it is a model which clearly defines ethnic minority status as a source of disadvantage rather than the butt of discrimination" (Tsolidis, 1990, p.57; see also Wenner, 1990). Dudgeon et al. (1990, p.79) argue that, when working with aborigines "a community referenced approach is more appropriate and meaningful because it relates to and derives from Aboriginal realities". Wyn (1990, p.126) makes a similar point about the applicability of self-esteem approaches to working-class girls:

> If raising 'self-esteem' is seen as a means of advancing individual girls to develop their particular talents, and to encourage competition, then this strategy is in direct conflict with the priority these young women themselves place on friendship and solidarity.

These critiques omit any consideration of, and indeed reinforce, dominant power relations. This pattern is supported by Renshaw's (1990) argument that the schemes to improve self-esteem are asking girls to become assertive, independent and boastful, in other words to become more like boys. Kenway et al. (1990) argue that such strategies want them also to display traditionally feminine traits such as communication and cooperation. However, rather than trying to revalue them (as do the strategies discussed in section 3.3.2), "the self-esteem literature treats them simply as a means to gain access to the very power structures in which such capabilities are derided" (p.40, see also the discussions in Cope & Kalantzis, 1990; Gilbert, 1990). Chetcuti & Griffiths (2002) question the assumption that more confidence and self-esteem are always better. They point out that the existence of words like 'arrogance' acknowledges this is not always the case and reject "those zero-sum games of self-esteem in which a person builds themselves up by comparing themself favourably with somebody else" (p.533). Their arguments are supported by Kenway's (1990) research in a girls' private school where there is no shortage of self-esteem. However, this is built on pressure to be a certain sort of person and the 'othering' of people, particularly state school students, who do not fit.

These critiques point to the overwhelming need to shift the focus from the individual to social structures, in order to make sense of the research findings on the gendering of 'ability', anxiety and self-esteem differently. This, and the related shift away from theorisations that operate with a deficit model of girls and women and position them as victims, are discussed in the next section.

3.3 Sociological explanations for gender differences

Second wave feminists distinguished between sex (the biological differences between men and women) and gender (the sociological differences).[5] This was an important theoretical move, which allowed for the investigation of environmental explanations for girls' educational results and choices. Liberal feminists emphasised the parts played by sex-role socialisation, stereotyping and discrimination. They worked to eliminate the barriers to female achievement in mathematics and other subjects. However, with a philosophy based on individual autonomy they were ill-equipped to deal with the issue of how women's choices ambush their equality. Thomas (1990) sees this as being behind their reluctance to pursue their agenda into further and higher education, where it is perceived that choices and not constraints are operating. Socialist feminists focused on the reproduction of the classed and gendered relations of production and reproduction, while radical feminists pointed to the male dominance of knowledge and the sexual politics of schooling. Because socialist and radical feminists added theorisations of ideology and power to the liberal feminist analysis, both socialist and radical feminists were interested in the social construction of choices. Importantly patriarchy, "the combination of social, economic and cultural systems which ensures male supremacy" (Coote & Campbell, 1982, p.32) was introduced as an explanatory variable.

The main sociological explanations for the gendering of education advanced by liberal, socialist and radical feminists, have been that:

- There is a lack of female **role-models**. This has been seen as a particular problem in mathematics and related fields and as resulting in girls seeing these academic and vocational paths as less gender-appropriate and less relevant to their lives.
- There is widespread gender **stereotyping** with biases being present in, among other places, textbooks, the mass media and the views of parents, teachers and peers. Again this has been seen as applying particularly to attitudes to mathematics, science, technology and physical education.
- **Boys dominate** school lessons, monopolising classroom space, equipment, interactions and teacher time. Although this has not been seen as unique to mathematics classrooms it has been looked to (often in combination with other factors) as an explanation for the gender differences in performance in the subject. In particular the use of computers in mathematics classes and the dominance of these by boys has been extensively discussed.

[5] However, this distinction was/is far less important or non-existent in languages other than English (see for example, the discussion of the uses of the word genero in Spanish in Brooksbank Jones, 1997).

- There is **sexual harassment** in schools, including the use by men of pornography, language like 'slag', and physically threatening behaviour towards female staff and students. Again this has not been seen as unique to mathematics although some have argued that the dominance of male teachers in mathematics has often resulted in particularly corrosive atmospheres in these lessons.
- **Knowledge is gendered** and implicated in power relations so that the things women are good at are socially devalued. Mathematics has been implicated in this in two ways: through the masculine nature of the contexts used to teach it (drawing largely on military and sporting applications) and through its abstractness and consequent exclusion of femininity.
- There are gendered preferences for different **teaching, learning and assessment styles**. It has been argued that those favoured in mathematics, such as the use of closed questions and multiple-choice tests, tend to benefit boys.

I will not be tackling directly the issue of harassment, reported in research such as Lees (1986) and Mahony (1989). I consider this to be an important factor but do not think that it can be used to explain the drop out of girls from mathematics, specifically, at 16+. I discuss the remaining explanations in two sections, discussing the first three in the first section. I group these together because they are all based on the idea that girls and boys have different experiences and that this results in them developing different 'abilities' and interests. The process by which this is seen to happen is sex-role socialisation. I argue that this is based on problematic assumptions about the nature of the individual and the relationship between the social and the individual. In the second section I discuss the final two. Both these explanations are based on an idea of gender difference, which I also argue is problematic. In these sections I illustrate my arguments with examples of the strategies used by feminists to intervene in the processes of reproduction of gender inequality. As a result it is worth noting that although I have opened by drawing clear distinctions between different feminisms, in terms of action in schools positions were (and are) blurred.[6]

3.3.1 Humanist essentialism: explanations from sex-role socialisation

Ideas about the impact of gender stereotyping, role-models and male dominance of school space and time, are based on the importance of environmental factors and so on the

[6] Acker (1994) argues that this tolerant approach is the result of the marginalisation of education within British feminisms, together with the way practice and research have been driven by teachers and ex-teachers who have always been pragmatic. She notes the tension between 'education as reproductive' and 'education as liberatory' and observes that socialist and radical feminists who, ideologically may argue for the former, necessarily behave in accordance with the latter. This may be genuine or duplicitous, since "the preference for equal opportunities discourse in British public policy means that under an equal opportunities cloak, a socialist or radical feminist heart may beat!" (p.53)

separation of gender from sex. In this theoretical move "the biological basis of sexual difference is assumed, and the 'roles' that children are taught by adults are a superficial social dressing laid over the 'real' biological difference" (Davies, 1989, p.5). Thus there is an assumed pre-existing essence of the person on which the social makes its mark. The process by which it is said to do this is called sex-role socialisation and can be characterised as follows:

> Within the sex-role socialisation model of the world the child is taught her or his sex-role by, usually, one central adult, but is also 'pressed' into maintenance of that role by a multitude of others (peers, media etc.). There is no room in this model for the child as active agent, the child as theorist, recognising for him or herself the way the social world is organised. Nor is there acknowledgement of the child as implicated in the construction and maintenance of the social world through the very act of recognising it and through learning its discursive practices. (Davies, 1989, p.5)

The child is positioned as passive, and as acted on, within the story of their socialisation. Moreover there is a simple model of cause and effect operating here, in which certain aspects of the social world are seen to be directly causing gendered behaviours in children (see also the critiques: Connell, 1987; Davies, 1989; Henriques et al., 1984, Walkerdine, 1998).

Feminist challenges to the model of sex-role socialisation were provoked by their investigations of what had gone wrong with a range of feminist interventions into the gender politics of schooling. They pointed out that the social world is far more complex and contradictory than the sex-role socialisation account allows for. This is evident in Byrne's (1993) critique of the claims that girls or boys will identify with same-gender role models in such a way as to induce them to change their educational choices or behaviours. She questions whether role-models have to be of the same gender to be effective and whether young women perceive sufficient similarity between their own lives and those of women in exceptional contexts for there to be any identification:

> We still do not know what the real messages are which reach adolescents and young adults when they see a same-sex role model ahead of them. Does a Grade 12 girl only think that 'women can do that' when she sees a woman engineer or a female University Professor, and not that 'I, Jane can do that'? And what is 'that'? Having a career? Combining a career with marriage? Settling happily for a single life with a rewarding career independence? Or handling machines or management ascribed in her circles as 'male' and therefore being an untypical woman if she follows her model? (p.92)

In the remainder of this section I will use recent feminist critiques of the initial feminist approach to sexist books, and girls' subject choices, to further illustrate where the

simple cause and effect approach fails to engage with the complexity of what is going on.[7] These examples, in particular, highlight the problems with positioning girls and boys as passive receivers of social messages. Early research on the effects of sexist images in books, for example Spender (1980a), assumed the passive receipt of these by boys and girls. Further they assumed "that sexist images in texts are unreal, as though the 'real' existed outside the pages of books, and the books themselves had no productive effect" (Walkerdine, 1998, p.151), and further that non-sexist images would help to produce feminist young women. However, more recent research has focused on the ways in which the content of textbooks and storybooks is taken up by young people. Probably the most famous example is Davies' (1989) account of how young children reading *The Paperbag Princess*, a feminist fairy-tale, prefer the wimpish prince to the assertive princess who rescues him. This "offers a rather pessimistic caution to those who believe that non-sexist curricular material might create major changes for girls" (Jones, 1993, p.162).

Kenway et al.'s (1998) discussion of interventions directed specifically at changing the educational choices girls make also offers a pessimistic caution to gender reformers. Many reports have noted that far more suitably qualified girls than boys opt out of studying mathematics (Kitchen, 1999; Landau, 1994). And feminist work in mathematics education has always been concerned with these 'missing girls', so that more women can gain the economic power and social status that mathematics confers, "the particular prestige of numbers" (Gould, 1996, p.58):

> Possibly the most pervasive and persuasive gender reform story of the past decade or so has been that girls and young women should 'multiply their choices' (by succeeding in male-dominated school subject areas), 'broaden their horizons' (by, for example, overcoming stereotyping in planning for paid work) and 'reach for the sky' (through, for example, improved confidence or self-esteem). Within this narrative, a major sub-plot has been the one about mathematics. (Kenway et al., 1998, p.38)

Kenway et al. (1998) used students' responses to the 1991 Victoria-based programme, 'Maths multiplies your choices', to critique such schemes. The programme in question

[7] Another relevant example is single-sex schooling. Recent work (for example, Harker, 2000) has cast doubts on whether, after controlling for social class, girls' schools really do produce better academic results than mixed schools, as has been assumed. However, my main problems with single-sex schooling arise from questions, not about its short-term effectiveness at raising girls' examination scores, but about its long-term impact on girls and boys. I have found no research looking at this. I wonder about the impact of removing children from their opposite gender peers rather than finding ways to help them interact responsibly and maturely with them. I wonder why we are "yet again asking girls to take evasive action, leaving boys to remain unsocialized with impunity" (Byrne, 1993, p.199). I wonder if there are not many other women around like the one, educated in a single-sex school, who is quoted by Spender (1980c) as saying that women educated in co-ed environments seem better able to cope than she, once they get to university. And finally, I wonder what are the psychic costs of the level of surveillance and the drive for success found in so many all-girls schools (Kenway, 1990; Lynch & Lodge, 2002).

consisted of advertising in print, and on radio and television, accompanied by packs of posters, stickers, and class activities which were sent to schools. These "exhorted parents not to 'pigeonhole your daughter' and told girls that 80 per cent of all jobs require mathematics and so they would have 400 per cent more choices if they took mathematics" (p.38). The visual images used in the television commercials contained 'before' scenes of girls "curled up in pigeonholes-colourless, confined and almost catatonic" (p.40). That year there was a dramatic increase in the numbers of girls, and of boys, continuing with mathematics courses. The 'Maths Multiplies your Choices' strategy thus had some success on its own terms, but it did this by positioning girls as not knowing what was good for them and by undermining the many girls who felt that their thoughtful rejection of mathematics was better than others' unconsidered choice of the subject. The vast majority of girls interviewed for that study, to a greater or lesser extent, felt patronised by the campaign and resented it. I would agree with Kenway et al.'s (1998, p.46) conclusion that we need to recognise female agency and help girls "articulate the constraints-material and social, real and perceived-on their choices...in the absence of such education, exhortations to 'broaden your horizons' and 'reach for the sky' are distorted and often even cruel".

Byrne (1993, p.1) has persuasively argued that the stories discussed so far in this chapter, of girls' lower mathematical 'ability' and self-esteem, of the need for non-sexist teaching materials and female role models, are classic cases of the "Snark Syndrome". This label comes from a poem by Carroll (1910, p.3):

> 'Just the place for a Snark!' the Bellman cried,
> As he landed his crew with care;
> Supporting each man on the top of the tide
> By a finger entwined in his hair.
>
> 'Just the place for a Snark!' I have said it twice:
> That alone should encourage the crew.
> 'Just the place for a Snark!' I have said it thrice:
> What I tell you three times is true.

In other words, these ideas become the accepted wisdom, not as a result of unequivocal research evidence, but due to their constant repetition. These ideas have become commonsense (as Weedon, 1997, and Fairclough, 1989, point out this is usually a dangerous thing). The explanations discussed in the next section also have a commonsense feel to them. This commonsense feel proceeds from the way they feed into not humanist essentialism but gender essentialism. By this I mean that they assume that there is something that resides within us that makes us who we are, but that this is not shared universally (as the humanist version of essentialism has it) but is differentiated by gender.

3.3.2 Gender essentialism: explanations from gender difference

The earlier discussion of anxiety, confidence and self-esteem, in section 3.2.2, looked at these as individual traits within a female deficit model. Other work on anxiety has located the problem in the context in which people learn mathematics. Buxton's (1981) analysis of his moving case studies of maths anxiety in adults associated the phenomenon with three aspects of mathematics learning: the public performance, the fast pace, and the (moral) authority of a subject where answers are either right or wrong. Similarly Tobias (1978, p.276-277), in her study of maths anxiety and gender, cites Sandra L. Davis' *Math Anxiety Bill of Rights* that contains the rights: "to say I don't understand", "to ask whatever questions I like", "to learn at my own pace and not feel put down or stupid if I'm slower than someone else", and "to evaluate my math instructors and how they teach". The idea that girls and women respond better to less competitive and more open-ended forms of learning and assessment is supported by work on alternate methods of teaching and assessing mathematics (for example, Barnes & Coupland, 1990; Forbes, 1996)[8] and by recent research in English secondary schools. Boaler (1997) and Bartholomew (2001) found that girls were more alienated than boys by fast paced, top set environments where they felt unable to pursue what Boaler calls their 'quest for understanding'. Mann's (2002, p.17) research on the gendering of the Cambridge University mathematics tripos (perhaps 'top set' mathematics taken to extremes) found:

> In practice, students arrive at understanding through a process which combines both coming to grips with fundamental concepts, and also working through examples which apply these concepts. Some students, however, are prepared to take information and/or theories that they don't immediately understand on trust...Others need to have a strong grasp of the fundamental principles which underpin the work before they can move forward with problem solving exercises...For some staff and students asking 'unnecessary' (male mathematics student) questions and, indeed, sometimes needing repetition of explanation is indicative of lower ability. 'Intellectual muscle-flexing' (female physics student) is more likely to be seen as a signifier of excellence then (sic) a readiness to listen, absorb, and finally to synthesize and work creatively and actively with new information. This has further implications for learning and teaching. Women may be overwhelmed by the speed with which male students move forward and may lose confidence in their own ability; the men, in turn, may underestimate women, and treat them with less respect than that shown to their male peers (thus increasing feelings of insecurity in women).

[8] However, research findings are far from unequivocal. Beller & Gafni's (2000) research challenges the apparent consensus that multiple-choice questions favour boys; Neria & Amit's (2002) work challenges the idea that girls' better verbal skills give them an advantage when responding to mathematics questions that demand verbal reasoning; and, Stobart et al. (1992) point out that girls' GCSE results continued to improve faster than boys' even when the proportion of coursework assessment involved was reduced and that one of the subject areas in which the gender gap in favour of girls was always largest, modern foreign languages, has never used coursework assessment at GCSE.

These explanations of the gendering of mathematics are based in the influential feminist work inspired by Gilligan's (1993) study of separated and connected ways of reasoning (see section 2.2.1), its development in the field of education by Belenky et al. (1986), and the ways these have been applied within the mathematics education research literature (for example, Barnes, 2000b; Becker, 1995; Brew, 2001; Povey, 1995, 1997).

Although all of these researchers pay more-or-less convincing lip-service to the idea that separated and connected ways of reasoning are not tied to men and women in any necessary way, it is difficult to rescue these approaches from essentialism (see the arguments in Faludi (1992) and in section 3.4). The notion of gender difference they are based on is also present in the arguments of feminists who focus on the way that women's lives, interests and skills are socially devalued, and on the need to re-value female knowledges. They advocate the use of single-sex environments, not simply to raise attainment or to enable girls to get access to the resources, which are dominated by boys in mixed environments, but "in the creation of a female learning culture" (Weiner, 1994, p.68). The revolutionary potential of this idea was given expression in Rich's (1979) vision of a woman-centred university.

These arguments, that we must recognise women's difference from men, are present not only in the market for self-help books but also in Greer's (1999) feminist best-seller, *The Whole Woman.* In this book Greer (1999, p.294) distinguishes femininity from femaleness and constructs the latter as the essence of woman, that which remains after "menopause burns off the impurities". I have some sympathy with these approaches; however, I also view them as problematic. Within education, providing access to girl-centred curriculum content, and methods of teaching and assessment, different from the dominant knowledges and modes of teaching and assessment found in schools, is not easy. Paechter (2000) pointed out that while having separate boys' and girls' versions of knowledge has been successful within marginal subjects, like physical education and technology, this has not proved a success in high status parts of the curriculum. For example, domestic science never offered any challenge to the power of 'real' science and never showed any signs of becoming the female alternative to this that its originators envisaged. The radical feminist response to the devaluation of the feminine by reclaiming those traits, values and understandings for the purposes of a separate feminist education, does not challenge the oppositional division of the world into masculine and feminine. This approach essentialises gender and can reinforce sexist practices, for example, as with biological approaches, it can lead to the gendered labelling of identical behaviour. Thorne (1993) points out, regarding her own study of children's play, that ideas of gender polarity initially resulted in her seeing matching actions as 'bitchy' or 'aggressive' depending on

whether they were performed by a girl or a boy. Most importantly, however, such approaches ignore differences between women and between men. Differences of class, race/ethnicity, sexuality and dis/ability intersect with each other and with gender in complex ways and, in many social and educational contexts, are more pertinent than gender differences[9].

As with the explanations based on sex-role socialisation there is a problem with the way that the relationship between the social and the biological is theorised, "the individual reduces inevitably to the biological in essence once its opposite number, the social, has been posed to explain the rest" (Henriques et al., 1984, p.15). I develop these arguments in the next section where I summarise my arguments up to this point and consider the ways in which the explanations I have looked at for the gendering of mathematics construct 'gender' and 'mathematics'.

However, before I do that I want to admit that I feel somewhat uncomfortable with the way that I am constructing my position in this chapter. Lather (1991, p.46-47), discussing Ellsworth's post-structuralist critique of critical pedagogy, points out that it is all too easy to criticise what has gone before:

> Her seizing of a moral high-ground and her demonizing of critical pedagogy's "repressive myths" perpetuates monolithic categories of dominant/dominated, thereby intensifying the conflictive nature of the semiotic environment. A way out of this might have been to foreground how her construction of herself as a privileged alternative inscribes as well as subverts, in essence deconstructing her own strategies of self-legitimation. Such a move would have added another textual dimension to the Foucauldian suspicion of every operation that seeks to center a subject who is in a position to know, a suspicion that is at the heart of her project.

By quoting this passage here I aim to (momentarily) disrupt my "own strategies of self-legitimation" (strategies that seem to me to be an obligatory part of the PhD game) to decentre my own claims to know in some final and universal way what is good theory and what is bad, and to acknowledge my debt to earlier feminist work.

Oh well, back to seizing "a moral high-ground"...

[9] There are many references that I could cite here. Within hooks' work there is a focus on the intersections of gender and race/ethnicity (for example, hooks, 1982, 1984), while in a recent book (hooks, 2000) she looks in more detail at class in America. Reynolds (2000) provides a concise overview of the intersections of class and race/ethnicity in contemporary Britain. Epstein (1995) explores how gender divisions in schools are tied to compulsory heterosexuality, an argument that is extended in Epstein and Johnson (1998), while the ways that dis/ability interacts with gender and class, are variously explored in Benjamin (2001), Cline & Reason (1993) and Hey et al. (1998).

3.4 A post-structuralist critique of the ways research on 'the problem of girls and maths' imagines 'gender' and 'mathematics'

My argument so far has been constructed in three stages: I have argued from the absences in biological explanations to the need for a sociological account of the gendering of mathematics; I have argued from the absences in sex-role socialisation to the need for a more complex model of the relationship between the social and the individual; and finally, I have argued from the absences in essentialist feminist accounts of gender difference to a need for a model based in non-oppositional understandings of gender. Dunne & Johnston (1994) develop a related post-structuralist critique of the early research on gender and mathematics education. They point out that while the biological determinist and the social constructionist positions appear to be radically opposed, they share and leave unexamined two major assumptions. First, "the power and position that mathematics holds as a discipline inevitably remains inviolate in the gender and school mathematics research, where the implicit message seems to be that all will be well once sufficient (but clearly not all) girls have access to the power and privileges of maths" (p.222). And second, gender categories are seen as natural and to pre-exist the research. As I argued above, even some of the most radical approaches, such as those advocating single-sex schooling and a girl-centred curriculum, which extol feminine qualities and values over masculine ones, function to reinforce the idea of male and female as binary oppositional categories and emphasise gender differences over similarities. As Walkerdine (1998, p.23) argues, "the reification of the categories 'girl' and 'boy' produces explanations which favour sex-specific characteristics, so that more complex analyses of masculinity and femininity are impossible". Such oppositional constructions of gender only make sense within structures of "compulsory heterosexuality" (Butler, 1993a; Rich, 1983).[10] At the centre of this thesis

[10] Similar points are made by Henwood and Miller (2001, p.237-238) employing the metaphor of a black box: "It seems to us that, all too often, the sciences, new technologies and mathematics are treated rather unproblematically in research and literature concerned with gender and education. It is as if these disciplines, as immutable and autonomous, are somehow still enclosed within an inviolable 'black box'...In systems engineering, the 'black box' refers to a box containing electronic or other devices from which, given specified inputs, there emerge specific outputs. What goes on inside the box, commonly found fabricated out of a black metallic substance or an opaque plastic, remains hidden...There is a tendency for gender, too, to become similarly boxed in or opaque. In particular, gender is often treated as a given category and one that maps neatly onto the sex of the particular individual or group being considered. Thus, there is no conceptual space within which the construction of gender as an active process (for example, through science and technology curricula and practices) can be explored. Furthermore, gender tends to be seen in dualistic and oppositional terms with the result that there are just two gendered positions available—the masculine and the feminine—within which men's and women's experience can be located, thus limiting the opportunities for more complex and contradictory gendered positionings to be noticed, let alone explored. Finally, heterosexuality is all too often assumed, rather than interrogated within such dualistic categorisations of gender, resulting in the normalising of hetero-gendered relations."

are attempts to move to new ideas of what mathematics and gender are. In particular, to move to ones that are less embedded in the Background (see section 2.6) of oppositional thinking. Thus, it is worth giving some thought to the reasons why gender and mathematics have remained relatively untouched by so much research in this area, before moving on to sketch a framework that seeks to adopt a more critical approach to them.

3.4.1 Our attachment to pure mathematics

The Gender Into Science and Technology project (described in Kelly, 1987) involved about 2000 children in 10 co-educational schools in the Greater Manchester area. During the early-1980s, these children were followed from the start of year 7 until after completing their option choices in year 9. Qualitative and quantitative data were collected as part of this action research project targeted at explaining the reasons for the low number of year 9 girls choosing science and technology and at exploring the effectiveness of interventions to change this and to make girls see such subjects as more relevant to their lives and their imagined futures. The project produced only moderate increases in the number of girls taking physical sciences and had no measurable long-term impact on the schools involved. In 1987, Kelly (quoted in Thomas, 1990, p.12, original emphasis), one of the researchers on this project, writing about its disappointing outcomes, reflected on an article that she had written in 1982: "The article suggests that it is necessary to change the *image* of science; I now think that it is necessary to change *science*." Mathematics has proved even more immune to change than the physical sciences.

Mathematics' immunity derives from the way that it is viewed as a body of external truths that are discovered by mathematicians, and is intimately connected with discourses that oppose the objective to the subjective and attach a greater value to the former. Hardy's (1969, p.130, original emphasis) view is typical:

> A chair or a star is not the least like what it seems to be; the more we think of it, the fuzzier its outlines become in the haze of sensation which surrounds it; but '2' or '317' has nothing to do with sensation, and its properties stand out the more closely we scrutinize it...317 is a prime, not because we think so, or because our minds are shaped in one way rather than another, but *because it is so*, because mathematical reality is built in that way.

The view of mathematics exemplified here is referred to as a Platonic or neo-Platonic mathematical epistemology because of its resemblance to the theory of forms elaborated in Plato's (1955) *The Republic*. That the experience of many people doing mathematics is of discovery rather than invention, led Davis and Hersh (1982) to jest that most mathematicians are Platonists on weekdays and formalists (who adopt a less overtly absolutist epistemology) at weekends.

Within such thinking, the pinnacle of rationality is the pure mathematical method of proof, and claims for mathematical certainty rest on this. However, as Kline (1980, p.306) shows, "no proof is final"; the acceptable standards of proof depend both on the time period and on the mathematical school one is working in[11]. Kline concludes that, "history supports the view that there is no fixed, objective, unique body of mathematics" (p.320) and "only the relatively universal acceptance of mathematics as opposed to political, economic, and religious doctrines may have lured us into believing that it is a body of truth existing objectively outside of man (sic)" (p.325). As Restivo (1992, p.102) says in his development of a sociology of mathematics, "this does not mean we do not and cannot know anything; it means that what we know is always social through and through". Such arguments find support in Hacking's (1975) genealogy of probability and Skovsmose's (1994, p.42) carefully developed argument for the formatting power of mathematics: "mathematics produces new inventions in reality, not only in the sense that new insights may change interpretations, but also in the sense that mathematics colonises part of reality and reorders it-just as the Indian social reality was changed after the English conquered the country and took power".

Alternative epistemological positions on mathematics are also contained in the work of Lakatos and of Burton. Lakatos (1976) describes mathematical knowledge as being produced through a process of proofs and refutations (this is developed in Ernest, 1991). Burton (1995, p.218) develops an innovative feminist epistemology of mathematics, a "position on knowing mathematics which is predicated on mathematical enquiry, rather than receptivity" and that recognises "its person- and cultural/social-relatedness" (p.220). This is an epistemology based in a thoroughly social understanding of mathematics that Burton has supported by her empirical study of the activity of professional mathematicians (Burton, 1999c) and that she has developed recently by arguing for a narrative understanding of the subject (Burton, 1996, 1999b).

My aim here is neither to do justice to the subtleties of these different approaches nor to advocate a particular alternative epistemology (although I return to this matter in Chapter 8), but to give some idea of the range of material available that challenges the neo-Platonic version of mathematical truth and to raise questions as to why this body of work has not had greater impact and is still met with denials (particularly from mathematicians, for example, Goldin, 2002). In thinking about such questions I was helped by Walkerdine's

[11] Kline (1980) describes four broad schools that attempt to secure the foundations of mathematics: the logistic school, the intuitionists, the formalists, and the set theoretic school. They differ in which axioms and principles of reasoning they deem acceptable for use in proofs and consequently disagree dramatically about the validity of different areas of mathematics.

(1990, p.143) Lacanian-inspired psychoanalytic reading of our attachment to mathematical certainty:

> Mathematical reasoning presumes mastery of a discourse in which the universe is knowable and manipulable according to particular mathematical algorithms. This, along with the production of 'hard facts', is usually understood as the very basis of certainty. However, conversely we might understand it as the fear, the necessity of proof against the terror of its Other, that is, loss of certainty, control and attempted control of loss. We might understand it as the impossibility of the object of desire, 'woman', and elaborate fantasies to control consequent desire and avoid dependency or powerlessness.

Perhaps the denial that mathematics is a social practice inseparable from the realities and phantasies[12] of the worlds we live in is due to our psychic investment in reason. Such an investment is inextricable from our attachment to gender.

3.4.2 Our attachment to binary oppositional gender

Both the initially empowering separation of sex and gender (Rubin, 1975) and the model of sex-role socialisation as imprinting upon a pre-given essence work with an idea of the interaction of the biological and the social in the construction of individuals. This idea raises many questions: What is it that is supposed to be interacting? (Birke, 1999) And where are these interactions taking place? (Blackman, 2001) Further, following from the Dawkins quote above (p.52): "How-if biologists themselves scorn the master molecule story-has that tale become so culturally predominant?" (Birke, 2001, p.139) And finally:

> Whether the discourse which figures the action of construction as a kind of imprinting or imposition is not tacitly masculinist, whereas the figure of the passive surface, awaiting that penetrating act whereby meaning is endowed, is not tacitly or-perhaps-quite obviously feminine. Is sex to gender as feminine is to masculine? (Butler, 1993a, p.4)

In this section I argue that the problem is that the "model of interaction (however complex an interaction is asserted) leaves the idea of an unmediated biology unchallenged" (Henriques et al., 1984, p.21) and the resulting social/biological dualism is problematic because it forecloses the possibility of building new ways of understanding the role of biology in making us who we are. I then look at recent work that, rather than rejecting

[12] My use of phantasy here is Kleinian (although used as a thought experiment rather than a description of how things **really** are, see section 3.6). Segal (2000, p.30) argues that while Freud thought that we symbolise repressed objects and that these exist among other neutral objects, Klein's work "turned Freud's upside down. She saw that we endow the world and everything in it with meaning derived from unconscious phantasies and the anxieties which lie behind these. It is our anxieties, our conflicting impulses and the derived phantasies which lead us to see and behave in the way we do. In this sense nothing is neutral. In phantasy all kinds of things are going on, in our heads, in our bodies, in our 'inner world'." In line with the psychosocial approach to phantasy (see for example, Hollway & Jefferson, 2000; Walkerdine et al., 2001) I put the emphasis on looking at how these are made possible by socio-cultural discourses.

bodies completely, as some social constructionist positions do, seeks to engage with biology by looking at the way that people's embodied practices become part of their identity work.

The sex/gender distinction was famously challenged in Butler (1999/1990). She builds on Wittig's (1992, p.32) argument that sex is a political rather than a biological category and:

> What is woman?...Frankly, it is a problem that the lesbians do not have because of a change of perspective, and it would be incorrect to say that lesbians associate, make love, live with women, for 'woman' has meaning only in heterosexual systems of thought and heterosexual economic systems. Lesbians are not women.

Butler's argument begins by pointing out that if sex and gender are seen as independent then, even if a binary form of sex is assumed, there is no necessary reason why there should be only two genders nor why male bodies should become gendered as masculine and female bodies become gendered as feminine (see also Halberstam, 1998). She continues to raise more questions provoked by this "radical splitting of the gendered subject" (p.10):

> Can we refer to a 'given' sex or a 'given' gender without first inquiring into how sex and/or gender is given, through what means? And what is 'sex' anyway? Is it natural, anatomical, chromosomal, or hormonal, and how is a feminist critic to assess the scientific discourses which purport to establish such 'facts' for us? Does sex have a history? Does each sex have a different history, or histories? Is there a history of how the duality of sex was established, a genealogy that might expose the binary options as a variable construction? Are the ostensibly natural facts of sex discursively produced by various scientific discourses in the service of other political and social interests? If the immutable character of sex is contested, perhaps this construct called 'sex' is as culturally constructed as gender; indeed, perhaps it was always already gender, with the consequence that the distinction between sex and gender turns out to be no distinction at all. (Butler, 1999, p.10-11)

In this passage Butler eloquently pushes the sex/gender distinction to its limits and, under the pressure, we can see it self-destructing before our very eyes. Sex itself is gendered; the pre-discursive category of sex is actually produced as an effect of the systems of cultural construction that we call gender.

The general reaction to the deconstruction of the sex/gender distinction is to shift to a social constructionist position. As discussed in section 3.2, biology has a history of being used to justify inequality as well as to regulate populations via eugenicist and other techniques. As a result, such approaches generally dismiss biology altogether and engage with it only so far as to critique its reductionism. With Blackman (2001, p.211), I am both

sympathetic to these positions and concerned that "what is often overlooked is that 'biology' as an object, shifts and changes in meaning and cannot pass as a stable, constant category, which we can simply reject". The result of this is to leave the biological/social dualism intact and to delegate to biology all discussions of what goes on beyond the surface of the body, in our insides, except for that small portion of it that is claimed by psychoanalysis (Birke, 2001). In my research I borrow Blackman's (2001, p.226) view of biological and psychological processes:

> As generative potentialities, which can be transformed through the strategies and practices we develop to identify and act upon these processes. These processes are also not static, constant categories, but are produced in relation to different ways of understanding what it means to be human, across a range of practices which 'make up' the social.

This resonates with Butler's (1993a, p.9, original emphasis) "return to the notion of matter, not as site or surface, but as *a process of materialization that stabilizes over time to produce the effect of boundary, fixity, and surface we call matter*" and with Connell's (1995, p.60, original emphasis) notion of circuits of body-reflexive practices through which he asserts "the activity, literally the *agency*, of bodies in social process". Such a conceptualisation enables a critical examination of the intersection of discourses of sexuality with those of gender in producing specific configurations of gender regimes. In Chapter 6 I make sense of these ideas of bodies and gender using my data.

Post-structuralist approaches "provide a way of examining structuring absences" (Skeggs, 1991, p. 261). In this section I have drawn attention to two such structuring absences in much of the literature on gender and mathematics: challenging mathematical power and privilege and engaging in the dynamics of the social reproduction of dualistic gender. I have presented evidence in this section that these two attachments are very deep-rooted. However, as I argued in Chapter 2, to point out these attachments and alternatives to them is simultaneously to displace them a little. To engage further with these two taken for granted assumptions, of mathematics as legitimately powerful and gender as naturally binary as well as with the problems of the individual/social dualism identified earlier, I adopt a post-structuralist position, similar to that in the work of Dunne, Johnston, Walkerdine, Davies and others. The next section introduces the main ideas used within these frameworks.

3.5 Power/knowledge and subjectivity

Post-structuralist approaches are very different from those based on sex-role socialisation:

> Poststructuralist theory argues that people are not socialised into the social world, but that they go through a process of *subjectification.* In socialisation theory, the focus is on the process of shaping the individual that is undertaken by others. In poststructuralist theory the focus is on the way each person actively takes up the discourses through which they and others speak/write the world into existence *as if it were their own.* (Davies, 1993, p.13, original emphasis)

The aim of this section is to unpack the ideas in this passage and, by so doing, to introduce some key concepts on which the analyses, in the remaining chapters of my thesis, are based. I begin by looking at **discourse**, I then move on to discuss **subjectification and power** and finally **identity work**.

3.5.1 Discourse

Discourses are structures of language and practice through which objects come into being. These knowledges about objects are powerful because they determine what can be said about something as well as who can say it, and even what can be thought or imagined. Or, as Foucault (1972, p.49), on whose version of discourse I am drawing here, succinctly put it: they are "practices that systematically form the objects of which they speak".[13] For example, some of the discourses of mathematics variously frame it as:

- A key skill, a source of knowledge necessary for the successful negotiation of life in a scientifically and technologically sophisticated society, and thus as a source of personal power.
- A process for discovering a body of pre-existent truths (see section 3.4.1).
- A route to economic power within advanced capitalism, with mathematics acting as a 'critical filter' controlling entry to high status positions.
- The ultimate form of rational thought and relatedly as a proof of intelligence.
- Demanding hard work in order to succeed.
- A skill linked to a particular portion of the human genome.
- Associated with forms of cultural deviance, where, particularly in the media, mathematicians are depicted as nerds or geeks, a species apart.

Taking a post-structuralist approach means that these discourses are seen as operating within regimes of truth, not because of their power to **describe** reality but because of their

[13] Some feminists have argued that there are problems with using Foucault's ideas. They point out his apparent lack of interest in gender and his dismissal of pre-discursive experience (see the arguments in Ramazanoglu, 1993). However, despite such points his work continues to be immensely useful for feminists as the post-structuralist work cited in this thesis demonstrates.

power to **produce** it. They are 'fictions functioning in truth'[14]. Mathematics is neither more nor less than that which it is constituted as in and through discourse.

It is within a range of discourses of mathematics, femininity, masculinity, and schooling, among other things, that an individual's educational choices and experiences are constituted. So the problem of gender and mathematics is not located within girls who make the 'wrong' choices or who understand their performance 'wrongly', but in the discursive context of gender, schooling and mathematics. This context makes the patterns of identifications that produce these choices and performances possible and indeed sensible (understood both rationally and irrationally/psychically). Instead of asking 'Why do girls engage in specific practices?' the question is reversed to ask 'How do specific practices do girls?' (Flax, 2002) This is a very different way of imagining the relationship between the social and the individual. However, it raises many questions. Notably: How do individuals become part of discourse at all? And why do they take up/are they taken up by one particular discursive position rather than another? I address these questions about the process of subjectification in the next section.

3.5.2 Subjectification and power

In Foucault's (1977) analysis of the growth of the prison as a form of punishment he traces how, through the surveillance and examination practices of the modern state, knowledges are created about individuals. These normalising discourses then position people within networks of power. They discipline us into certain ways of being and acting and create within us a certain relationship to self. This mode of operation of power is called biopower:

> I have always found this idea of Foucault's very important because...it presupposes not an ideology foisted upon but separate from subjects, but practices of disciplining and regulation which are, at the same time, practices for the formation of subjects. (Walkerdine, 1997a, p.15)

So power inhabits us shaping us from the inside as well as from the outside. However, in this discussion of the power/knowledge nexus, the discursive networks and disciplinary technologies appear to tightly fix what is possible for those individuals constituted within them. Subjects are over-determined. Flax (1990) argues that within Foucault's work there

[14] This lovely phrase is borrowed form the work of Walkerdine, who in turn (I think) derives it from the following statement of Foucault (1980, p.193): "I am well aware that I have never written anything but fictions. I do not mean to say, however, that truth is therefore absent. It seems to me that the possibility exists for fiction to function in truth, for a fictional discourse to induce effects of truth, and for bringing it about that a true discourse engenders or 'manufactures' something that does not as yet exist, that is, 'fictions' it. One 'fictions' history on the basis of a political reality that makes it true, one 'fictions' a politics not yet in existence on the basis of a historical truth."

seem to be only two possibilities for the self. It is either conceived of as unitary and essentialist but 'false' or it is a 'true' self that is entirely historically and textually constituted. In the latter case a person is just a 'tissue' of discursive practices; there is nothing beyond this. Such a dual-conceptualisation cannot explain how some people rather than others come to occupy particular positions within discourse or how they come to resist dominant practices. In an exploration of choices I need theoretical tools that can do this. While I would agree with Flax's assessment of Foucault's early work, I think that the model of power (and resistance) developed in his later work opens up a third possibility for the self, and it is to this work that I turn for the necessary tools.

Foucault (1980, p.119) writes:

> If power were never anything but repressive, if it never did anything but to say no, do you really think one would be brought to obey it? What makes power hold good, what makes it accepted, is simply the fact that it doesn't only weigh on us as a force that says no, but traverses and produces things, it induces pleasure, forms knowledge, produces discourse. It needs to be considered as a productive network which runs through the whole social body, much more than as a negative instance whose function is repression.

So discursive practices are imagined as negative and positive, oppressive and productive, simultaneously and always. Foucault elaborates this notion of capillary power in his three volumes of *The History of Sexuality* (Foucault, 1976, 1984, 1986). Power is "not something that is acquired, seized, or shared. Something that one holds on to or allows to slip away; power is exercised from innumerable points, in the interplay of nonegalitarian and mobile relations" (Foucault, 1976, p.94). Power is in relationships that exist in work places, families and schools, and "major dominations are the hegemonic effects that are sustained by all these confrontations" (Foucault, 1976, p.94). Thus power is exercised locally and that is also where it is resisted. The Foucauldian idea that wherever there is power there is also resistance is important because it captures the double-edgedness of power. Thus the third Foucauldian possibility for a self is the very contradictory one that exists only through the power/knowledge nexus that it is simultaneously resisting.

Although Foucault rejected psychoanalysis, seeing it as just another disciplinary technology[15], Butler (1997, p.86) argues that it is the psyche that makes resistance possible. The psyche "is precisely what exceeds the imprisoning effects of the discursive demands to inhabit a coherent identity, to become a coherent subject". The idea of unconscious being used here is a socially embedded one, in which "psychic processes form a central component of how social and cultural fantasies work" (Walkerdine, 1997a, p.184) and

[15] This is a view shared by some contemporary Foucauldians, notably Rose (1999a; 1999b).

through which the discursive environment becomes a "melting pot of psychical conditions of possibility" (Walkerdine, 1997a, p.185).

This framework, that combines post-structuralism and psychoanalysis, offers a radical re-conceptualisation of the rational, autonomous, unified subject of liberal humanism. It is difficult to continue using the word 'identity' when we are faced with a multiple, fractured, contradictory self. 'Identity' sounds too certain and too singular, as if it already exists rather than being in a process of formation. However, I would agree with Hall (1996, p.2) when he argues that it is also "in the attempt to rearticulate the relationship between subjects and discursive practices", that is, in understanding subjectification and investment, that the need for some version of identity reasserts itself. It is to what this version of identity might be that I now turn my attention.

3.5.3 Identity work

Hall (1996, p.2) describes identity as a concept that is "operating 'under erasure' in the interval between reversal and emergence; an idea which cannot be thought in the old way, but without which certain key questions cannot be thought at all". As a result, in this thesis I will use 'identity work' or Hall's (1996) term 'identification' rather than the word 'identity'. I hope that this difference "sets the word in motion to new meanings yet without obscuring the trace of its other meanings in its past" (Hall, 1991, p.49). The new meanings I am in motion towards, and that I am trying to operationalise within the empirical chapters, are that:

- Who we are is always in a process of formation and is never complete. However, we are not "going forward to meet that which we always were" (Hall, 1991, p.47), that 'originary essence' is also always being worked on. Another way of thinking this is to read identity as a verb rather than as a noun. It is something that we do, and are done by, not something that we are; it is the product not the source of our actions.
- Processes of identification are also psychic ones. For example, we are establishing patterns of sameness and of difference which can be understood as happening through "splitting between that which one is, and that which is the other" (Hall, 1991, p.48), so producing relationships to those abjected and ejected others (exemplified in Said's, 1995/1978, use of the term), and to those others that belong inside of oneself, those with whom we have relationships that are compounded by love and desire.
- Our notions of who we are are always narrativised:

> [Identity] is always within representation. Identity is not something which is formed outside and then we tell stories about it. It is that which is narrated in one's own self. (Hall, 1991, p.49)

My theorisation of subjectivity, described in this section, incorporates psychoanalysis and, before returning to develop this into an idea of agency in the conclusion, I need to explain a little more about how the psychoanalytic material fits in.

3.6 Adventures in psychoanalysis

Early feminist writers were antagonistic towards psychoanalysis and classic texts by Firestone (1979) and Greer (1971) contain fierce critiques of Freud's ideas. There is certainly a strong misogynistic strain in Freud's writings, that is particularly apparent in his work on female sexuality (Freud, 1991b, 1991c) and in his case study of Dora (Freud, 1990)[16]. However, pioneering work by Chodorow (1999/1977), Dinnerstein (1999/1976) and Mitchell (1975) located psychic processes within a social context and began the process of re-appropriating the work of Freud, and of subsequent psychoanalysts, for feminist purposes.

There are real tensions when combining post-structuralist with psychoanalytic approaches. Notably, the former seem to deny the idea of a 'deep inside' that the latter seem to require; psychoanalytic terms such as 'repression' carry the implication that there is a true self that is being repressed rather than one that is just another effect of discourse (Flax, 2002). I share these concerns about the assumptions of psychoanalytic knowledges and about the ways these have been used historically as a means to discipline populations (Foucault, 1980). However, for me, psychoanalysis has epistemological potential for feminism as a tool in the quest for new stories:

> Psychoanalysis does not intend to uncover objective causes *in* reality so much as it seeks to change our very attitudes *to* that reality. This it achieves by effectively deconstructing that positivist dichotomy in which fantasy is simply *opposed* to 'reality', as an epiphenomenon. Psychoanalysis dismantles such a 'logic of the supplement' to reveal the supposedly marginal operations of fantasy at the centre of all our perceptions, beliefs and actions. The object of psychoanalysis is not the 'reality' of common sense, and (in a prevalent view) of empirical science; it is what Freud termed 'psychical reality'. Contrary to psychologism, psychoanalysis recognises no state of totally unambiguous and self-possessed lucidity in which an external world may be seen for, and known as, simply what it *is*. There is no possible 'end to ideologies'. Unconscious wishes, and the fantasies they engender, are as immutable a force in our lives as any material circumstance. (Burgin et al., 1986, p.2, original emphasis)

[16] When Dora, aged 14, is kissed by a married friend of her father, she is understandably disgusted. However, Freud (1990, p.59) judges her to be hysterical because "an occasion for sexual excitement elicited feelings that were preponderantly or exclusively unpleasurable".

In this thesis I use psychoanalysis as a kind of toolkit that can provide thought experiments that move us beyond the current wisdom, rather than getting hung up on defending the positions adopted by particular psychoanalytic schools of explanation, which are likely ultimately to be rejected as historically contingent. My discussion of the psychic investment in reason (in section 3.4.1) was one such thought experiment, one that enables a radically different understanding of the quest for certainty. Other thought experiments pepper this thesis. I finish this section with one that re-orients my main theme, subject choice.

3.6.1 Subjects as comfort blankets

Shaw (1995), drawing on the object relations school of psychoanalysis, argues that subjects are transitional objects, analogous to the comfort blankets to which children cling. The idea of a transitional object is drawn from the work of Winnicott (1991). He argues that it is through them we attain a sense of individual identity and agency as an infant moves away from the relationship with the mother. They manage the process of transition between the illusion of omnipotence, produced by 'good enough' mothering, and the realisation of the existence of external objects. "This intermediate area of experience, unchallenged in respect of its belonging to inner or external (shared) reality, constitutes the greater part of the infant's experience, and throughout life is retained in the intense experiencing that belongs to the arts and to religion and to imaginative living, and to creative scientific work." (Winnicott, 1991, p.14) So cultural artefacts, including academic disciplines, function in this transitional space of play and so maintain one's identity/separateness in adulthood. Shaw (1995) argues that as education becomes an increasingly anxiety-filled activity we rely more and more on choosing subjects that we feel comfortable with as a defence against anxiety. We relate to subjects as we do to people. We expect things from them, we get used to them, are upset when they change and so do not give us what we want, and we feel let down by them. Subjects are a source of comfort or, if the wrong choice is made, of distress, anxiety and even terror. They function like people, "they have to be related to and identified with...one has to 'get on' with" (Shaw, 1995, p.113) them. And, like people, academic disciplines have different 'personalities'.

This idea has transformed the way that I see people's relationships with the subjects they choose and enabled me to see a greater depth of feeling embedded in statements like those that follow. The first of these quotations is taken from an interview study of women mathematics undergraduates, the second is from an interview with a postgraduate mathematics student, and the third is from an autobiographical piece by a woman who has decided not to continue with a career in research beyond her doctorate in physics:

> The three women all talked about their love of mathematics ending, which caused severe distress for each of them-one described this as causing her relationship with mathematics to "spiral out of control". (Boaler, 2000, p.38)

> I had taken a lot of this material before and I'd sit there in horror. He was slaughtering this stuff. This was stuff I thought I wanted to study [for] the rest of my life and he's sitting there just slaughtering this beautiful math. It was horrible. I just wanted to start screaming in the middle of class, "No! You're not talking about it right! Make it clear!" (Herzig, forthcoming)

> I am in mourning. I have lost the love of my life. Well I've lost what I thought was the love of my life but with the insight afforded to me in my newly bereaved state I am beginning to realise that I may have been blind to my love's faults and may well be better off without them. I tell myself that I deserve more, I don't have to put up with the casual abuse, the discrimination and not having my needs met by this relationship. How could I have been so foolish? Love does not conquer all-isn't this a pathetically familiar tale? It would be if I were talking about a person but I'm not; I'm talking about physics. The love of my life, all I ever wanted to do, the dream I clung to all through adolescence and sacrificed all manner of things for is science. (Hawkins, 2002, *online*)

3.7 Conclusions

While writing this chapter I have been aware that another person looking at my question and my data might have approached it very differently. In particular they may have selected a different theoretical framework. Many recent studies of educational decision-making have worked with Bourdieu's ideas (for example, Ball et al., 2000; Bloomer, 2001; Bloomer & Hodkinson, 1999, 2000; Gewirtz et al., 1995; Hodkinson et al., 1996; Macrae et al., 2001; Reay, 1998). There is much that I value in these approaches and I use ideas from them in the analyses that follow. However, there are also things that I do not get on with (and theories are perhaps also best thought of as comfort blankets). I had particular problems with Bourdieu's attachment to social **science**, and found his concepts of habitus and field too vague to work with empirically (both of these points are evident in Bourdieu, 1984; Bourdieu & Wacquant, 1992; and are thoroughly discussed in Jenkins, 1992). I am aware that many people have problems using Foucault.

> The theories we use arise from a variety of influences: disciplinary location; access; their ability to address concerns produced from our experiences and histories; their explanatory power and their practical adequacy. Why is it that some theories have the ability to encapsulate experiences whilst others make no sense? And why do we gravitate towards particular theories? The theories I used were based on their explanatory power to help me understand what was happening during the research. I was continually modifying theories in a dialectical relationship with the [students]. (Skeggs, 1997, p.23)

I do not know from where the theoretical lens through which I look at the issue of gender, mathematics and subject choice and at my data, comes. I know that post-structuralist work has changed the way that I understand the social world and continues to challenge me. There also seems to me to be a peculiar resonance between doing post-structuralism and doing mathematics (see the What-if-not approach of Brown & Walter, 1983). However, I will not attempt to demonstrate that post-structuralism 'washes whiter' and can do everything that all the other approaches do not. In this chapter, I have argued that it has a great deal to offer and the rest of this thesis can be seen as developing that argument.

I began this chapter with a critical survey of the main approaches used in the literature to explain the gendering of mathematics. I then outlined a post-structuralist framework through which I hoped to avoid both biological and social reductionism, simple 'magic bullet' answers to complex questions. I finish by returning to my research question and considering what has become of choice within this framework. It is clear that the autonomous choosing subject has gone forever, replaced by a subject forever trapped within power relations. However:

> It is not the case that there are no choices, but those choices are heavily circumscribed and shot through with conscious and unconscious emotions, fantasies, defences. It is the complexity of the production of the intersection of subject and subjectivity that I [am] exploring. (Walkerdine, 1997a, p.171)

Since individual agency is generally understood as being exercised through choice, I now consider what agency looks like with this new understanding of choice. This has relevance not just to the agency of the students whose choice of mathematics I am researching, but also to the agency of the teachers in whose classes they learn to do mathematics, and to my agency as a researcher interested in the possibilities for changing (albeit ever so slightly) the social world through my work.

At first the idea that we can never escape power seems to foreclose possibilities for agency. However, I would agree with Butler (1999, p.187, original emphasis) that "paradoxically, the reconceptualization of identity as an *effect*, that is, as *produced* or *generated*, opens up possibilities of 'agency' that are insidiously foreclosed by positions that take identity categories as foundational and fixed". It is useful to return to the debate introduced in section 2.2.4 about whether the loss of the autonomous subject and of the assumed subject of feminism, women, makes a feminist politics impossible. To make such a claim "that politics requires a stable subject is to claim that there can be no *political* opposition to that claim" (Butler, 1995, p.36, original emphasis). Obviously political action necessitates that we speak for women. However, that is always going to be a contested act, and this is something that I want to celebrate rather than to mourn.

> To deconstruct the subject of feminism is not, then, to censure its usage, but, on the contrary, to release the term into a future of multiple significations, to emancipate it from the maternal or rationalist ontologies to which it has been restricted, and give it play as a site where unanticipated meanings might come to bear. (Butler, 1995, p.50)

Thus agency exists in the possibility for variation in the repetitive performances, the discourses, through which 'women', and other objects, come to exist. If gender is something that we do then it **can** be done differently. However, in case this is all beginning to sound too easy, Butler (1999, p.189) reminds us that "to enter into the repetitive practices of this terrain of signification is not a choice, for the 'I' that might enter is always already inside: there is no possibility of agency or reality outside of the discursive practices that give those terms the intelligibility that they have". The key question for an investigation like mine that is interested in social change is thus "how can we work the power relations by which we are worked and in what direction?" (Butler, 1997, p.100)

Chapter 4 Classroom spaces

4.1 Introduction

Mathematics lessons take place in distinctive physical locations and this has implications for what is learnt within their walls. While often ignored by mathematics educators, mathematics students are very aware of these points.[1] For example, Mei Jin, a Grafton student, explains that mathematics is different from other subjects because of the "environment." Because "you get surrounded by different things, so you sort of grow up, you get used to it."[2] And so in the end "you see it in different ways." Students and teachers give a lot of thought to how they locate themselves within these spaces. The teacher regulates students' movements within as well as into and out of these spaces, and the mode chosen is an indicator of what sort of teacher they are constructing themself to be. Very quickly in the year regular seating arrangements are established, and many students relate their position in these to their relationships with others and to their self-presentation. For example, Claudia (a Westerburg student discussed in detail in section 6.3.3) identifies herself as someone who likes to sit at the back "to get a view of the whole class." She explains, "I've never been one to sit at the front" which she associates with being "like 'ooh, miss, I know the answer' all the time."

However, these classroom spaces are not just physical, they are also temporal (Jenks, 2001; Lesko, 2001) and, more generally, 'discursive landscapes' (Bibby, 2001). Mei Jin gives a sense of the importance of this when asked to elaborate what she means by "environment" in the comment quoted above, "first of all the classroom, the people who you're around, and just you think towards that thing," so that when you are in mathematics you are "trying to push everything out the way and getting all the numbers in your head, but in English, you sort of, also push everything out your mind but you think of all the possible opinions." These landscapes are places where students are engaged in making themselves in a creative response to the constraints imposed by the situations in which they find themselves. These landscapes and the processes through which students are locating themselves within them are the subject of this chapter.

[1] Skovsmose & Valero (2002) surveyed the articles published in six leading mathematics education journals and found just one sociological study of mathematics classrooms compared with 65 that they classified as 'logical' or 'psychological'.

[2] In this and all the other passages in this thesis that were transcribed from tape recorded interviews or taken down verbatim during my observations, I have used the following conventions:
[ ] to enclose words that are not said but whose addition helps to clarify the meaning of the passages and to enclose non-verbal parts of the communication such as laughter.
( ) to enclose sections of talk that are unclear on the recording.
... to indicate the omission of one or more words.

I begin by describing the three organisations in which I did research: their buildings, their ethos, their populations, their approaches to A-level mathematics teaching and learning, and the different tensions operating in each. All of the teaching that I saw could be classified as 'traditional' as opposed to 'progressive' (Boaler, 1997, contains a useful discussion of these terms as applied to mathematics pedagogy). By this I mean that the teachers broke the material down into small chunks, worked through examples on the board and then set similar exercises for students to do from textbooks. It is evident that, even during the most 'radical' periods in recent educational history, few mathematics teachers departed significantly from this model. But the diverse environments sketched out in this chapter illustrate that the oppositional division of classroom practices into 'traditional' and 'progressive' ignores important differences within those labelled 'traditional'. It is central to my argument about how students locate themselves, that superficially similar classroom landscapes can actually make very different positions available to the students within them, and that these positions determine who comes to enjoy mathematics and who to hate it, who becomes successful at it and who a failure, and so who chooses to continue with it and who to reject it. I develop this argument through four case studies drawn from my data, using situated cognition as a 'theoretical lens' (Lerman, 1998). The first two case studies are drawn from Westerburg. In them I compare the motivational practices engaged in by the teacher in a single mathematics class with those engaged in by the teachers in a further mathematics class. The next two case studies, drawn from Westerburg and Sunnydale respectively, illustrate that not all positions are equally available to all people, by looking at the ways that gender and ethnicity affect how students take up and resist positions within the dominant discourses. My purposes in this chapter are thus to introduce the places and people that populate the rest of this thesis, and to flesh out the model of 'identity' whose bones are contained in the later sections of the last chapter.

4.2 The research settings

4.2.1 Grafton Comprehensive School

Grafton School is an inner city 11-18 comprehensive with a multi-cultural, mainly working-class intake of about 1200 pupils. Over half of Grafton's pupils are eligible for free school meals and about one-third speak English as an additional language; it is located in an area that Ofsted described as "deprived". However, Grafton has a respected headteacher and a hard-working staff. Ofsted inspected the school during the research period and judged it "a good school that has several impressive features, particularly the

successful cultural and racial mix of the school community and its citizenship initiative". Grafton's active approach to equal opportunities is also reflected in its community involvement and in a range of policies (on bullying, racism, the Ethnic Minority Achievement Strategy, equal opportunities and gender).

Grafton School has about 150 sixth-formers and operates as part of a consortium with two local schools in order to offer them a wide range of curriculum options; most students also take courses at Sunnydale College. Grafton sixth-formers have a common room and are identifiable by not having to wear uniform. They are aware that being in a school rather than a college has advantages and disadvantages. As Simon puts it "college is more independent" and "a lot more grown up than in here" where they are "monitoring you all the time, seeing when you come in and when you haven't." 'College' signifies Sunnydale to Grafton students, and their generally negative impressions are based on their own experiences of doing courses there and on those of friends and family members. For example, Simon describes how "my friend was doing maths in college and he doesn't go to any of the lessons now because he found out that the teacher was just like, arrive at that time...leave at when you're supposed to be leaving, just teaching what he had to teach and not teaching anything else, like, say you didn't understand how to do something basic, he wouldn't explain it to you, he would like teach you what he's got to do, basically get his money". Simon was typical in concluding that "they don't really care that much".

James had taken business studies at Sunnydale during the previous year and had struggled with the course "the teachers weren't helpful. I find that at college a lot." He relates this to the relationship between teachers and students "whereas at sixth-form you know the teachers," he pauses, "or you've had them at GCSE so they know what you can and can't do, they know your weaknesses and strengths so they can help you." (For more about Simon and James see sections 6.2.1 and 6.2.2 respectively.)

The students involved in my research were part of a larger than expected cohort of AS-level mathematics students at Grafton. As a result, although they were originally taught in one group, after three weeks they were divided into two based on their 'ability' as judged by their GCSE mathematics result. Since GCSE mathematics can be entered at one of three different tiers-higher, intermediate and foundation-each associated with a different syllabus, the entry level as well as the grade attained were crucial in this setting process (grades A*-D, B-F, and D-G are available at each level respectively). The 'top' set included all those who obtained an A*, A or high B on the higher level exam and it continued to be taught by the same three teachers as the original group, although by the second term, when a member of staff left and department timetables had to be rearranged, they were taken by only one teacher, Matt Delling. This group contained five girls and nine boys. The 'bottom'

set consisted of six students who had obtained an intermediate grade C and three who had a higher grade B. I took them for all their lessons. This group contained six boys and three girls. These groups developed different identities, with the 'top' set being quieter and all but two students working and sitting individually; the 'bottom' set had more students who worked cooperatively, and, by my design, all students sat around the same table. The students became a single group again at the start of the third term, just a few weeks after I conducted my interviews. It is evident from the interviews that the setting created tensions for some students (see Michael's and Julie's stories in sections 6.2.3 and 6.3.1 respectively). The mathematics department follows the AQA (Assessment and Qualifications Alliance) syllabus. For the AS-level they cover the compulsory modules of methods (a combination of pure mathematics and statistics), and pure 1, and an optional unit in discrete mathematics. The results, during the research period, were as follows:

Table 2: Grafton examination results

LEVEL:	AS						A					
GRADE:	A	B	C	D	E	U	A	B	C	D	E	U
2000/1	3	0	2	3	2	6	-	-	-	-	-	-
2001/2	3	0	1	0	2	15	3	1	0	0	0	2

My involvement as a teacher at Grafton makes it more difficult to describe the teaching there. The lessons that I observed were relaxed and structured around preparing students for the examinations. There are a number of tensions for all Grafton teachers in their classroom pedagogy. A central tension lies in their desire to protect students from negative learning experiences but to avoid spoon-feeding them (perhaps related to the tension in the student talk about college vs. school between a desire for autonomy and a desire to feel cared for). This is evident in the way that Trisha talks about the tests that she sets for her AS and A2 groups in lessons that I observe. She explains that the tests are to "scare them" into taking a more "proactive" approach to their work and to make them aware of what they will face in the end. But she then moderates this by offering students help after about thirty minutes. Another tension is illustrated by her refusal to allow students to use textbooks or notes, or to collaborate on these tests, but instead she makes herself the only source of help. This tension is between ceding control of the learning process to the students and keeping it in the hands of the teacher, between positioning students as adults who can take responsibility for their own learning and as children in need of monitoring and regulation; this is not only a tension for Trisha at Grafton but is central to the culture at Westerburg.

4.2.2 Westerburg Sixth Form College

Westerburg educates approximately 800 ethnically-diverse, largely middle-class young Londoners. It is located around the corner from a busy high street whose cafes and takeaways provide lunch for many of the college's students. A large hall functions as the students' social space although they also hang out in other smaller spaces around the buildings and, when it is sunny, flood into the college grounds, leaving behind the customary teenage debris (to the equally customary disapproval of the staff). Westerburg has two entry policies. Although oversubscribed, it guarantees places to members of local partner schools and allocates the remaining (majority of the) places competitively. Its curriculum is largely academic, although some vocational courses cater for the less qualified partner school entrants. The impact of college selection procedures on different ethnic groups had been analysed during the year prior to my research but there is no routine monitoring of recruitment, retention or achievement by gender or ethnicity. I had difficulties getting hold of the Equal Opportunities policy, which was and is embroiled in a lengthy revision process.

Westerburg has formal disciplinary systems. During my observations I encountered students on report for poor attendance, in one case for five months, and others who had been given detention. Attendance was monitored through an electronic registration system and punctuality was an on-going point of tension. Typically in one of Andy Rhodes' lessons straight after lunch several students were missing at 13:15 when the class started. Mark arrived at 13:20. Mr. Rhodes pointed out that this was not the first time he had been late and asked him why. Mark was unsure. Craig followed at 13:21, and seconds later Deji. Mr. Rhodes told Craig that this was his fourth instance of lateness and asked why. Craig blamed his watch. For Deji, Mr. Rhodes explained: "constant lateness is a disciplinary offence" leading to application of the disciplinary procedures and ultimately perhaps to exclusion from college.

"I was only six minutes late," protested Craig, apparently thinking the punishment disproportionate to the crime.

Analia (who is always punctual; see section 7.2.3 for Analia's story) argued that bells were needed so "you'd know where you're going and when."

Their teacher refuted this, drawing on notions of personal responsibility, and the discussion ended. This incident suggests a tension that exists for Westerburg students, caught between discursive practices that position them as adults, free to make their own choices, and that demand they take responsibility for their own learning, and ones that position them as children in need of constant control.

Westerburg's mathematics department has over 350 students being taught advanced courses by six full-time teachers and one part-timer. To qualify for entry to an AS mathematics course students must have at least a higher grade B at GCSE (although occasional exceptions are made). Students with an A or A* grade have the option to study further mathematics. The Edexcel syllabus is followed and students are provided with the official textbooks. I observed the further mathematics group, an AS group studying modules in pure, mechanics and statistics and an AS group studying modules in pure, statistics and decision mathematics. These groups consisted of two girls and eighteen boys, four girls and twelve boys, and nine girls and ten boys, respectively. The results during the research period, 2001/2, were:

Table 3: Westerburg examination results

LEVEL:	AS						A					
GRADE:	A	B	C	D	E	U	A	B	C	D	E	U
MATHS[3]	41	33	42	25	14	25	63	51	17	25	9	2
FURTHER	4	0	0	0	1	0	5	2	2	0	2	1

The department has a small suite of dedicated classrooms and a staff office with individual workspaces, a kettle, two computers, a printer and comfy chairs. The office is meticulously organised with copies of past examination papers in colour-coded drawers and a whiteboard where agenda items for the weekly department meeting and other work-related information are written up. Most conversations in this office relate to mathematics teaching. The classrooms have impressive displays of posters, including many focusing on careers and university courses involving mathematics, the series *Mathematics on the Underground* and an historical overview, *Men* (sic) *of Mathematics*. Teachers prepare lessons carefully and provide excellent web and paper-based resources for students; they always welcome students who come to the department office seeking help and offer drop-in workshops. However, the idea of the accessibility of mathematics is in tension with the idea of its exclusivity, for this support happens within an environment in which certain assumptions are made. These assumptions-about what mathematics is, about how it is best taught and learnt, and about the role of examinations-are explored in section 4.4. Some of them, in particular that mathematics is more demanding than other subjects, are evident in a sign pinned to the noticeboard in the foyer between the classrooms:

[3] Some students took A-levels or AS-levels in Applied Mathematics and some in Mathematics. For the purposes of this table I have simply added these together.

MATHS IS HARD!

Independent research shows that Mathematics is the most challenging subject at A-level. Nationally, last year's AS results in maths were far worse than any other subject.

If you don't really enjoy Maths and if you're not genuinely good at it, don't do it! Two years of struggling and constantly being "stuck" is not an experience we would wish on anyone.

Success at A-level Mathematics usually depends on:

Positive attitudes. Do you enjoy solving problems? Do you *like* Maths?

Persistence. Do you give up easily and ask for help? Or do you prefer to get the answer for yourself?

Independence. Do you need spoon-feeding every step of the way? Can you learn it by yourself?

A student could not be blamed for gaining the impression that some subjects, other than mathematics, would be recommended for those who "give up easily" and "need spoon-feeding every step of the way".

In many ways Westerburg is a typical representative of the sixth-form college tradition. Robinson & Burke (1996) argue that the very different histories of sixth-form and FE colleges meant that they responded differently to the 1992 Further and Higher Education Act which removed post-16 providers from Local Education Authority control. Sixth-form colleges had, in 1992, a tradition of combining comprehensive ideals and academic excellence; their teachers came from schools and were employed on the same terms and conditions; they "had a history which was imbued with an elitism which was both academic and social" (p.7) and which was visible in their adapted grammar school buildings. FE colleges, by contrast, had been associated with the education of working-class men and had been more closely allied with polytechnics than with schools. They, more than sixth-form colleges, are populated with the 'new sixth' created by the massive expansion of the numbers entering post-compulsory education. This alternative FE tradition is exemplified by Sunnydale College.

4.2.3 Sunnydale Further Education College

Sunnydale College is one of England's first beacon colleges and has about 13,000 students of whom about a third are full-time and more than a third are studying for qualifications at entry level or level one. The college also attracts a large number of foreign students; of the thirteen mathematics students whom I interviewed, six had non-British nationalities and all could be described as from ethnic minorities. The average age of students is about 30. Sunnydale thus caters for different needs than either Grafton or

Westerburg, and most of the courses are part-time and/or vocational. The top floor of one of Sunnydale's two campuses forms an Academic Centre, offering a range of AS and A2 daytime courses designed for 16-19 year-olds with only a few mature students enrolled. Thus the Academic Centre's intake, location and programmes of study mark it out from the rest of the college and this creates certain tensions for its teachers and students. The mix of students at Sunnydale means that it has a more informal, less hard-working feel about it than either Grafton or Westerburg. In fact, Toni (I tell her story in section 6.2.4) thinks the college contains a large number of "useless boys" and while some boys are "really into their work" most are "more like into girls". She complains, "I don't even know why they come to college. You see some of them walking down the corridor...their trousers half way down, with their boxers. No books with them."

For some students the FE ethos is an advantage. Nefertiti tells me, "my parents didn't, didn't want me to come to Sunnydale College because you see like, there's a lot of higher learners, older people in this college, 'cos it's not like sixth-form" and they wanted her to go somewhere that has got "more people straight from secondary school and like you can interact more, like teachers help you more." She rejected this advice because college "is more open, if you do you do, if you don't you don't."

Sunnydale is in walking distance of Grafton. The college was inspected during the research period, and the report (like that for Grafton) describes the local area as "deprived", citing as evidence:

> Unemployment in the area is 11.7%, which is about three times higher than the average for Greater London...In 2000, only 34.8% of Year 11 students from [local] schools gained five or more General Certificate of Secondary Education (GCSE) grades at C or above, compared with 49.2% nationally.

While at Grafton I identify as a teacher and at Westerburg I identify as a researcher, at Sunnydale I identify as both a researcher and a student (of Spanish). In both roles I am aware of the chaos circulating through Sunnydale. Alex's desk in the mathematics office, by April, has every inch of it covered with books and papers to a depth of about a metre; it takes four hours to enrol for one GCSE evening class; the computer-printed mathematics class lists bear little resemblance to who shows up; the wrong people are entered for the GCSE Spanish examination; and at my first meeting with Nick Bennett, the Head of Department, I wait over an hour for him. This chaos means that it is easier for students to get lost. Because of timetabling clashes some students are splitting their mathematics lessons between the two AS groups. Their teachers are unaware of the details of these arrangements, and it is up to the students to decide which, if any, of the homeworks set they will do. When I go to collect the exam results it is apparent that the A2 group teachers

are unaware of their group's AS results. In contrast, at Grafton and Westerburg, students' first year results are used to determine who is allowed to progress to the A2 course. This laissez-faire approach is perhaps one reason for the poor punctuality and attendance, although these are also systemic features of FE life (Wallace, 2002).

There were two AS groups and one A2 group, following the Edexcel syllabus. Each group's three ninety-minute teaching slots were shared between two teachers (from the three who teach A-level mathematics). Both AS groups covered modules in pure mathematics, mechanics and statistics. The groups contained eighteen boys and six girls and six boys and ten girls respectively. The imbalance was due to the second group being scheduled against physics. With only four and a half hours per week and a later start and earlier finish to the year, Sunnydale allocates the least teaching time for the AS-level of all the three research sites. The examination results for 2001/2 were[4]:

Table 4: Sunnydale examination results

LEVEL:	AS						A					
GRADE:	A	B	C	D	E	U	A	B	C	D	E	U
MATHS	1	1	0	3	6	9	0	2	2	1	0	0

The Academic Centre has one dedicated mathematics classroom, containing four computers, an overhead projector, a whiteboard and several mathematics themed posters including a series of photographs of everyday objects (Toblerone, Cornetto, Cornflakes) accompanied by an isometric drawing of the solid shape that they exemplify. Adjacent to this classroom is an office where the five department members have desk space and access to a computer. The office is small and narrow and the contrast with the Westerburg office, which is over three times the size, is stark. Discussions here between staff rarely focus on teaching mathematics and are usually general conversations, jokes, or complaints about the poor pay and management in the college.

Sitting in mathematics lessons at Sunnydale, I often feel as if I am in a lecture with the teacher working at the board for most or sometimes all of the ninety-minute session. Few students' names are used, and I never see Alex, who teaches more than half of the advanced mathematics lessons, call or mark a register; instead he uses a signing-in sheet. As someone who has always worked in sixth-form colleges and schools, I was shocked the first time I saw a student leave the room, to take a mobile phone call or to talk to a friend signalling them through the classroom windows, without any comment to or from the

[4] There was also one grade X at AS-level included in the official results, however, even with this addition the total number of results is significantly fewer than the total number of members of both AS classes. The reasons for this are unclear to me.

teacher. The teachers also normally ignored late arrivals. However, occasionally tensions were evident, for example, when Abdi jokes to a student whose mobile phone has just gone off for the second time "popular man, I must remember to shoot your friends."

These features of classroom life matter to the mathematics that is learnt, to the ways in which learners come to relate to the subject and to whether they choose to continue studying it at the end of the course. However, few studies of mathematics teaching and learning consider their impact. "It seems presupposed that noise in the classroom, students making obstructions, students not turning up in schools, etc. do not reveal adequate information for researching the learning of mathematics." (Skovsmose & Valero, 2002, p.9) The case studies in this chapter highlight some of those disappeared features. The first two focus on the practices through which teachers, explicitly and implicitly, answer the frequently asked student question "why are we doing this?" since constructing a rationale for one's actions is a central part of identity work. The next two highlight the unpredictability and variation in the ways that students do this identity work and the role of social divisions in this process. First, in the next section, I explain the way of looking at classrooms that generated these analyses.

4.3 Situating practice: meaning and becoming

> *Mrs. Sawyer has just marked the second homework of a first year AS-level group at Westerburg. The homework topic was completing the square although a lot of the errors occurred in the students' manipulation of fractions. As a result she decides to suspend the normal curriculum and spend an hour looking at prime factors, highest common factors, lowest common multiples and then the four operations on fractions. She describes this as a "very, very simple" topic "dealing with very, very basic things" and further as "babyish". The students progress through the work largely in silence and with few problems. Their teacher interrupts them at regular intervals to offer advice, call out answers, deal with queries and remind them how to deal with the operation rehearsed in the next set of questions. Vicky is one of the first to complete the fractions exercises and has had no problems with them. This surprises her teacher who had commented at the beginning of the lesson that, given the mistakes Vicky made in her work, this lesson will be particularly useful for her. Mrs. Sawyer asks her: "So it wasn't that that was the problem? What was it?" Vicky pleads ignorance and suggests that, "perhaps it was just a bad day." Mrs. Sawyer simply adds that it cannot be that because she has made these same errors twice, and the discussion ends.*[5]

This incident struck me as typical of how, often, the assumptions of teachers about how mathematics is learnt cannot explain learners' behaviours. The teacher's conversation with Vicky indicates that she has assumed that the latter's inability to apply a skill (in this case, the manipulation of fractions) in one context (in this case, completing the square)

[5] Indented italicised passages like this one are taken from my field notes with only minor changes to improve the grammar, readability and sequence of events in the passages.

indicates a general inability to apply that skill in all contexts, and one that could be remedied by decontextualised drill and practice of the given skill. There is now a mounting body of evidence (some of which is discussed in the next paragraph) that this is not how mathematical skills are learnt. Despite this, mathematics teachers continue to act as though they are 'delivering' transferable skills to students and, as in this case, disappear the parts of their lived experience that cannot be understood within such a model.

The weakness of the traditional, functionalist model of the transfer of skills within mathematics, highlighted by the mismatch between Veronica Sawyer's expectations for the lesson and its actual outcomes embodied in Vicky, was famously challenged by Lave's (1988) study. She compared the near perfect performance of people she names 'just plain folks' on best buy calculations with their much weaker scores on mathematics tests covering the 'same' numerical skills (Nunes et al.'s, 1993, study of street mathematics amongst Brazilian farmers, fishers and street traders makes similar points). Lave developed a different way of looking at learning to help her understand her findings, a perspective she calls situated cognition, in which mathematics and learning are conceived of as social practices, taking place within communities, and learning is never context free. This is a significant shift for it recognises that although "people clearly do transfer ideas, feelings etc. from one context to another under all kinds of conditions...what they transfer is not always what we in education would like them to transfer"[6] (Evans, 1998, p.285). Evans' (1998, p.274, original emphasis) work on adults' mathematical problem-solving points to the complex interweaving of desire and discourse out of which individual performances are constituted:

> In a given setting subjects in general *are positioned by* the practices which are at play in the setting *and*...a particular subject will *call up* a specific practice (or mix of practices) which may differ from those called up by other subjects, and which will provide the context for that subject's thinking and affect in that setting.

So the meanings of the practices for those doing them are complex mixes of the structural, the environmental and the psychic, and hence are intimately tied to the way we talk about ourselves, that is to our identity work.

Recent work within this perspective (Holland et al., 1998; Wenger, 1998) has developed this connection between learning and identity. The idea of identity in these studies is of a 'self-in-practice' an 'authoring self' derived from the work of Bakhtin (for

[6] In this work Evans is using a framework from post-structuralism not from situated cognition. However, the sections quoted here could apply to both.

example, 1981). There are similarities to the post-structuralist model of identity which I developed in section 3.5, as these quotes illustrate:

> People tell others who they are, but even more important, they tell themselves and then try to act as though they are who they say they are. These self-understandings, especially those with strong emotional resonance for the teller, are what we refer to as identities. (Holland et al., 1998, p.3)

> [Living identities] do not come into being, take hold in lives, or remain vibrant without considerable social work in and for the person. They happen in social practices. (Holland et al,. 1998, p.vii)

However, there are also differences. The most significant of these stems from how the word practice is used in the situated cognition literature as compared to how it is used in the post-structuralist literature. Walkerdine (1997b, p. 63) draws attention to this:

> For Lave, practices were activities and people acting in a setting, specified by a dialectical relationship. I do not think that this is at all clear and carries the danger that neither the people nor the setting is theorized. Thus we are left rather too close to the traditional individual-society dualism than I would presume Lave would like. In [post-structuralist] analysis, the discursive practice is the place in which the subject is produced.

This reluctance to abandon the individual/social dualism is evident when Holland et al. (1998, p.33) reject Hall's (1996) idea of the 'suturing' of person to position in favour of co-development:

> A better metaphor for us is not suture, which makes the person and the position seem to arrive preformed at the moment of suturing, but codevelopment-the linked development of people, cultural forms, and social positions in particular historical worlds.

Relatedly, situated cognition is also under-theorised in terms of power (Paechter, 2003).

To avoid any problems deriving from these differences I use situated cognition, within a post-structuralist framework, as a lens through which to look at classrooms. In this reading, situated cognition is just another discourse about learning, but it is one that is useful for my purposes here. Situated cognition has many attractive features. It is an approach that displaces the power of mathematics; mathematics is no longer seen as an absolute body of knowledge, but as something people do. Within this framework the opposition of abstract and concrete knowledge is viewed in terms of the socio-cultural practices within which the differently classified objects are learnt. The explanatory burden for problems experienced in teaching is shifted from the cognitive and the pedagogical to "issues of access, and...the transparency of the cultural environment with respect to the

meaning of what is being learned" (Lave & Wenger, 1991, p.104-105). If the 'ability' to perform a certain skill is tied to the context in which we are asked to perform it, then a variety of things impact on it, including the language and situation in which the task is framed, the physical environment, the actions of other learners and of the teacher, and the other experiences of the learner in which these are embedded.

It is this research that situates my approach to classrooms. In what follows, I explore the meanings that students and teachers give to what they are doing in their communities of practice. It is not what mathematics is or is not that matters but what it is constructed as being and as not being, the stories we tell about it, the discourses through which it is constituted, and the subject positions that these make available to learners, the ways in which mathematics becomes part of their identity work.

4.4 'Why are we doing this?' Case studies of motivational practices in mathematics classes

The case studies in this section are drawn from my observations in Westerburg because sixth-form colleges are now the most common route through which young people gain AS and A-level mathematics qualifications. In addition, the larger number of groups to which I had access at Westerburg means that I have more and richer data from there. I start my analysis with Veronica's group because, of the four Westerburg teachers I observed, she was the one who most commonly invoked the requirements of the examination as an explanation for her teaching practices and so provides the most unambiguous message to students regarding the purpose of her classes. However, there are also more personal reasons for my choice. While Veronica is clearly a good and experienced teacher who cares a great deal about the young people she teaches, she told me, "most of the [students with GCSE grade] B's fall by the wayside." This statement troubled me more than any others I heard teachers say and I think that I wanted to look at the ways in which such an outcome could seem natural and unproblematic. Retrospectively, I suspect that the way I see Veronica's teaching style as the most different from my own was an unconscious motivation for my choice, since it makes my analysis less threatening to the identity work I do in constructing myself as a 'good mathematics teacher'. Further, although the comparison with the further mathematics group was similarly theoretically driven, it is notable that, as a result of this choice, it is only Andy, the Westerburg teacher with whom I feel the strongest affinity, that I have avoided writing about in detail.

4.4.1 Veronica Sawyer's class

The lesson described at the beginning of section 4.3 was typical of the way students in this class generally work individually on repetitive exercises that practice set procedures, when they are not being taught didactically. Mrs. Sawyer's decision to improve the group's skills by going back to basics exemplifies the way she feels that mathematics has to be done in a particular order. Within this discourse of a hierarchy of knowledge in which she inscribes mathematics, some topics are located near the top of the scale, as 'hard' and others near the bottom, as 'easy'. As the lesson described at the start demonstrates, Mrs. Sawyer often describes 'easy' topics as 'babyish'; this association with a younger state being carried through by their being labelled as junior school or GCSE work. Such references draw on and fuel a series of parallel binaries in which 'baby' work is 'easy' and is opposed to 'grown up' methods that are 'hard'. These are gendered and hetero/sexualised, with the masculine 'hard' also opposing the feminine 'soft' and 'yielding', and classed, because certain aspects of middle-class 'cultural capital' are commonly taken as signifiers of mathematical maturity and 'ability' (Morgan, 1998).

In looking for meanings in mathematics classes, researchers have discussed the absence of sense-making from overly procedural, competitive lessons. Boaler (1994, p.554, original emphasis) commented:

> It seemed to me that in most [mathematics classrooms], it was as if there were a kind of check-in desk just outside the classroom door labelled 'common sense', and as the pupils filed into the classroom, they left their common sense at the check-in desk saying 'Well we won't be needing *this* in here'.

In a later study Boaler (1997) reported that many students, but particularly girls, found their 'quest for understanding' frustrated by the fast paced repetition of techniques that dominates top set mathematics pedagogy. Mrs. Sawyer's approach to the 'quest for understanding' is interesting. On two occasions she substitutes belief for understanding[7]. For example her discursive framing of a topic shifts from comments like "I know this is hard for an afternoon lesson," to "you've got to believe me, it's not magic, you've got to believe me, I'm not fooling you." Alternatively she often suggests deferring the quest, "you've got to be patient with yourself when you're learning." Understanding will result from time, effort, and hard work. This construction of understanding is used as a rationale for stemming the flow of student questions. However, I would argue that the most important difference between the 'quest for understanding' of the girls in Boaler's study

[7] Tobias (1978) points out that, while wilful suspension of disbelief is associated with literature, it is also necessary for mathematical and scientific learning and that this process is linked to safety and trust.

and the one that Mrs. Sawyer wants her class to pursue is motivational. She makes clear that it is the examination that defines not only what understanding is needed, but also whether you have understood or not; external authority replaces internally authorised sense-making.[8]

4.4.1.1 The spectre of the examiner as a disciplinary presence in the classroom[9]

In all the classes I observed there was some mention of the exam. However, the frequency and nature of such mentions varied greatly. In Mrs. Sawyer's class the exam itself was discussed often and the teacher used many opportunities to describe exam technique. However, it was largely through the constructed figure of 'the examiner' that the exam made its presence felt. This (assumed male) examiner is sometimes a hard taskmaster rigorously insisting on one form of answer over another and at other times a doddery old man who may find messy work "confusing". The examiner guides the choice of methods as when Mrs. Sawyer instructs her students to score neatly through each term when expanding brackets so that the person marking your script can still see it and to write "comparing" when comparing coefficients in order "to show off to the examiner that you're a logical person".

That the examiner is also the ultimate arbiter of right and wrong in the eyes of the students is clear from Imran and Saeed's comments to me during a lesson on inequalities. When I point out to Imran that he has used = instead of <, he says twice "you know what I mean," and then shifts to "the examiner will know what I mean."

Saeed, who gets the answer '$-x<-4$', wants to know how to get the answer at the back of the book. After I explain, he wants to know "will they mark that [his original solution] as right in the exam?"

However, exams carry with them constant evaluation, not only against the requirements of the examiner, but also against each other. Denscombe (2000, p.370) found that students saw exams as offering "the prospects of success or failure which could be used as a 'measure of the person' on which to make comparisons with others". Next I look

[8] "Words like 'understanding' require some caution because they can easily reflect an implicit assumption that there is some universal standard of the knowable. In the abstract, anything can be known, and the rest is ignorance. But in a complex world in which we must find a livable identity, ignorance is never simply ignorance, and knowing is not just a matter of information. In practice, understanding is always straddling the known and the unknown in a subtle dance of the self. It is a delicate balance. Whoever we are, understanding in practice is the art of choosing what to know and what to ignore in order to proceed with our lives." (Wenger, 1998, p.41)

[9] Paechter (2000) argues that coursework acts as a disciplinary technology analogous to Foucault's (1977) panopticon. My argument in this section is similar: at least in mathematics, students and teachers internalise the requirements of the examination to such an extent that they end up functioning to police their own behaviour, that is they become self-disciplining, without the need for continuous assessment.

at the way these processes of producing comparisons were played out and encouraged in the classroom.

4.4.1.2 How do I measure up? Competition within the classroom

During the fifteen hours of lessons that I observed there were two short tests. These tests are clearly linked to improving student performance in the exam. However, the competitive element goes beyond this, as students are required to declare their marks in front of the rest of the class. Mrs. Sawyer also sustains competition between this group and her parallel first-year class, "my other set, my decision maths set, that you're in competition with." When several members of the group provide her with the correct answer to the product of $4x^3$ and $3x^2$ she praises them with the words "you've already beaten my other group." And while the students are working in silence on a test she describes the errors made by her other group as her reason for doing this test adding to me, but clearly audible to the whole group, "I just wanted to see if this lot could beat them." Black & Wiliam (1998, p.6) in their review of research on assessment identify two negative impacts on learners of practices such as these:

- The giving of marks and the grading functions are over-emphasised, while the giving of useful advice and the learning function are underemphasized.
- Use of approaches in which pupils are compared with one another, the prime purpose of which appears to them to be competition rather than personal improvement. In consequence, assessment feedback teaches pupils with low attainments that they lack 'ability', so they are de-motivated, believing that they are not able to learn.

Mrs. Sawyer emphasises not only differences between her groups but also differences within them. She draws on two discourses to explain these differences: 'lack of preparation' is used to explain how some are doing less well, and 'natural ability' is used to explain how some are doing better. Although not explicitly invoked to explain failure, the use of a discourse of 'natural ability' to explain success necessarily carries with it the implication that lack of 'natural ability' contributes to lack of success. Yasser is an example of how these positions are lived:

> *Yasser is referred to by his teacher as "naturally able" and is clearly marked out as different. He is sometimes given different work to do and on one occasion is asked to teach the class his method for tackling quadratic inequalities. At first he tries to explain his solution verbally, but this proves difficult so he suggests, "shall I write it?" Mrs. Sawyer responds, "please do." When Yasser writes up his solution there are many looks from students that combine amusement and bemusement. Imran declares "that is so complicated, I've never seen that in my life!" Next to him AJ has his hand up, while Saeed says to his teacher "he's clever isn't he?" then adding "he should do further maths." She agrees with him, "he should but he's busy doing other things." Saeed asks her "why don't you encourage him to do further*

maths?" She responds, "I've tried, it's his choice." Yasser has now completed writing up not just his original solution but also the graph that Mrs. Sawyer asked him to do when his first approach appeared obscure. AJ asks, "What is that?" and then repeats the question. Sanjay has a furrowed brow and his hand up. Then Mrs. Sawyer steps in and goes up to the board and explains the graphical method while leaving up Yasser's work because "it is worthy of honour." She further suggests that you could make sense of his diagram by putting numbers in "but you've done it theoretically like a good pure mathematician."

Yasser is constructed here as a mathematician. However, the manner of this construction as an esoteric being, a curiosity, "the spectre of mathematical 'genius'" (Bartholomew, 2000, p.4), as **Other**, makes it more difficult for the rest of the group to share this position[10]. This raises the question of what positions are available to them.

4.4.1.3 Becoming a mathematician?

I have argued above that Mrs. Sawyer's classroom, in common with many mathematics classrooms, is one where the motivational practices promoted are not the intrinsic ones of pursuing a challenge or a 'quest for understanding' or of gaining enjoyment from it. The absence of these practices makes subject positions as a mathematician less available to learners. Instead learners become rule-followers, good or bad students, 'naturally able', bottom or top of the class, among other things, and, above all, exam-passers (or exam-failers). This latter goal is officially about progression through the educational system and building a career. However, for students, exams are not just to get jobs; they have a powerful impact on their self-image. That this is not recognised within classroom discourses creates conflicts for learners, particularly those who previously saw themselves as enjoying mathematics, who often come to see the mathematics that is on offer as incompatible with their identity work:

> Where there is no cultural identity encompassing the activity in which newcomers participate and no field of mature practice for what is being learned, exchange value replaces the use value of increasing participation. The commoditization of learning engenders a fundamental contradiction between

[10] There is a fascinating connection here with a passage in the biography of the mathematician John Nash. During the 1970s students of mathematics or physics at Princeton would discover "'a very peculiar, thin, silent man walking the halls, night and day,' 'with sunken eyes and a sad, immobile face.' On rare occasions, they might catch a glimpse of the wraith-usually clad in khaki pants, plaid shirt, and bright red high-top Keds-painting painstakingly on one of the numerous blackboards that lined the subterranean corridors...More often, students would emerge from an 8:00 A.M. lecture to find an enigmatic epistle written the night before: 'Mao Tse-Tung's Bar Mitzvah was 13 years, 13 months and 13 days after Brezhnev's circumcision,' for example...Or a letter from Nikita Krushchev to Moses with arcane mathematical statements...Eventually, some sophomore or junior would clue in the newcomer that the author of the messages, aka the Phantom, was a mathematical genius who had 'flipped' while giving a lecture; while trying to solve an impossibly difficult problem; after discovering that someone else had scooped him on a major result; or upon learning that his wife had fallen in love with a mathematical rival...Among the students, the Phantom was often held up as a cautionary figure: anybody who was too much of a grind or who lacked the social graces was warned that he or she was 'going to wind up like the Phantom.' Yet if a new student complained that having him around made him feel uncomfortable, he was immediately warned: 'He was a better mathematician than you'll ever be!'" (Nasar, 2001, p.332-333, footnotes omitted)

> the use and the exchange values of the outcomes of learning, which manifests itself in conflicts between learning to know and learning to display knowledge for evaluation. (Lave and Wenger, 1991, p. 112)

In the next section I explore how the discourses about examinations and mathematicians within the Westerburg further mathematics classes hold out different possibilities for identifications for those who operate in them.

4.4.2 Alan Rudolff and Jason Dean's further mathematics class

The further mathematics students spend ten hours each week having lessons together. The practice of teaching them mathematics, as well as further mathematics, as a separate group is part of the discourse of their difference from 'normal' mathematics students. However, the further mathematics teaching and learning practices have much in common with those described above. The teacher rehearses techniques at the board accompanied by questions to check understanding, then students work through similar exercises; regular homework is set and marked; and tests are used, for among other reasons, to assess progress and to motivate students. Both further mathematics teachers, Alan Rudolff and Jason Dean, frequently refer to the examinations and to the actions of examiners and I begin with this aspect of their practice.

4.4.2.1 The spectre of the examiner as a disciplinary presence in the classroom

In Mr. Rudolff's lessons, I observe two discussions on the decision mathematics examination answer booklets, one on why tippex is banned from exams, and lots of training on how to present answers clearly to the examiner and use the format of the question and the number of marks allocated in order to assess what is required. On more than one occasion he exhorts his students to "pity the poor examiner" who gets very little money in exchange for deciphering their work. Similarly, Mr. Dean emphasises the important goal of examination performance. For example, when discussing the merits of alternative methods he emphasises: "What I really care about is that when you're sat in the exam you do it [in] a way you're happy with and you get the right answer."

As in Mrs. Sawyer's group, students take up this concern about the requirements of the examination/examiner. These concerns surface particularly when they are tackling questions they find difficult. Students ask how many marks such questions would be worth and how long they would have to do them. However, there is an important difference from the attitudes in the other group. These students do not abandon questions that go beyond the examination's requirements. This suggests that alternatives to becoming exam passers are available to learners. Below I consider what alternatives are supported by their classroom practices.

4.4.2.2 You're a further maths group so...

Mr. Dean teaches the group pure mathematics. It is his first year at Westerburg and his first time teaching further mathematics. He thinks the group is different and makes this apparent to the class. After three weeks he tells them they are already over two weeks ahead of a normal mathematics group, and he often begins a phrase with the words "you're a further maths group so..." These comparisons with normal mathematics students are related to the easy/hard opposition.

For example, when the group are tackling integrals involving trigonometric substitutions Mr. Dean says, "you're a further maths lot so you should be able to do this sort of question." He then recalls giving this question to one group three times and they still could not do it. Graham asks if they were a further mathematics group. And when Mr. Dean says that they were not.

Graham responds, "so there is some hope for us".

In another case Mr. Dean relates this to the unequally valued terms of the theory/practice opposition explaining to the group that, "again we're doing all the theory. You won't actually be asked in the exam but we should, as a further mathematics group, know where it all comes from and why it works."

Another way that Mr. Dean inscribes the group's difference relates to how he likes to work through material in the correct order and seems disturbed when his plans to do this are disrupted. Sometimes, as when Peter supplies a full solution of an equation rather than just the next step, Mr. Dean re-imposes staged progress. He goes back a step and says, "I'll do that in a minute, you've got a bit ahead of me." Sometimes, as in the incident that follows, he lets go of ordered progress:

> *When Mr. Dean is detailing the three possibilities for the discriminant of a quadratic, Gary asks what the zero case looks like graphically. First, Mr. Dean explains they are doing this later. But, after a pause, he asks: "What do you think?" Gary suggests a straight line, then Ahmed indicates a parabolic shape with his hands and says it will "be on the x-axis." Mr. Dean works through all three cases graphically. He expresses anxiety at having deviated from his plan: "I'm a bit worried that we've done it all at once. I was going to stop and let you do a few questions after the formula bit." He asks: "shall we stop where we are at the minute and go back to the graphs later?" The consensus is clearly in the negative, student responses include "let's just get it done now" and "we're on a roll!" Mr. Dean asks: "is there anyone who doesn't want to carry on now?" He tells them that there is nothing wrong with admitting this and, on the contrary, it is a sign that you are "mature enough to admit it." They carry on when there is a silent response to this.*

Seeing his concerns, I ask Jason about this lesson. He tells me that this was the lesson when he realised the difference between a further and a 'normal' mathematics group. I ask him if he would teach this topic differently to another group. He explains he would, going slower

and perhaps use the computer.[11] His understanding of further mathematics students as different enables him to teach them less hierarchically and prescriptively but also prevents him from considering shifting the ways that he teaches other people mathematics.

In addition to comparisons with other groups, tests, evaluation and individual comparisons are also classroom motivational practices. For example, when Mr. Dean returns their first test he tells them that four of the scripts are good and the others need work. Then, while going through specific questions, he provides information on how many people within the group succeeded at each. Another form of competition is embedded in his use of challenges. Jason tells me they are becoming a further mathematics group because they "want challenges." He regularly describes questions as "challenging" or asks the group to "test" some equations for him. Competition here is first against mathematics itself and second against others in the group. Challenges also play a role in Mr. Rudolff's interactions with students. However, he links these rhetorically to their being not further mathematics students but mathematicians.

4.4.2.3 Becoming a mathematician

Mr. Rudolff stresses problem-solving and beauty as aims. He praises solutions that are "beautiful" and sets worksheets where "the idea is not to find the answer to the problem, it's to find a method to the problem." He connects these to an identity as a mathematician. For example, he gives two reasons to care which graphs are planar. Mathematicians care because there is a problem/puzzle and so they want to solve it, whether it is useful or not, and others care because of applications to microchip technology.

There are several classroom practices, in addition to his general problem-solving orientation, which are illuminated by reading Mr. Rudolff's classes as a mathematical apprenticeship. For example, he uses language like "theorem" and "conjecture" and material on the history of mathematics. He is also involved in coordinating the work of a group (consisting of Apu, Bart, Desmond, Graham, Jacob, Paul and Peter) for the Cambridge University *Motivate* scheme. Students have to use mathematics to tackle problems and then present their solutions to Cambridge lecturers at a videoconference. In one lesson:

> *Mr. Rudolff gets the* Motivate *group to the front and sets questions for the other students. Mr. Rudolff talks to the group very publicly. He stands at the front and uses the board (why can't he sit with them?) He runs through the progress they have made for Wednesday's*

[11] That teachers of mathematics see different activities and approaches as appropriate for groups they believe to have different 'abilities' is evident in Houssart (2001) and Bartholomew's (2000) research on the effects of setting on mathematics teaching and learning in primary and secondary schooling respectively.

presentation and summarises this on the board. Graham and Jacob are writing a computer program. Mr. Rudolff records "constructed-demonstrate-results". He asks Graham if this program represents a mathematical or a computational achievement. Graham feels that it is both. Since the other two groups have made less progress he suggests that they combine and look at the diabetes issue and arranges times to meet with them. Bart wants advice. Mr. Rudolff reads from the sheet: "Find out as much as you can about Type I and Type II diabetes." He adds: "I wouldn't spend too long on that because it's not mathematical." He suggests they re-read the relevant talk and then he will help them.

Mr. Rudolff also tells students that mathematicians are "lazy," that they "like to find easy ways" to do things, and "that as a mathematician you're over the hill at 28."[12] Importantly: "good mathematicians tend to find frustrating" the need to show your 'method' and not just find the 'solution' and so they do not necessarily come top of the exam. Through this discourse intelligence is separated from exam success and is even constructed as a disadvantage in exams since "bright students are often impatient and just want to solve the problem," "you have to go out of your way to show that you have answered the question," and "this penalises the best students because they will go straight to the answer." Thus the alternative to exam-passing in this class is based on the idea that those who score highest in mathematics assessments are not synonymous with the best and the brightest mathematicians. The ways that this story is rooted in the Western construction of gender and rationality are traced in section 5.4.

In theorising identity in Chapter 3, I looked at the interplay between structure and agency, the social and the individual. Re-thinking the analyses above with this in mind, there are two necessary **corrections**:

- That people respond to discursive landscapes, situating themselves in relation to the dominant practices in contradictory ways, as often resistant as compliant.
- That social structures and wider power relations relate to classroom discourses, for not all positions are equally available to all people.

In the next section I aim to correct these omissions by looking at two specific examples of students' classroom practices.

[12] See Gray (1996) for a discussion of the misogyny embedded in such myths as mathematicians do their best work when they are young. An alternative view is expressed by one of the characters in DeLillo (1991, p.163-164): "You shouldn't be allowed to touch a mathematical text until you're seventeen or eighteen. Rudiments, yes, all right, certainly. Advanced work, not until you're older. You lack the broad-based education that produces a savage spark of intellect. Yes, all right, it's easy to cite Abel and Galois. Epochal work while still in their teens. But look how they ended. One destitute and tubercular, dead at twenty-six. The other shot to death at twenty, buried in a common grave."

4.5 Corrections: students finding places in classrooms

As well as finding a physical space-to-sit in a classroom, students have to find a space-to-be within its discursive landscape. As with seating arrangements students are restricted by the geography of the classroom, but do have some room to manoeuvre. Where they locate themselves is influenced by who they think they are, their previous experiences, and their friends' actions. They do not have to stay in the same place; although once patterns are set in the first few weeks, it becomes more difficult to move. The two brief examples below of students fitting into classrooms are a group of male Muslim further mathematics students and a group of female students subverting their teacher's aims for the lesson and instead pursuing a 'quest for understanding'.

4.5.1 The Brothers

In the first further mathematics class I observe, Mr. Dean sets the group a test. Initially I think that this will be an unpromising source of data then I notice that some students are communicating, breaking the classroom rules for tests. Mohammed looks furtively at Ahmed's, and occasionally Rachel's, work, unless Mr. Dean is occupied elsewhere when he talks directly to Ahmed. Mohammed signals this change by nudging him. This appears to be consensual and Ahmed's attitude contrasts with the severe look that Rachel gives Mohammed when he next sneaks a look at her work and after which he stops doing this. Bart and Ali are also consulting, and towards the end of the test they shift beyond the privacy of whispers to each other to talk more loudly and to those sitting behind them. After a minute or two Mr. Dean reprimands them. Ahmed, Ali, Bart and Mohammed are members of 'The Brothers', a self-named group of further mathematics students that also includes Ishmael and, after a few weeks, two new members of the class Apu and Khalid. They are all South Asian Muslims. Although the dominant practices in their mathematics classroom, and in Westerburg generally, are individualising, a collectivist spirit can be read in practices like their sharing of answers in the test. Further examples of collectivism are provided by how they will not be interviewed individually[13], how members of the Brothers usually work collaboratively with one or more other members of the group, and how, when Ishmael's name is called on the register, Ahmed answers for him even though he is in the room.

They also 'share' seats since, unlike other students, they do not have fixed seats but instead occupy a group of chairs, each of which can be used by any one of them. When

[13] I do not manage to interview the Brothers. Although eventually Ali negotiates a time with me on behalf of the group, they forget and by this point I am too near the end of my time at Westerburg to arrange an alternative.

Apu and Khalid join the class, this shared space expands and then splits into two smaller groups one on the right and one on the left of the horseshoe of chairs. They describe these, in the language of Ali G, as the "Eastside" and the "Westside". The two groups maintain a connection by talking across the room and also throwing paper balls at each other. Such behaviours get them into trouble with their teachers, as does the 'cheating' in tests, frequent lateness and the copying of homework. The group police their own boundaries. For example, when in one lesson Mohammed collaborates outside the group, with Desmond and Petros, Bart questions his behaviour: "why are you shouting all the way across the room [to Desmond] when you could be shouting to me?"

The Brothers' behaviour, in substituting an ethic of collaboration for one of competition, looks like student 'resistance' to, rather than 'compliance' with, the dominant classroom and institutional discourses. This is a description that also applies to my example in the next section, and this could be because such cases are more exciting to observe and to write about (Francis, 2000). However, I prefer to argue that this distinction between resistance and compliance is not helpful. Both elements are mixed in all our actions. A nice example of this is provided by the young British Muslim women interviewed by Dwyer (1998, p.57) who resist the "equation between 'rebelliousness' and 'English clothes'" suggesting not only "how false assumptions about your behaviour were assumed from your dress but also...the ways in which dress could function as a 'cover-up'". So "the most contested item of 'appropriate' Muslim dress, the headscarf", or hijab, can be used by the wearer to position herself above suspicion and so conceal her relationships with boys. This possibility, "that dress styles can be used 'strategically' within certain places in order to escape parental approbation or to safely negotiate particular spaces", emphasises the way that actions are always improvised reactions and responses to the contexts in which they arise, they are what Franzen (2001) metaphorically refers to as "corrections" in his novel. Relatedly, the boys in Willis' (1977) study, through their resistance to schooling, reproduce their class position and so are compliant in terms of the wider socio-economic system. While their actions make them feel powerful, social power resides elsewhere.

The actions of the Brothers provide many examples of the ways both that resistance and compliance are a function of the discourse through which an act is read and not of the act itself, and that students are continually negotiating the way that others see them in and through their actions. Their behaviour in the next incident can be read as either compliance to religious rules and to the peer group or as resistance to college rules and to the teacher's authority:

On my first Friday in Westerburg I meet Ishmael, Mohammed and Ahmed in the corridor at lunchtime with two other Muslim boys and they tell me that they have to go to the mosque to pray, they seem anxious and stress that they had assumed that the Muslim society would organise something and that it will only be for one week. They ask me to tell Mr. Rudolff whose afternoon lesson they will miss. I promise to do this. When I do tell him he looks annoyed and says: "that's what they said last week." Later, at 14:00, they enter the class and Mr. Rudolff asks them lightly "So is it worth it?" But they have only come to collect the homework not to stay. Mr. Rudolff says abruptly that there is no homework so he will see them on Monday. Mohammed asks: "Is it OK? Did Miss talk to you?" Mr. Rudolff responds: "I won't say it's OK but Miss did talk to me." Mohammed's parting words are "I'll talk to you Monday."

Mr. Rudolff reads their act as disobedience and this is assisted by dominant discourses:

> For more than two decades, African-Caribbean boys have been positioned as the main disciplinary problem (Gillborn 1995). They are currently being joined by Muslim boys as the new folk devils, with corresponding negative categorization, stereotyping and moral evaluation. (Mac an Ghaill, 1999, p.76)

Being Muslim is very important to the group's identity work. The second day of my observations at Westerburg was September 11th, 2001, and the Brothers often discussed these events and their aftermath. It is not easy to incorporate Muslims within the categories of the dominant black and white understanding of racial difference in the UK (Mac an Ghaill, 1999; Modood, 1992)[14]. In addition to this there is a huge variation in the approaches and characters of the different members of the Brothers. However, it is clear that the Brothers' ethnicity, along with their gender, is a central factor in how they fit into the discursive landscape of the further mathematics class.

4.5.2 The 'quest for understanding' in action

This section focuses on one lesson I observed in Sunnydale, but I start with a short incident from Westerburg. In section 4.4.1, I argued that in Veronica Sawyer's class the examination provides the dominant meaning of understanding, and that external authorisation replaces internally authorised sense-making. However, students do not passively accept this substitution as this next incident, which happens immediately after my interview with AJ, Maryam and Imran, demonstrates:

Mrs. Sawyer has been asked to go through the homework and says she will but that she will also "try not to give the whole game away." She solves the first two parts and then leaves the group to find C, the constant term. Maryam asks about the possibility of a missing constant term and what would happen if it were negative. Mrs. Sawyer clarifies that in the first case the constant term is zero while the second case is "the same" as the one they are doing (it is

[14] This is apparent when Mohammed explains his theory concerning race/ethnicity and seating in the group. In mapping race/ethnicity and space he classifies Will as white (Paul challenges this and Will explains that he is mixed heritage, Indian and English), Petros as white because he is European, and Saldon (who is Bangladeshi) as "a discrepancy."

evident that it is not "the same" for Maryam). When the students still look doubtful, Mrs. Sawyer adds: "use your commonsense" and "use the answers at the back of the book." Mrs. Sawyer then asks Imran if he's OK. He says "yes." Then, after a few seconds pause, he adds "no actually, I'm not, I'm going to be a bit brave here, what's going on with C?" Robert asks the same question. Mrs. Sawyer responds with "these two want me to do the homework for them!" There is some chatting and giggling from AJ, Maryam and Imran. Mrs. Sawyer picks up on this and explains firmly that she doesn't think it's a good idea for AJ and Imran to sit together. Robert asks if "it's like completing the square at the end" and Mrs. Sawyer sounds frustrated at this point when she says "you don't have to do anything difficult at the end, you've done completing the square already." She turns to Imran and AJ who are chatting, and tells them "grow up, you're in big school." However, she immediately apologises for her sarcasm since a teacher should never be sarcastic. She recovers her teaching manner but does not finish the example.

There is a power struggle going on here between the teacher and the students. Ultimately it is the teacher who gets her way, by positioning her challengers as 'naughty' and positioning herself as an understanding teacher by apologising for her momentary lapse into sarcasm. I now turn to a similar power struggle that happened at Sunnydale.

The main A-level teacher at Sunnydale is Alex Harris. His lessons are dominated by teacher exposition but usually include some individual work on exercises. During teacher exposition students may be listening and taking notes, continuing with the exercises, or discussing amongst themselves what their teacher is doing. I often find Alex's lessons lethargic and my field notes contain comments like "it is hard to explain why but it feels like people aren't completely focused on what Alex is doing" and "there is a distracted feel and people softly communicate with others". The lesson I focus on below is one where Alex, realising that he is behind with the syllabus, has decided to step up the pace. His intention is subverted. There are five girls and fourteen boys in the lesson, but it is the girls who manage this process of subversion. It is their agenda, their 'quest for understanding' (Boaler, 1997), and not the teacher's objective to get through the syllabus, that controls the direction of the lesson. Normally in this group more boys than girls interact with the teacher. Here the pattern is reversed and the deluge of questions includes only one from a boy.

Alex announces his intention to tackle indices and surds but, before he can, Avnee asks him to go over polynomial division, from a previous lesson. Alex asks if any other students have a problem with division. Presumably his intention is to isolate the problem, identify it as not needing attention in front of the class, and so return to his agenda. Actually the result is to delay things further because Alex goes over to help some students in the back row. Although Alex, returning to the front of the class, points out that there is not enough time to deal with homework questions during lessons, and that this is what the drop-in sessions are for, he does go through polynomial division. It is 15:01 (sixteen minutes after the lesson's start), Alex is going through this and the class is attentive, when Avnee spots her error. Perhaps seeing a chance to get back on course, Alex asks: "should I stop now?" Avnee very stridently says "no!" Alex finishes and she says "thank you." Now Alex jumps straight into today's topic

with a fractional power of a fraction. At 15:10 Lucy asks: "can you remind me how to do a negative power?" Alex responds: "that's what I'm looking for an example of." Alex writes up 10^{-1} and 10^{-2} with answers. Julianne asks "why?" and "can you explain that again?" Avnee adds: "Is there a completely different way of doing it? I learnt a different way but I don't remember." Alex says "no, not really" and Julianne asserts, "I don't understand." Alex backtracks to whole number positive powers. However, when Lucy erroneously converts $4^3/4^5$ to 1^{-2} (because 4/4=1) Alex shifts back another step. At this point Julianne has stopped writing and is looking unhappy. Alex then deals with $(x^4)^{1/2}$ and then with this same expression with x replaced by 10. Julianne interjects: "I don't understand, why did you choose 10?" Alex explains: "I could have chosen any number but I just thought that powers of 10 would be something you were more familiar with." Julianne asks: "Is that how you do it then?" Alex continues jumping from one idea to another, finally covering the rules for multiplying and dividing expressions involving indices. It is now 15:25 and William asks: "What if the powers are equal and the bases are different?" Alex deals with this. Then the questions from Lucy, Avnee and Julianne continue for a further ten minutes. Alex sets work for the group at 15:35, Julianne puts her hand up and he goes straight over to her to help.

This is a more successful attempt by students to define the course of the lesson than the first example, and perhaps it is the combination of the fast pace with Alex's laidback teaching style that makes this kind of agenda capture possible. However, it is also down to Lucy, Avnee and Julianne's actions. Their improvised acts are **corrections** that, as is always the case, exceed the conditions of their possibility. It is in that psychic excess that agency, as conceptualised in section 3.7, resides.

4.6 Conclusions

In this chapter I have described the spaces in which I collected my data, in such a way as to introduce key themes and arguments. I develop these in the next three chapters, which are structured around the interview-based student narratives. Thus I am concluding by connecting the work I have done in this chapter with that which I do in the chapters that follow.

- In this chapter, I have demonstrated that different institutions, and different classes within the same institutions, produce environments within which there are different possibilities for students' educational aspirations, attainments, confidences and opportunities (see also Roker, 1993). In the chapters that follow, I explore the ways these environments, together with other spaces such as those of home and family and the media, construct/are constructed by the students in their talk.
- In this chapter, I have argued that the identifications of students with mathematics are centrally related to the discourses to which they have access about what mathematics is and about what it means to be a mathematician. Here I looked only at examples of classroom meanings of mathematics and mathematicians. In the chapters that follow, I look at other meanings, including those contained in

commonsense and in popular culture, and at the ways that students make sense of these.

- In this chapter, I have begun the process of looking at the ways that students negotiate other aspects of their identity in forming their relationship with mathematics through their taken-for-granted practices, and at the ways that this process re-produces social inequality. In the chapters that follow, I look at the ways students make sense of these negotiations and expand my sketchy treatment here of the impact of gender and race/ethnicity. My concern in the rest of the thesis is to analyse in detail the intersection of these factors with other dimensions, particularly class, dis/ability and hetero/sexuality.

Throughout this chapter, an implicit question has been how to enable teachers to work with students in mathematics classrooms in ways that promote social justice. The two examples of the Brothers and the 'quest for understanding' in action, suggest that students need to be heard. Thus some concept of student voice may be helpful within such a practice. Voice is a popular metaphor among educationalists concerned with gender and with youth issues (Hadfield & Haw, 2000), and one that underlies my treatment of the student narratives in Chapters 5, 6 and 7, and to which I return explicitly in Chapter 8. The student 'voices' in the rest of this thesis must be treated with care; they are ventriloquised through me and also tell of the conscious and unconscious work of the disciplinary technologies of the examination and of mathematics. Before moving onto the student stories, I would like to comment briefly on an absence from this chapter. Although I have made much of the interplay of structure and agency in the students' identity work, I have said little about how this applies to the identity work of the teachers. Without such an understanding the classroom portraits discussed could be read as an attempt to blame the teachers involved. This is not my intention. Rather, I think we need to look to the wider social discourses, for example, around performativity, to make sense of the practices in which teachers engage/that engage them. Many such discourses are discussed in this thesis although the emphasis, consonant with my research question, is on their impact on students not teachers.

Interlude

The next three chapters are devoted to using what my participants told me in order to address the central question of this thesis about why the choice to study mathematics is gendered. In the search for patterns in my data I grouped the 43 students by their main reason for choosing mathematics.

Table 5: How it is that people come to choose mathematics?

For chosen career and for enjoyment			**For enjoyment**		
Ashley	Hina	*Jonathan*	**Rachel**	*Yasser*	*Graham*
Nazima	Ling	*Kanton*	**Nefertiti**	*Salvador*	*Desmond*
	Priya	*Matthew*	**Analia**	*Darren*	*Peter*
		Vijay	**Natasha**	*Deji*	*Saldon*
			Maryam	*Sam*	*Phil*
					Kiriakos
For chosen career and NOT for enjoyment					
Vicky	Mei Jin	*Imran*			
	Niamh				
To prove something to others			**To prove something to themselves**		
Mika	*James*	*AJ*	Julie		
Toni	*Jean*		Lucy		
	Lee		**Claudia**		
	Michael				
	Simon				
		Unclear			
		Melanie	*Jingki*		
			Kenjin		

The unmarked, plain text, names belong to working-class women, while italicised names belong to boys and bold names to members of the middle-class. I have used information on parental employment and educational background to make divisions into middle-class and working-class.

There are some overall patterns:

- There are more middle-class students (86%, 18/21) than working-class students (36%, 8/22) in the top row of the table, which is occupied by those who chose mathematics because they enjoy it.
- There are more girls (42%, 8/19) than boys (17%, 4/24) who chose mathematics because of specific career goals. However, male students dominate the employment-related category: 'to prove something to others' (see section 6.2).
- One group, 'to prove something to themselves', is entirely female (16%, 3/19).
- In the right-hand column of the group who enjoyed mathematics I have put those who evidenced the strongest identifications as mathematicians. This group is exclusively male (25%, 6/24).

Such patterns are fascinating and I could go on now to offer 'representative' quotes from each group. However:

- Such generalisations tend to obscure the variations of gender and class within the groups and the ways that there are no simple relationships between someone's demographic profile and their identification with mathematics.
- Classifications were not easy to craft and I had to make decisions about which factor I felt emerged most strongly from their interview. So students in the same section of the table may tell very different stories.
- While divisions into male or female are relatively straightforward, divisions into working or middle-class are much less so. Additionally, as work on educational pathways shows (Brooks, forthcoming-b; Walkerdine et al., 2001), there is huge within-classes variation.
- Many important elements, notably family, friends and teachers, are absent from the table. These featured in most interviews but were rarely given as the explicit and never, in my readings, as the main reason for a student's choice of mathematics (although Rachel, discussed in section 5.3.2, gets closest to doing this).

These points, together with those discussed in section 2.4.2, raise questions about what is lost in an analysis based on coding data in this way. This is a method that exists because of "the dominance of a quantitative tradition which has little compunction about reducing complexity to single scores" (Hollway & Jefferson, 2000, p.109).

The purpose of the next three chapters is to increase complexity, to open out some of these groupings, to look for differences as well as similarities within them, and to do this by using the context that this table disappears. In doing this, I use detailed stories of eight

of the boys and six of the girls and draw on the stories of many others. I have decided not to explore in detail those young people who chose mathematics mainly because of their desire to follow particular career paths (ranging across accountancy, architecture, computer science, forensic science, medicine, and primary school teaching).

- Chapter 5 starts from differences within the group who chose mathematics **for enjoyment**, exploring differences and similarities between those who identify as 'good at maths' and those who do not and between those who identify as mathematicians and those who do not.
- Chapter 6 looks at two groups: those who chose mathematics **to prove something to others** and those who chose it **to prove something to themselves**. The starting point is the male dominance of the former group and the female dominance of the latter group.
- Chapter 7 explores the theme of mathematical pleasures and uses three stories drawn from the group of those who chose mathematics **for enjoyment** and one from the group who are doing mathematics **for chosen career and for enjoyment**.

Chapter 5 A Beautiful Myth? The gendering of being/doing 'good at maths'

5.1 Introduction

Peter: Well, I chose double maths and computing because I want to be a computer programmer. And because maths is what computers do, it's all they really do. And it's just, so maths is really, and I'm quite good at maths, so. And computing, obviously, 'cos I want to be a computer programmer. And I did physics because I need another subject and I'm really good at physics, so it's what I did.

Saldon: What I found most interesting though was when we had to do investigations or courseworks. Those were the things I really liked because then it was my own work, and I could work it out myself. That's the main part I like about maths is I can work it out and figure it and it's like a challenge for me to do. I'm very good at investigations 'cos I can sort of imagine the shapes or the puzzles in my head and then see what will fit in well.

These statements are taken from the transcripts of two interviews with Westerburg further mathematics students. They are interesting for many reasons, but above all because they contain rare examples of students identifying as 'good at maths'. Out of the 43 advanced mathematics students I interviewed about their experiences of learning mathematics only five located themselves in this way (although more spoke about idyllic past times when they **were** 'good at maths', about being good at **other things**, or about **other people** being 'good at maths' in a generic or a specific sense). As someone who, although well-qualified mathematically, has always felt embarrassed admitting this in public, I am jealous of these few students' apparent ease at describing themselves as 'good at maths' and so, given the social stories that attach to the subject, as de facto clever.

In this chapter I explore what makes it possible for someone to occupy a position as 'good at maths' and what are the effects of this, starting by re-telling the stories the students told me and then by theorising the work done in these stories. In telling tales of student choices, I am interested in the ways they locate themselves within discourses of difference or sameness between maths and non-maths people and practices, and the connections between these and their identification as 'good at maths' or 'not good at maths'. I am not interested in whether any of their claims to possess or not possess 'mathematical ability', whatever that may be, are right. I do not think that this question is answerable, and luckily also find it neither interesting nor relevant to understanding either success/failure within the subject or enjoyment/hatred of it. My starting point, of course, is that such things are socially constructed. However, as Rose (1999a, p.x) points out:

> The language of social construction is actually rather weak. It is not very enlightening to be told repeatedly that something claimed as 'objective' is in fact 'socially constructed'. Objects of thought are constructed in thought: what else could they be? So the interesting questions concern the ways in which they are constructed.

Thus in this chapter I explore the questions:

- How do young people position themselves-as 'good at maths'/'not good at maths'-within their talk?
- What are the discourses they draw on to do this and that make these positions possible?

However, these questions give a one-sided impression of young people engaged in a pick-and-mix construction-of-self.

> Whereas postmodernist theories imply that there can be a voluntary free fall through the social positions that are available to people to inhabit, this study demonstrates how restriction on access is central to subjective constructions. (Skeggs, 1997, p.12)

In particular, I argue that the socio-cultural constitution of gender as oppositional, and the connection of this to the series of binary relations through which mathematics is constructed, makes it more difficult for girls and women to identify as 'good at maths'. This can be used to understand the drop out of girls and women from mathematical fields of academia and employment in England, and internationally. As a result, I want to rewrite these questions as:

- How are young people positioned-as 'good at maths'/'not good at maths'-within their talk?
- What are the discourses that do this to them and that make these positionings possible?

These questions do not replace the earlier ones. All four remain active in a constant and, it is hoped, productive tension throughout this and subsequent chapters of the thesis.

I begin this chapter by looking in detail at the experiences of the further mathematics students since three of the five students who identified as 'good at maths' were in this group. Within this group this identification was clearly gendered since all three of these students were male and the two female further mathematics students did a great deal of work in their interviews to deny the possibility of their being thought 'mathematically able'. However, looking overall, the pattern was not oppositional since the overwhelming majority of both the girls and the boys whom I interviewed thought of themselves as 'not good at maths' and the other two students to identify as 'good at maths'

were a boy and a girl at Grafton[1]. However, the starkness of the contrast in the further mathematics group struck me as worth exploring and was the starting point for this chapter. After these stories I explore and question the socio-cultural context that makes these stories, with their oppositional discourses about mathematics, possible. I focus on the gendering of rationality within Western Enlightenment thinking and within contemporary popular culture. I argue that these discourses socially construct 'mathematical ability' as natural, individual and masculine, in such a way as to disappear that process of construction.

5.2 Doing 'good at maths'

The three students, Peter, Saldon and Graham, whose stories are explored in depth below set up differences between people who like/are good at maths and those who do not like/are not good at it[2]. In each case, I explore how this opposition works them/is worked by them through a series of related oppositions that parallel the discursive binary of masculine/feminine.

5.2.1 Peter's story

Peter is studying for AS-levels in double mathematics, physics and computing, as he puts it "very mathematical stuff." He wants to be a computer programmer and already knows a considerable amount about this from books and magazines. I got to know him better than the other Westerburg students because we chatted when I sat next to him during my initial two weeks of observations. He is white and his mother and father are a teacher and a surgeon respectively.

Peter's identification with mathematics is structured through his division of the world into "two different people. People that can do maths and people that can't do maths." In his discussion of what other people, not doing mathematics, think about the subject he explains: "People that can't do maths just don't, find it really boring and they don't enjoy it and they just don't really bother with it, because they don't like it much. And people that do do maths like it and they do it." He elaborates when I ask how he thinks people become one type or the other: "because they got, their mind works in a certain way or is ordered" so "to be creative, it's very difficult to be mathematical at the same time." He offers the example of writing poetry, "even when you read poetry you find some poetry is like quite mathematical and it's ordered...and some of it isn't, and it's much more

[1] They are Julie, whose story I tell in section 6.3.1, and Salvador who enjoys mathematics and is aware that he is good at it but whose passion is politics.
[2] The conflation of enjoying something and being good at something in mathematics happened often in the interviews.

emotional. And I obviously prefer the emotional one 'cos that's the point of poetry." The possibility that order can express emotion and creativity is precluded here and the two domains, of ordered activities and of creative ones, are constituted as mutually exclusive. When I ask whether mathematics can be creative, Peter develops his argument to incorporate the idea of mathematical activity as governed by rigid, unambiguous rules, "all very strict and defined...and to be creative you follow, you just look at different rules." Even when mathematicians "find a creative solution...they're still looking at all different things that have happened in the past and following the rules still. When in English it's not like that at all. It's really working with things, there's rules, but there aren't really any proper [rules], none of them are rigid." He sums things up thus: "They always say the best artists are, they learn rules and break them, and that's true. There aren't so many rules in English. And they aren't rigid." In these sections Peter is drawing on the oppositions:

MATHS PEOPLE/NON-MATHS PEOPLE

ORDERED AND RULE BASED/CREATIVE AND EMOTIONAL

MATHEMATICS/ENGLISH AND ART

Peter sees mathematicians as different from other people but equal with them and positions himself within this group. This is enabled via his identification as dyslexic and the way that this facilitates his location within a series of oppositions:

FAST/SLOW

COMPETITIVE/COLLABORATIVE

LEARNING BY ROTE/LEARNING HOW THINGS WORK

Peter was diagnosed as dyslexic "I think when I was about eight or nine...What happened was my school, I went to special needs at my school, and they said 'no, you're not dyslexic,' I was like, because I was at the bottom of everything, I literally, I didn't finish any work for a year and...I was doing really badly, and they said 'no you're not dyslexic.'" This provoked some scepticism "because obviously I'm quite articulate...but I was doing at the bottom of everything." After a year in special needs "my mum took me out of school for a day...to the Dyslexic Institute and paid, like, five hundred quid for a test or something, and they said 'yes, he's dyslexic,' like after five minutes! So, I went to the Dyslexic Institute once a week and I went to a tutor and I just spent a lot of time just getting over it. So now, like my spelling is almost as good as most people's." This identification as dyslexic is central to how Peter constructs himself. As Cline & Reason (1993, p.30) point out, it is classed, for dyslexia is unique within special education since "it offers additional and targeted help without carrying a significant social stigma" and so is acceptable to middle-class parents. Since dyslexia is defined by the exclusion of other disabilities, socio-economic and cultural

'disadvantage', and 'inadequate' teaching, it is mainly those from 'good' homes and 'good' schools who get so labelled.

Peter tells me that his dyslexia affects the ways that he learns best, although "it's not that different to normal people, I guess. 'Cos obviously I don't have much comparison. But it does take me longer to learn something and it takes me longer to get good at something." This has implications for mathematics because "a lot of the things in maths...you learn a sequence. And I'm really bad at learning sequences...and it takes me a long time...to learn a sequence. So usually what I just do is I don't learn the sequence I learn [where] it came from and then in the exam I can work it out as I go along. And it just, it works out quicker." Since Peter works slowly he finds doing repetitive exercises "a waste" and "annoying." They are time-consuming and he finds that he gets the idea after a few questions. However, he is aware that rapidity is normally associated with 'mathematical ability'. At the start of the interview Peter describes a typical GCSE mathematics lesson: "And there were about two people that were always ahead. Always, always ahead because they were really quick and, so most of the time, I was a little bit behind because I'm dyslexic and it takes me longer to do stuff." But the exams were another story and "I was always like either ahead of them or even with them." Here Peter has no problem in asserting that he is better at mathematics than those who raced ahead in class. His dyslexia enables him to reverse the usual associations of speed and 'mathematical ability' and to position himself as a mathematician despite his slow pace. Related to this are his feelings about competitive as against collaborative activities. He feels that mathematics is often taught competitively and he disliked this aspect of his GCSE class "continuously competing and always trying to get ahead of everyone." His dyslexia legitimated his opting out from this.

Peter also connects his mathematical likes and dislikes to his being dyslexic. He likes visual mathematics, such as graph work and algebra. He dislikes and has difficulties with "simple" mental arithmetic and singles out tables ("I learnt my fives but that was it"), factorising, and manipulating sequences of numbers as particularly problematic. So although he does worse than others at numerical problems again his dyslexia is read to mean that this is not a judgement on his 'mathematical ability'. His emphasis on the how of mathematics (mentioned earlier) is a case of making a virtue out of a necessity. He asks, at the end of his discussion of whether mathematics is about understanding why rules work, or simply learning rules, "but, I mean, why rules work is much more interesting, isn't it?" This allies him culturally with mathematicians. However, it is not just his dyslexia that enables his positioning as a mathematician despite his deficiencies at calculation. For:

> To be thought of as calculating is not complementary. Calculating is often what the other is: women; scheming; wheeling, and dealing bargainers. The refined mind reasons, but does not calculate. Indeed, witness the oft-told joke that mathematicians cannot add up. (Walkerdine, 1997b, p.57)

Here I am not suggesting that Peter is consciously aware of all these associations. However, I am arguing that his positioning is in part made possible by a socio-cultural slippage between the binaries:

REASON/CALCULATION

REASONABLE/CALCULATING

MASCULINE/FEMININE

I return to the gendering of reason in section 5.4.1. It is reliant upon the discursive construction of 'routine calculation' as inferior to and opposed to 'real understanding' and on a series of associated, unequally valued, oppositional binaries. In Saldon's story the rejection of routine repetitive calculation in favour of problem-solving takes on aspects of a quest as he uses/is used by the oppositions:

INDEPENDENT/DEPENDENT

ACTIVE/PASSIVE

5.2.2 Saldon's Story

Saldon is studying for AS-levels in biology, chemistry, mathematics and further mathematics. He is Bangladeshi and his mum is a primary schoolteacher and his dad an underground supervisor. He came to Westerburg because "it's quite a good school" that is "mainly for A-levels so I thought it would be more focused." Mathematics is his favourite subject and although "my parents obviously want me to [be a] doctor, so that's why I chose chemistry and biology" he has other ideas and thinks that medicine's "very competitive, and also it's very stressful and so I'm not sure if I actually want to do that." Instead he is thinking of "maybe going into either the IT area, or the financing area" or even, as he later reveals, into engineering. His choice of engineering is motivated by its problem-solving orientation, something that is also what he likes most about mathematics.

Saldon's active, independent, problem-solving approach (the mathematics education research literature would see him as having a constructivist epistemological position with respect to the subject, see Ernest, 1991; von Glaserfeld, 1995) is the basis for his identification as a mathematician. This is evident when he reminds me that his teacher, "Rudolff, he talked [about] how true mathematicians always look for problems in real life, and like to solve those problems...that's what mathematicians like to do, and that is what I agree with, that we like to look for real problems in real life and solve those ones."

Through the pronoun "we" he names himself as a mathematician. In this statement he also claims teacher validation for this identification and for his interpretation of mathematicians' activities. He tells me that his summer holiday reading has helped him to understand what mathematicians do: "what I noticed mainly was, um, they, mathematicians, have gone deeply into small details which I never knew existed. I mean, they've given names to like lots of different graphs, like surjective graphs, bijective graphs, and so on. And just because one might have two values for x, and they've given it a whole new name. That's what's quite surprising because they've gone into such detail and explained everything, every aspect in such detail." His use this time of third person rather than first person pronouns to refer to mathematicians suggests that he is in a process of becoming, reminiscent of the apprenticeships and 'legitimate peripheral participation' described by Lave & Wenger (1991).

What Saldon dislikes most about mathematics is working through a series of repetitive questions, and what he enjoys most is investigating as he explains in the quote at the start of this chapter, where he again emphasises doing things independently and learning actively. Regarding his independent approach, he explains that "I probably learn best...not when teachers tell me, but when I figure it out and if I get it wrong, then they tell me." He tends to work individually in class something that he connects to his constructivist position because he sees mathematics as "something that you think about." Whereas "in science there are some times when I do group work because sometimes it's not a matter of working it out, it's a matter of remembering or something you can't do, so sometimes yeah we tend to ask each other 'how this works' or 'do you remember how this is done?'"

His success in mathematics GCSE came when he took it independently in year 10. I ask, "So you didn't do the GCSE through the school? Why was that?"

"Mainly because I wanted to do it early," he pauses and continues, "yeah, and the thing about maths is that sometimes when they do the parts we have to do loads and loads of repetitive questions, that I tend not to do so well in because often I find, I often lose interest after a while, so the thing is with puzzles I'm doing it myself, I'm building it myself and so everything is new and different." He suggests that "maybe the school thought I wasn't ready for it and so I took it privately and got the A*." This speaks of a confidence in his 'ability' in the face of contrary assessments.

As with Peter, Saldon feels that his enjoyment of and success in mathematics make him different. Notably, he feels that his active approach makes him different from other people, because "most people might remember the text they saw in a book," but "what I

do is I have an active diagram of what it's like, in my head." Later he tells me that what other people, not doing mathematics, "don't like the most is the part where you actually have to think about it. They find that a lot of hard work. When you have to work out and actively think. They find that very tiring." So they "rely more on their natural talents, like most of them who don't like maths are extremely good at languages, like foreign languages, and English, and they're sort of like naturally good at that." He cites the example of a friend of his who "did alright in maths, he got A, which is quite good, but he didn't like it at all because he found it was too hard," he prefers languages. He is constructing this opposition as natural[3]. So mathematics and languages represent "two probably opposites." And science is related to mathematics because "they've got like algorithms, they depend on theories...you have problems...they're constantly changing and improving and that's what we're doing in maths, constantly like finding out new theories and new problems, and new ways to solve problems." In contrast, English "stays like more or less the same all the time," and "there hasn't been much change in English now, apart from in language, than it was, like a hundred years ago, whereas maths is constantly new." Here the static, passive picture of English is contrasted to the dynamic, active picture of mathematics. Mathematics is an active discipline and Saldon and other mathematicians are active disciples of it. Saldon is clear about which side he is on, being more comfortable with and better at, the precision of mathematics and its numbers than with the vagueness of English and its words. In this comment, about geography, he expresses some of his frustration when working with words: "I know the answer, but when I write it in and the teacher marks it, she says 'well you didn't actually put that sentence in or that', which I would have thought it naturally implies" however the teacher insists, "'you have to write that part in.' And so I kept losing marks like that, so I was never very good at that English part." So in constructing this opposition Saldon draws on several inter-related oppositions:

MATHEMATICS/ENGLISH

DYNAMIC/STATIC

NUMBERS/WORDS

When I ask Saldon about why boys and girls tend to choose different subjects, his discursive opposition of mathematics and English becomes explicitly gendered. He tells me that girls are better "at expressing themselves and tend to have more viewpoints." Whereas "boys are probably a bit more superficial about things. But that's about it. Erm, yeah I think, erm, boys also are probably more interested in challenges like a boy will probably be

[3] Although Saldon also explains that teachers, by saying that only students with an A* should consider taking further mathematics, give the impression that it is only for "professors and geniuses." This suggests that he sees a secondary role for social factors within the construction of mathematics as 'hard'.

like very interested, more interested in playing a sport like football or basketball, or probably doing something like chess or something, whatever, whereas girls will probably prefer talking and friendship and actually socialising." It is interesting to see how Saldon transforms boys' superficiality, with which the passage starts, into their more positive interest in challenges, by the end of the passage. Additionally Saldon reads masculinity both within the physical challenges of football and basketball and within the intellectual challenges of chess (the socio-cultural discourses that support this are discussed in section 5.4.3; see also the discussion of the ways that the further mathematics classroom practices connect challenge to competition in section 4.4.2.2).

To sum up, Saldon tells a similar story to Peter, drawing on the discourses of mathematicians as naturally different, of his independence and confidence in his talents in the face of others' disbelief, and of a dislike for routine and repetitive calculation in favour of investigational work and problem-solving. However, while Saldon and Peter both draw distinctions between mathematicians and non-mathematicians, they go to considerable pains to stress that these are complementary and equally valuable groups. Often students' stories of difference are imbued with unequal value judgements. Some attach associations of superiority and some of inferiority to being a mathematician. Graham does the former and, because he includes himself in this group, he does a lot of discursive work in order to avoid looking arrogant.

5.2.3 Graham's story

Graham, a white, middle-class young man, is studying for AS-levels in double mathematics, physics, computing, that is "maths, even more maths, further maths, physics, which is just another name for maths, and computing, which is just maths on computers," and psychology. When I ask Graham why he chose physics he tells me: "I'm good at physics, I was probably the best in the year at physics." He knows this because he got the highest test marks and his teacher "didn't really like physics and she always got me to like tell the whole class some new concept." Regarding computing he recounts, "I've been interested in computing since I was about ten or eleven, properly interested, not, I mean, most kids if they're given a computer will like computer games, but interested in mucking about with computers, without games." He then tells me how he did GCSE Information Technology outside school in eight months and got an A*. Psychology offers him a break from his other mathematically-oriented subjects and relates to the way "I usually find I can," he pauses and then continues, "see what people are thinking and why they're thinking, quite a lot. I can usually help my friends sort their lives out if they're, you know, if

they've got problems and stuff." This is an impressive range of skills to which he lays claim, but to claim 'mathematical ability' he has more to negotiate.

I tell him, "I want to know if you have any idea what people not doing maths think about maths and further maths."

He begins, "They think it's unenjoyable, sometimes. And sometimes I could have not chosen maths, I could have chosen biology, chemistry or anything I did well at...I usually find if someone doesn't work hard early on, then if they leave it too long without working then they find they're behind and then they think they're stupid, which gets into a kind of cycle." Although my question sets up a distinction between Graham, who is doing mathematics, and others, who are not, Graham's answer speaks of similarities between himself and those imagined others. Immediately after telling me that they do not enjoy maths, he imagines himself in their position. He then posits a psychological mechanism whereby early experiences of failure produce defences against the possibility of future failures. However, difference, in the sense of 'natural ability', is reintroduced when he concludes that: "depending on the ability of the student to start with, it will depend on how long they can leave it before they can sink or swim." This introduces the opposition:

NATURALLY ABLE/HARD WORKING

It is an opposition that is central to the discursive work that Graham does in the interview.

This interaction of 'hard work' and 'ability' in determining success is also evident in Graham's description of his GCSE mathematics experiences with which the interview begins. His group had four teachers. "The first teacher I had was pretty good, looking back on it" but "sometimes the class mucked about so I don't know, didn't get a vast amount of work done." This teacher left and their next "wasn't very good at all" because "the class didn't respect her, really and therefore not many people did much work." Once again Graham "must confess I didn't do much work during then." Their third teacher was "brilliant" and "she got the class under control" with her "dynamic kind of teaching," although she too left, this time a few weeks before their examinations. He summarises the situation: "we got through a lot of teachers...I think we had a bit of a reputation as being a pretty bad class." He continues that teachers found it "shocking" that a higher mathematics group did not behave because "they think intelligent people should, I dunno, want to work harder, which I think is quite illogical because how intelligent you are does not mean how hard you want to work. It's purely just how good you are." He ends by constructing two types of academic success: "there are going to be some people who are going to be less intelligent and got into the higher group by working hard...but there's always the people who just find maths easy and then didn't have to work hard to get into the higher group,

and never did work hard." 'Hard work' is the province of the "less intelligent" and opposed to 'effortless achievement'[4].

Throughout the interview Graham is positioning himself within the 'authentically intelligent' group he has marked out. For example, he chose to come to Westerburg for practical reasons of accessibility and because "they do have a grade limit to get in so I'd probably end up with...people with more of my kind of level." Then, when discussing what he likes about his pure mathematics teacher, he explains: "He'll go through loads of clever little shortcuts ... which reinforces your learning. But the problem is, I think, that if anyone couldn't, if anyone was less able, and they might not be able to cope and they would fall behind."

However, claiming 'authentic intelligence' means he must carefully negotiate the role of 'hard work' in his academic success, something he defines as necessary but that is always a threat to his performance of 'effortless achievement'. In the passages relating to the sequence of GCSE mathematics teachers, Graham repeatedly tells me that he did not do much work. I now look at the places where he says that he did work hard.

After telling me that he got the top A* GCSE grade, I suggest, "the end really helped, I guess, the last teacher."

"Yeah," Graham says and then qualifies this, "I probably could have done it without. I worked hard on my own I actually revised a fair bit, not, not a vast amount I suppose. I actually tried to understand the concepts in the lesson, so I found that if...I understood what was being said and understood it at the beginning of the lesson it was fine...I didn't work for the rest of the lesson, which really annoyed some teachers."

In asserting his independence from the teacher Graham concedes that he did work for his exam. He then immediately withdraws this since it threatens to align him with those he dismissed earlier as "less intelligent," only in the top set through 'hard work'. This illustrates his continual balancing act in which all admissions of effort are accompanied by evidence that this was not the norm. For example, "I actually finally worked in year 11 for my GCSEs to pull them up," and the shift from primary to secondary school was "about the first time in my life I actually tried hard," he pauses, "for a bit, even though to most people that's still mucking about."

Five further oppositions play their parts in establishing Graham as 'mathematically able' within the space of the interview:

[4] This phrase comes from Mac an Ghaill (1994). His work highlights that this position is associated with middle-class masculinity. Walkerdine (1998) also evidences these masculine associations. She details how boys' lack of effort was seen as signifying greater intelligence than girls' better, but more effortful, performances.

INDEPENDENT/DEPENDENT

FAST/SLOW

ACTIVE/PASSIVE

REASONING/CALCULATING

THINKING/WRITING

These are all present in his discussion of investigations: "I really still do love maths challenges or investigations because...most maths teachers, almost all of them, teach you, if you see what I mean. Whereas maths investigation, you're really left to yourself which is more of a challenge." He recalls how quickly he was able to complete a particular investigation: "I really enjoyed that one and I did it in a day, I think...I didn't write it up though. I'm quite lazy about writing it up. I enjoyed thinking about the problem. I'm quite good at seeing patterns in stuff. But the bad thing is I'm terrible at mental arithmetic. I was probably the worst in my class at mental arithmetic." Here the process of writing is constructed as peripheral to the mathematical thinking, which is essentially about spotting patterns and rising to challenges (however, see Morgan's (1998; 2001) work for evidence that writing is central to the process of doing mathematics and to the production of mathematical truth). Not writing up is linked here to his laziness and difficulties with mental computation. There are important distinctions inscribed in his talk about these. While he describes himself as "very, very lazy," he does not want a lazy mind and values a teaching style that "doesn't just let the brain get lazy and passive...it makes you actively involved in the lesson." Similarly when given an investigation he looked at "how visually it would fit together whereas some people just played round with actual numbers", the "just" in this sentence relegating numerical work to a secondary status.

Graham aligns himself with mathematics as a signifier of 'natural intelligence'. In addition to the oppositional constructions examined above, it is the socio-cultural myth of the 'mathematical genius' that underlies this identification. In the next section I explore the stories of those who deny being 'good at maths', despite their excellent results in the subject. In these stories this myth of 'genius' can have negative consequences, setting up a figure who defines what being 'good at maths' is but with whom identification is impossible.

5.3 Doing 'not good at maths'

This section draws on the stories of the remaining further mathematics interviewees: Ling, who was born in Macau and moved to Portugal when she was six and England only a year and a half before I met her, Rachel, Desmond and Darren, and

Yasser[5], who although not in this class is working through the further mathematics syllabus in his own time with the assistance of his teacher.

5.3.1 Yasser and Ling

That Yasser and Ling do not see being 'good at maths' as making you different is evident in their thoughts on other people's views of mathematics:

> *Ling: When I tell people that I do two maths, they say, they always say, 'then you must be very clever' or something. And so I think, um, they must think that to do two maths the people need to be very clever or intelligent, but that's not, I don't think that's the case.*

> *Yasser: They think that it's hard, and it's just for brainy people. That's what they think usually. However, it's not true. As our teacher always says, you need just to persevere and that's it. It doesn't need you to be really clever or whatever.*

However, while Yasser sees no essential differences between those who do mathematics and those who do not, and as a result seems to find being mathematically successful unproblematic and easy to incorporate into his identity, Ling's response is more complex. While Yasser jokes that perhaps the idea of mathematics being "hard" was started by some mathematics student wanting the kudos, Ling tells me that she does not know why they say that "and I feel a bit like embarrassed because I'm not, I'm not clever."

"Why are you not clever?" I immediately ask.

"I just don't feel I am," she replies, "they ask me some questions like, the, the tricky questions like, and I can't answer them."

I inquire as to whether she knows anyone who she thinks is clever and she tells me "I don't know anybody who says that they are clever themselves," but that there is one person "not in this maths, it was in the other school. So like he can solve all the problems, I don't know how but." Here Ling is projecting[6] onto her classmate the phantasy (see Chapter 3, footnote 12) 'mathematical genius'. The power of this phantasy helps us to understand the strength of another denial of her 'mathematical ability' that comes when I ask for her GCSE grade. She replies: "Um, A*. But erm that was the, a re-take, like, I took one in year 10 and I took one in year 11 as well." Here Ling finds a way of immediately denying that her top grade implies that she is '**really** good at maths'. The suggestion is clearly that being good would imply not having to retake the exam but getting an A* first time, although year 11 is the usual year in which to sit the GCSE and being selected to

[5] Yasser had covered much of the AS-level syllabus in Iraq, where he lived until he was fifteen. I argue in section 4.4.1.2 that he is constructed as different from the others in his group through classroom practices. However, in his interview he does not construct himself in this way.

[6] Projecting "involves feelings which cannot be tolerated being evoked in someone else, where their fate can be observed from a safer distance" (Segal, 2000, p.66).

enter for it a year early could be seen as evidence of her talent in the subject (especially considering that she had been in the country for only a few months at that point).[7] The reasons for this denial, and the gendered socio-cultural work that it does, are discussed in section 5.4.

5.3.2 Rachel

Rachel's denial of her own 'ability' is even stronger than Ling's. Early in the interview she identifies the private tuition she receives from Bradley, a friend of her father, as pivotal for her decision to continue with mathematics: "Bradley was really nice, just like finally realising that it [mathematics] actually made sense after all. 'Cos I came out of year 10 thinking 'yeah, at the end of year 11 I can give it up' and, um, hopefully I might even get a C and I was going to ask to do the intermediate paper, and then, and now I'm not just doing A-level, I'm doing two A-levels." So for Rachel mathematics is not independent of the teacher and this contrasts with the ways it is constructed by Graham and Saldon. She describes her lessons with Bradley as "where he sits down and very, very, very patiently, um, sits down and explains everything even though it must feel so much like pushing water uphill." Rachel constructs herself as a dependent learner; she clearly ascribes no brilliance or talent to herself. Both her 'ability' in and enjoyment of mathematics began with her tutoring by Bradley and there is the possibility that that is also where they will end. This makes them tentative and context dependent and introduces contradictions. For example, after protesting how vehemently she hates physics, she reflects: "If I'd had a teacher like Bradley for physics, I probably would have really enjoyed it and done it at A-level. But I didn't, so." This story of the teacher being intrinsic to her enjoyment and success in mathematics, since "I don't do anything myself,"[8] is very different from the versions of mathematics as person-independent drawn on by Graham, Saldon and to a lesser extent by Peter. Like Ling, Rachel explicitly denies a position as clever, this time when discussing possible careers. She tells me that her "dad thought I should do accountancy or law, but I haven't got, I'm not going to get the A-levels for law." First she explains that she is doing the wrong subjects "I'm doing English, but I think you need history and stuff for law," but then she adds, "I wouldn't like it anyway, because it's too difficult."

"What, what would make it difficult?" I ask.

"'Cos it is. All the people that I know that do law are really, really, really clever."

[7] It is interesting to contrast this with Saldon's reaction to his school's decision **not** to enter him for his GCSE in year 10. He simply enters privately, gets an A* and so proves them wrong (see section 5.2.2).

[8] My classroom observations confirm Rachel's assessment of herself. Often she would not even alert the teacher when she wanted help but just sit staring into space or fidgeting until he noticed her mathematical inactivity and came over.

"And," I pause and then pursue this, "so why aren't you really, really, really clever?"

"'Cos I'm not. I'm me."

"How do you know?"

"Because I just aren't," she insists.

Thus, regardless of however brilliant her academic results may be, Rachel will not be able to use them as evidence of her own intelligence since there are people out there who are "really, really, really clever" and "I'm me."

5.3.3 Darren and Desmond

Darren and Desmond complete the picture of the further mathematics respondents at Westerburg. Desmond identifies with a competitive, problem-solving mathematics: "I just like solving things. Like if no-one else can do it, it's even better. If no-one can do it and I can do it, that's the icing on the cake...So I push myself [on investigations] so that I could go a step further than other people to get the top grade, because investigations is intriguing. They're nice. That's what mathematicians really like, I think."

However, Darren, of the five male further mathematics interviewees, gets closest to a denial of his being 'good at maths'. After telling me that he got an A*, he continues: "I don't know how though. I see other people in my class and they are all so much better than me."

"They were better than you?" I ask.

"They seemed like they were better than me...They just seemed to get what they say before me."

"That's really interesting, so you thought they were all better than you?"

"It seems like it, yeah. 'Cos they just seemed to go 'oh yeah, got you'. And they asked them questions, and they know the answer."

Darren's interview contained many such ambiguous exchanges. On a first reading, this passage, like those I quoted from Ling and Rachel's interviews, seems haunted by the myth of 'mathematical genius'. However, his response here is inseparable from the context in which it occurs, as part of a joint interview with Desmond (the other students discussed so far in this chapter chose to be interviewed alone) and this exchange comes immediately after Desmond's discussion of how upset he was at not getting an A*. In addition Darren does not actually say that he thinks those other students who "seemed" better than he is actually are and perhaps the examination has led him to revise his earlier view of his and these other students' relative 'mathematical abilities'.

5.4 What makes this possible?

Central to the stories I have constructed here are the ways that the fragmented, contradictory and fluid identitifications of learners with mathematics are constituted through patterns of sameness and difference: the samenesses/differences between mathematics and **other** subjects, and between mathematicians and **other** people. Key features of this are the ways that students position themselves/are positioned within a series of inter-related binary oppositions. Collecting together all these oppositions produces the following list:

MATHS PEOPLE/NON-MATHS PEOPLE

MATHEMATICS AND SCIENCES/LANGUAGES AND ARTS

ORDERED AND RULE BASED/CREATIVE AND EMOTIONAL

NUMBERS/WORDS

THINKING/WRITING

FAST/SLOW

COMPETITIVE/COLLABORATIVE

INDEPENDENT/DEPENDENT

ACTIVE/PASSIVE

DYNAMIC/STATIC

NATURALLY ABLE/HARD WORKING

REAL UNDERSTANDING/ROTE LEARNING

REASON/CALCULATION

REASONABLE/CALCULATING

MASCULINE/FEMININE

REALLY GOOD AT MATHS/GOOD AT MATHS

This list is, of course, not exhaustive, and to it can be added the entries:

OBJECTIVE/SUBJECTIVE

HARD/SOFT

These two were discussed in Chapters 2 and 4 respectively. More will be added before the end of this chapter. However, the important things are that: in each pair the two terms are unequally valued, and the term with the higher value is associated with masculinity. The underlying logic of this Background (see section 2.6) means that new pairs are easy to incorporate into what is a mutually reinforcing system.

In section 3.5.1, I suggested that instead of asking 'Why do girls engage in specific practices?' the question be reversed to ask 'How do specific practices do girls?' (Flax, 2002) So in this section I interrogate the socio-cultural practices that make such imaginings a central feature of young people's relationships with mathematics. This is not a new approach. Walkerdine (1990) argued, before the 'reversal' in gendered patterns of mathematical attainment, that the issue was never about girls' and boys' 'real' performances but the stories we tell about them, the discourses in which they are inscribed and the positions these make available to learners. She warns us to "avoid getting caught in the empiricist trap in which we are led to attempt to prove the mathematical equivalence of girls" (p.135). In order to avoid this trap Chapter 4 looks at the classroom communities of which these students are part and now I move to the wider context in which they make meanings. Below I describe three clusters of socio-cultural stories. These tell of Enlightenment rationality, of socially incompetent mathematicians and of heroic mathematicians. I have selected these because they help to make sense of the patterns of discourses in the talk of the further mathematics students. They are stories that organise the student stories narrated above, stories that are a part of their conditions of possibility. I include more detail on the latter two clusters of stories because there is less existing literature that deals with them.

5.4.1 Unreasonable women

The binary oppositions that organise the stories in this chapter draw on the gendering of rationality and reason as masculine and irrationality and unreason as feminine. Feminist writers have traced the ways in which this truth has been produced through the history of Western Enlightenment thinking[9]. This work is fascinating and constraints of space allow me only to examine some indicative examples.

Lloyd's (1993), Fleener's (1999) and Oakley's (2000) analyses, focusing on the fields of philosophy, mathematics and science respectively, demonstrate science has from the first been imagined as a gendered project to know and conquer nature. For example:

> The intellectual virtues involved in being a good Baconian scientist are articulated in terms of the right male attitude to the feminine: chastity, respect and restraint. The good scientist is a gallant suitor. Nature is supposed to be treated with the respect appropriate to femininity overlaid with long-standing associations with mystery-an awe however which is strictly contained. (Lloyd, 1993, p.17)

[9] Gendered oppression is not the only one supported by Enlightenment thinking. For example, Gilroy's (1993; 2001) work traces how such knowledges have been implicated in colonialism and slavery.

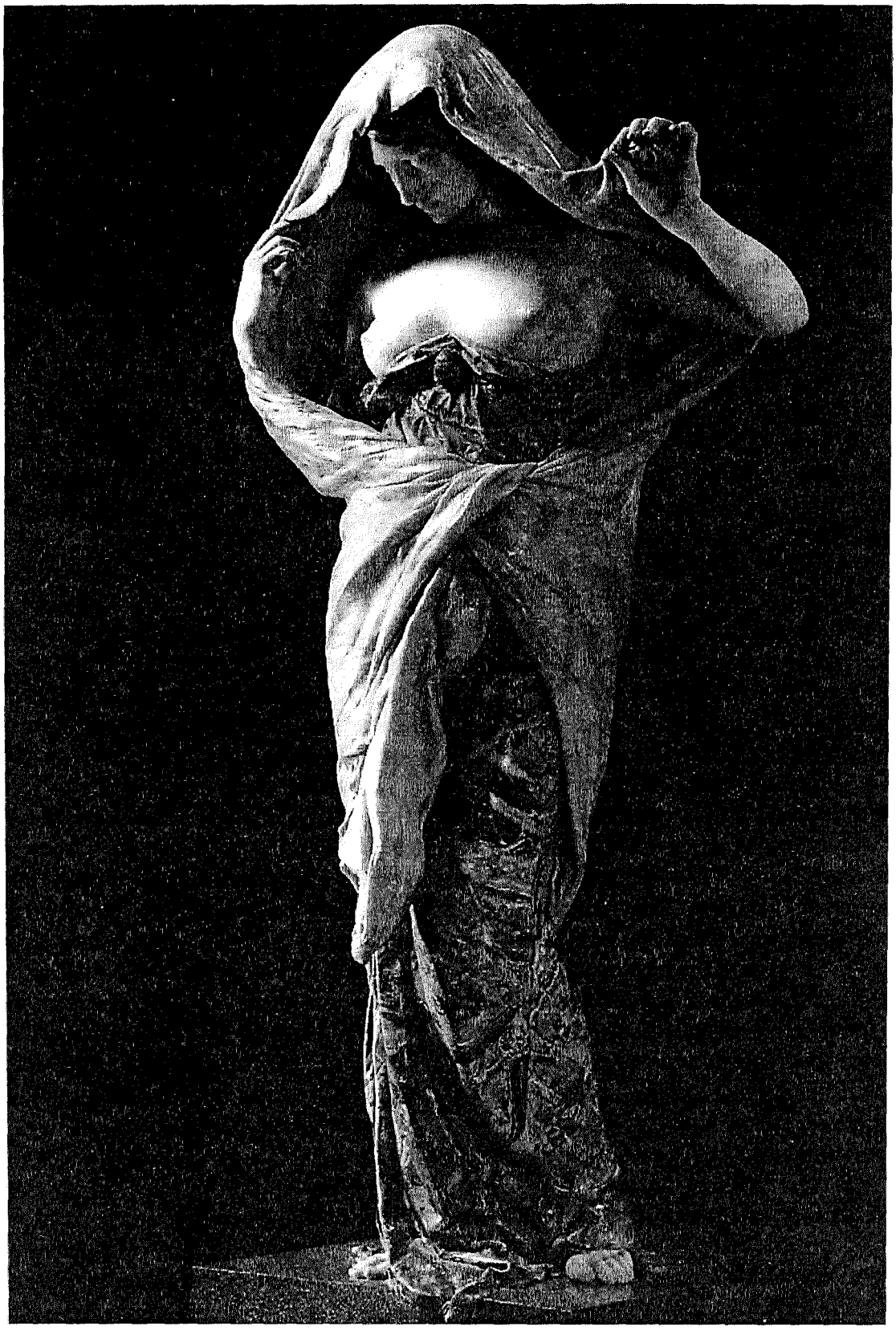


Figure 2: Nature unveiling herself before science (La Nature se dévoilant devant la science), 1899, by Louis Ernest Barrias.

This attitude is illustrated in the sculpture pictured in Figure 2 (reprinted from Oakley, 2000, p.98). So masculine reason's goal was to have control of and power over feminine nature, a goal perhaps prompted by a fear of the Other: chaos, disorder, women (see the discussion in section 3.4.2). Thus the pattern of oppositions in these examples runs:

SCIENCE/NATURE

ORDER/DISORDER

MASCULINE/FEMININE

The problem of women's closeness to nature is tackled in de Beauvoir's (1988) book, *The Second Sex*. She argues that this has resulted in women submitting to being the Other to men. The goal for both men and women is to move beyond their attachment to nature and the body to a state of infinite freedom of the will, or as she phrases it to move from immanence to transcendence. Lloyd (1993) describes how de Beauvoir's idea of transcendence derives from Sartre, and, before him, from Hegel. She argues that from these male perspectives it is the feminine and, above all, the female body that must be transcended. Hegel's transcendence "is a matter of breaking away from the nether world of women" and Sartre's "is associated with a repudiation of what is supposedly signified by the female body, the 'holes' and 'slime' which threaten to engulf free subjecthood" (p.101). That this heritage marks de Beauvoir's version is evident in her slips "into those disconcerting passages where it seems that women must struggle not only with their own bad faith and male power, but with their own bodies, if they are to achieve true selfhood and freedom".[10] So de Beauvoir's transcendence is a masculine ideal that "feeds on the exclusion of the feminine" through the oppositions:

MASCULINE/FEMININE

CULTURE/NATURE

MIND/BODY

TRANSCENDENCE/IMMANENCE

SELF/OTHER

Walkerdine's (1990) genealogy of reason supports Lloyd's arguments. She demonstrates that femininity is discursively produced "as antithetical to masculine rationality to such an extent that femininity is *equated* with poor performances, even when the girl or woman in question is performing well" (p.134, original emphasis). She demonstrates that the Enlightenment turned its scientific gaze on the human body and produced a 'truth' about women's nature as outside of rationality. Since the gendered body

[10] The critique of transcendence here is very similar to Braidotti's critique of objectivity as a flight from the feminine discussed in section 2.2.1.

was the basis for explaining the mind, gender is "internal to, and productive of, the means by which we understand reason" (p.68).[11] Women could fail to fit the stereotypes and could resist the power of the truth established by the dominant scientific discourses:

> But the necessity to struggle and the form that struggle took was completely bound up with determining that truth. And because the account was located in women's bodies, it immediately placed them as naturally external to a capacity for reason. It is important not to see this as a distortion or a simple mistake, but as a productive force which had effects. (p.68-9)

The result of this, "the way in which femininity is read as a constellation of signs that mark it off as antithetical to 'proper' performance to an incredible degree" (p.134), is not only evident in teachers', parents' and peers' constructions of young women's 'abilities'. It is clearer still in the ways that these young women write themselves, in Ling and Rachel's denials of intelligence; their denials derive their force from the strength of their investment in a femininity that is part of an oppositional gender regime.

5.4.2 Geeks and nerds

Certainly rationality is a powerful thing to which to lay claim in contemporary society and mathematics is an effective way of making such a claim. However, there is another side to the label 'mathematical ability'. Damarin (2000, p. 74) argues that although much of the gender and mathematics literature is "based on the reified idea that mathematical knowledge and skill is a sufficient condition for enhanced power and prestige within Western society...this is a minority view which is countered every day in the press and other media". So, while it might be expected that students who have chosen to do, not one, but two AS-levels in mathematics would all identify as 'good at maths', perhaps, given these negative connotations, it is not surprising that they do not.

These discourses are present in the interviews. For example, three students are discussing a group of boys in their class whom they label as both 'good at maths' and "nerds," when AJ asks: "Do you think socially they're lower?"

Maryam laughs and says, "yes."

AJ continues, "because...they're really fast in maths and everything, but they have no social skills whatsoever."

Imran agrees, "It's true. That's true."

[11] This perhaps explains why Thomas' (1990) review of the relevant empirical work revealed there to be no feminine discipline cluster. She concluded, while the arts are not perceived as masculine, that does not imply that they are seen to be practised by women but rather by 'effeminate' men: "The practice of discovering knowledge, of creating works of art, in short, of making the world we live in, is seen to be conducted entirely by men; masculine men or feminine men-but not women." (p.34).

"That's true, actually, I'd rather be like medium stage in maths, and have social skills. I wouldn't want to be like them," concludes Maryam (suggesting that one cannot be good at both mathematics and social skills).[12]

I now look at the gendering of rationality through this discourse of social deviance attached to being 'mathematically able' within popular culture. These analyses (and those in section 5.4.3) have been inspired by attitudes such as those expressed below:

> We practice culture criticism and feel the fun and excitement of learning in relation to living regular life, of using everything we already know to know more. (hooks, 1994, p.2)

> If media fictions are part and parcel of the living of life in the present, these need to be explored as one aspect in which the fictions and fantasies of the subject are constituted through, or in relation to, the regimes of deeply interdiscursive meaning through which subjects understand themselves and others. (Blackman & Walkerdine, 2001, p.196)

The dominant discourse around mathematicians in popular culture depicts them as boring, obsessed with the irrelevant, socially incompetent, male, and unsuccessfully heterosexual. In a typical example from the cult TV show *Buffy the Vampire Slayer* (Batali and DesHotel, 2002, p. 6*), Buffy, Xander and Willow are discussing how straight-laced is Giles, the librarian, and imagine him as a teenager. Xander comments: "Giles lived for school. He's still bitter that there were only twelve grades."

"He probably sat in math class thinking. 'There should be more math! This could be mathier'," adds Buffy. They complete the stereotype by asserting that even his diapers were tweed.[13]

Even in a 'quality' newspaper the two mathematicians who solved a puzzle, so earning a £1,000,000 prize, are described as posing "for pictures resplendent in patterned jumpers and sensible haircuts, seem[ing] to typify a certain academic type renowned-to put it diplomatically-more for their fluency with numbers than for their acquaintance with the cutting edge of dance music" (Burkeman, 2000).[14] Such figures are closely related to computer nerds or hackers who:

[12] See section 7.2.3 for the context of this passage.

[13] It is interesting that *Buffy* also disrupts the nerd stereotype. So, by the end of the episode quoted from here we find out that Giles' past was very un-tweed; between series one and four Willow grows out of her nerd status into an elegant, gay witch (with near apocalyptic consequences, interestingly discussed in: Battis, 2003); and the three male nerds who are the baddies of season 6 include one who is sexually attracted towards men.

[14] There are many other examples. Two of my favourites are the portrayal of the teachers and children at an elementary school for those with high IQs and of three college science students in *The Simpsons* episodes 'Bart the genius' and 'Homer goes to college' respectively (scripts and other information can be found in *The Simpsons Archive* at http://www.snpp.com). The opening line of the Radiohead hit *Karma Police* is also fascinating in this respect, "karma police arrest this man he talks in maths he buzzesLikeAfridge hes like a detuned radio (sic)" (taken from the album notes).

> Are invariably male, usually in their late adolescence or early adulthood, who are typically portrayed as social misfits and spectacularly physically unattractive: wearing thick, unflattering spectacles, overweight, pale, pimply skin, poor fashion sense. Their bodies are soft, not hard from too much physical inactivity and junk food...According to the mythology, computer nerds turned to computing as an obsession because of their lack of social graces and physical unattractiveness. Due to their isolation from the 'real' world they have become even more cut off from society. (Lupton, 1995, p.102)

Lupton (1995, p.103), echoing Damarin, points out the stark contrast between the body of the nerd and the "rationalized, contained body of the masculine cyborg".

This construction of bodies has effects on women learning mathematics. It is productive to understand these using Damarin's (2000, p.73) argument that 'mathematical ability' and 'femininity' are marked categories because members of these groups are: ridiculed and maligned, portrayed as incompetent when dealing with daily life, and "are feared as powerful even as they are marked as powerless". Additionally this marking forms the basis for community membership. Usually the unmarked category is in the majority but, if this is not the case, then "the marked category is not recognized as the major or majority category, but as a 'special interest group' or group whose 'membership' claims are suspect". Membership of a marked category is thus contradictory carrying both shame and safety, holding out the promise of both social exclusion from the mainstream and social inclusion within the group. She argues that, since being doubly/multiply marked "places individuals at the margins of each marked community of membership", it is more difficult for women to occupy a position as 'good at maths'. In Chapter 6, I develop a complementary argument that the conflict between mathematical performances, that are discursively inscribed as masculine, and bodies, that are discursively inscribed as feminine, creates particular problems for girls and women doing mathematics. My argument there, that doing mathematics is doing masculinity, can also be used to understand the ways that the nerd image affects boys something that is not discussed by Damarin.

In addition to the other-ing of mathematicians as nerds there is the other-ing of mathematicians through their idealisation as adventurers and as geniuses. These discourses are present in the student stories narrated earlier:

- Peter, Saldon and Graham identify with mathematicians as adventurers. Seeing both mathematicians and themselves as active, dynamic, problem solvers.
- Ling and Rachel fail to identify as mathematicians, even though they do not think you have to be different to do mathematics, because their idea of the intuitive, mathematical genius stops them from thinking of themselves as '**really** good at maths'.

I now move on to the popular cultural sources of these versions of mathematicians.

5.4.3 Heroes and madmen

'The mathematical genius' was at the centre of the recent films *A Beautiful Mind* (Goldsman, 2001), *Enigma* (Stoppard, 2001), *Good Will Hunting* (Affleck & Damon, 1997) and *Pi* (Aronofsky, 1998). Celluloid presentations of mathematicians largely avoid the 'fact' of the mathematics and bring the stereotypes discussed above into play in covert and overt ways. The plots of these films interweave conventional storylines, for example, of generational change, finding love and espionage and counter-espionage, with narratives that depend on mathematics. I focus here on two such narrative strands each of which is central to three of the films: tales telling of quests for rationality and those depicting the costs of that same rationality.

In *A Beautiful Mind* and *Enigma*, the love stories are central. In both films the main characters start with the social unease of the nerd and end as heterosexual heroes. In *A Beautiful Mind*, based loosely on Nasar's (2001) biography of the mathematician John Nash, our hero conquers his mental illness and wins the Nobel Prize. In *Enigma*, set in Bletchley during World War II, he uses his mathematical skills to triumph over German codes and his action hero skills to triumph over British spies. In both films our hero gets the girl; *Enigma* includes no reference to Alan Turing the gay real life hero of Bletchley (see Hodges, 1983) and *A Beautiful Mind* leaves out John Nash's bisexuality, first family and marital problems. The images they present of mathematicians are flattering, as are those in the discourses of difference threading through the stories of Peter, Saldon and Graham. Mathematicians are puzzlers/problem solvers, active, independent thinkers; they follow their own road and triumph in the end. These are stories of masculinity, of separated rather than connected ways of relating to the world (Gilligan, 1993), of the love of a good woman, and, above all, of the determined pursuit of a quest.

Quests, with the exception of Boaler's (1997) appropriation of the word to describe girls' mathematical activity as a 'quest for understanding', are usually discursively constructed as masculine enterprises from *Lord of the Rings* to *To the Lighthouse*. In the latter book Woolf uses an interesting metaphor for Mr. Ramsay's philosophical progress. She describes how he uses his "splendid mind" (Woolf, 1994, p.57) to range across all the letters from A to Q one by one, but he cannot reach R:

> Qualities that in a desolate expedition across the icy solitudes of the Polar region would have made him the leader, the guide, the counsellor, whose temper, neither sanguine, nor despondent, surveys with equanimity what is to be and faces it, came to his help again. R-...Feelings that would not have disgraced a leader who, now that the snow has begun to fall and the mountain-

> top is covered in mist, knows that he must lay himself down and die before morning comes, stole upon him, paling the colour of his eyes, giving him, even in the two minutes of his turn on the terrace, the bleached look of withered old age. Yet he would not die lying down; he would find some crag of rock, and there, his eyes fixed on the storm, trying to the end to pierce the darkness, he would die standing. He would never reach R. (p.58)

In this passage Woolf makes explicit the masculinity of Mr. Ramsay's intellectual project in the connection of mental challenges with physical ones. There is a sense here of a boys' own adventure. Woolf's writing also highlights the linearity of the imagined quest and its futility and narrowness. That the rational thought processes demanded by mathematics impose restrictions and that these have consequences is another theme of films about mathematicians.

In all four films the central mathematician has mental health problems. In *Good Will Hunting* and in *Enigma* the suggestion is that these are only indirectly related to mathematics, deriving instead primarily from experiences of childhood abuse and romantic abandonment respectively. However, in *Pi* and *A Beautiful Mind* the character's madness is directly linked to his mathematics.[15] In both films this connection is made in the way that the process of doing mathematics is presented as individual, fevered, mysterious and intuitive. In *A Beautiful Mind*, John Nash is shown scribbling formulas on every available surface, in a state that is indistinguishable from his later insanity. His original work on game theory, the only one of his mathematical results mentioned in the film, is presented as the result of a flash of inspiration brought on in an attempt to maximise his and fellow mathematicians chances of 'success' with a group of women they encounter in a bar.

The connection between mathematics and madness is more marked and more disturbing in *Pi*, being achieved through the use of high contrast black and white film, a fast paced dance soundtrack and the rapid inter-cutting of visual sequences. The main character's unusual and reductive 'philosophy of life' is repeated in voice-over at various points in the film:

> Restate my assumptions: 1: mathematics is the language of nature; 2: everything around us can be represented and understood through numbers; 3: if you graph the numbers of any system patterns emerge. Therefore there are patterns in nature.[16]

He also repeatedly recounts details of how, as a six year-old child, he stared at the sun for a very long time:

[15] This is a link that is also made in the book *A Beautiful Mind*, in statements such as: "A predisposition to schizophrenia was probably integral to Nash's exotic style of thought as a mathematician." (Nasar, 2001, p.19)
[16] I transcribed this passage and the next from the film (Aronofsky, 1997).

> The doctors didn't know whether my eyes would ever heal. I was terrified alone in that darkness. Slowly daylight crept in through the bandages and I could see. But something else had changed inside of me. That day I had my first headache.

He is often seen self-medicating with injections of strong drugs to control his headaches and seizures. The final scene, which comes immediately after some kind of breakdown, depicts him as now unable to calculate and seemingly having found the inner calm that was denied him while he was mathematically active.

Good Will Hunting initially looks rather different from *Pi* and more like the other two mainstream films. It too is a love story, telling of a socially awkward young man who overcomes his own background of childhood physical abuse and poverty, to find his true love and true self. However, like *Pi* it is a story of the costs of rationality and of the pain of mathematics that ends with the central character, Will, abandoning the subject. Although this time leaving behind mathematics in order to "go see about a girl" is Will's choice, the internal logic of the film presents this choice as inevitable because of the nature of mathematics. It does this through a series of binaries:

MIND/BODY

SEPARATION/CONNECTION

THEORY /EXPERIENCE

READING BOOKS/LIVING LIFE.

Mathematics is attached to the first terms in these oppositions and Will's relationship with his girlfriend Skyla is associated with the second terms. At first, Will, who lives the life of the mind absorbed in books, refuses the emotional connection and experience offered by his relationship with Skyla. He lies to her and, when they begin to get close, denies his love for her and ends the relationship. When, through counselling, he becomes ready for this emotional connection, he abandons mathematics. The idea that mathematics requires such separation is reinforced in the film for example by the actions of the professional mathematician who takes Will under his tutelage. This man relates to women only as conquests and not as partners. Since Skyla is the only female character who gets to say more than one line in the film, femininity too is associated with embodiment, connection, experiencing and living. The film presents these as more valuable ways of being but as ones that exclude mathematics.[17]

[17] The film also raises questions about the intersection of class and gender and perhaps it is Will's working-class identity that enables him to take the more feminine path (his counsellor, who also opted for love and connection, at some cost to his intellectual development, has a similar class background). Throughout the film Will's embodiment is emphasised. Unusually for Hollywood we see more of his body than of his female co-star's and he is depicted as very physical: he fights, plays baseball, works construction, and makes love.

In conclusion, the stories of mathematicians discussed in this section help to maintain rationality as masculine and being 'good at maths' as a position that few men and even fewer women can occupy comfortably. Further, although they widen a little the range of behaviours that might be considered to be part of the 'mathematical personality' (to include heroism and madness along with social incompetence), they persist in constructing the mathematician as something you are or are not 'naturally'. Thus they support a key feature of the nerd stereotype. So while literacy is seen as an essential part of being fully human, "in contrast to this framing, arithmetic is not naturalized as genetically human, but as *genetically determined within humans*" (Damarin, 2000, p.76, original emphasis).

5.5 Conclusions

In this chapter I have looked at the way that students position themselves as 'good at maths' or 'not good at maths', something that is intimately connected with whether they experience pleasure or pain when doing mathematics. I have explored the rarity and the complexity of occupying a position as 'good at maths'. I have argued that the gendering of mathematics is not only a matter of teacher and peer stereotyping and discrimination, or of the difficulties of combining a career in mathematics with the family responsibilities that still disproportionately fall to women, but is about the gendering of mathematics itself, above all the gendered phantasies of rationality and of genius, and the way these work with the construction of masculine and feminine as oppositional categories. I have made this argument using the post-structuralist theorisation of 'identity' outlined in section 3.5 showing how students write themselves/are written by the dominant socio-cultural stories.

As I noted in section 3.4, post-structuralist approaches "provide a way of examining structuring absences" (Skeggs, 1991, p.261). Post-structuralism and popular culture, are two such structuring absences in the mathematics education literature. Despite a growing recognition of the need to "ponder the role of school in the 'age of desire'...to contemplate the purposes of schooling if the distinctions between advertising and entertainment diminish" (Kenway & Bullen, 2001, p.7) and to wonder where mathematics would be in such a scenario, there seems to be a resistance to doing so. I end this chapter by considering reasons for this resistance to the idea that mathematics is a social practice that is inseparable from the realities and phantasies of the worlds we live in.

It is a central argument of this thesis that the most useful alternative to the valorisation of mathematical reasoning as the ultimate intellectual achievement is to use a psychoanalytic thought experiment to explore the denials and fears contained by this investment in reason. Using this approach, as I did in section 3.4.1, the psychic investment

is seen to derive from our terror of its Other: "the loss, the object desired, [which] exists waiting in the wings, in the external reference suppressed in the discourse. The Other of mathematics is uncertainty, irrationality, out of control, madness and so on." (Walkerdine, 1988, p.199) Such thought experiments are necessary because, as I have shown in this chapter, our current investment in reason is gendered, and to imagine ways that mathematics might be otherwise, ways that might create more spaces for women, and men, to engage successfully and pleasurably with the subject, we have to see our practice of 'pure mathematics' and our desire for certainty as phantasies premised on the exclusion of women (and other Others) and to relax our tight hold on reason. The stories in this and the following chapters are perhaps best thought of as examples of such thought experiments.

This raises questions about what becomes of students, like those discussed in this chapter, who like the certainty and black and white-ness of mathematics, those who find safety in numbers. This is a matter that I return to in section 8.2. Before that, in the next chapter, I shift from considering the ways mathematics is gendered as masculine through discourses that associate it with rationality, to considering how it is gendered as masculine through discourses that associate it with high status, and financially lucrative positions in the labour market. I am concerned to trace the impact of these masculine constructions of mathematics for learners of mathematics, particularly young women.

Chapter 6 Doing mathematics/doing masculinity: students proving things with mathematics[1]

6.1 Introduction

Mathematics education researchers (for example, Stanic & Hart, 1995) frequently report that students describe mathematics as being useful throughout everyday life but are then unable to give any concrete examples of its applications beyond such customary illustrations as adding up the bill in the supermarket or checking a bank statement (neither of which I, or I suspect most people, actually do). In this chapter I tell stories of seven students whose relationships with mathematics help to make sense of this apparent contradiction. The first four students have in common that, while they question the utility of mathematics in terms of its relationship to 'real' life (in common with many of the participants in this study), they are simultaneously **using** mathematics to prove things about themselves to others.[2] They are:

- Simon who chose mathematics, in spite of the way its curriculum violates his notions of 'commonsense', in order to prove his worth to potential employers.
- James who also chose mathematics as a way of securing his future within the labour market.
- Michael who chose mathematics because he wants to use its reputation as a hard subject to prove his intelligence to those around him.
- Toni who chose mathematics because she wants to be respected as intelligent and to be able to influence others.

The three stories that follow are of Julie, Lucy and Claudia. This is the small group of students in this study who chose mathematics because they wanted, through success in it, to prove to **themselves** something about who they are and what they can do.

These stories are offered as a resource for the arguments in both this chapter and the next ones. They speak of the role of human relationships, particularly with friends, family and teachers, and of emotions in the learning of mathematics; of the disconnection of mathematics from their current lived experience and their imagined futures; and, of the

[1] The argument in this chapter owes a great deal to the insightful comments of Chris Breen (who reviewed for publication a paper based on the stories of Simon, James and Michael) and to the Gender and Education Research Group based at King's College, London, who heard a version of this same paper.

[2] This relates to debates in mathematics education on what is/should be the relationship between mathematics and 'real life' and whether mathematics should be compulsory at Key Stage 3. However, it is beyond the scope of this study to tackle these here.

ways the phantasy of the absoluteness and objectivity of mathematics impacts on learners. I pick up on all these themes in Chapters 7 and 8. However, the argument in this chapter is that choosing mathematics is one way in which these students do gender and that this, combined with the gendering of mathematics as masculine and the social power that attaches to the subject, is a significant source of inequity.

So, my concern in telling these stories is to look at how mathematics becomes part of each student's gender identity project. Thus they provide an opportunity to elaborate the theoretical approaches to gender and to identity developed in Chapter 3. **Identity** in general, and gender identity in particular, are seen both as playing a central role in organising our experience and as unstable and fragmented; things that are always in process and never attained, and on which we need continually to be working. **Gender** is thus seen as a verb rather than as a noun, as something that we do and are done by rather than something that we are (Connell, 1995). As Butler (1999, p.33) argues, "gender is always a doing, though not a doing by a subject who might be said to preexist the deed" for "there is no gender identity behind the expressions of gender; that identity is performatively constituted by the very 'expressions' that are said to be its results".

6.2 Students' stories: using/being used by mathematics to prove something about oneself to others

Many writers have stressed that the insecurity around our 'identities' applies particularly to masculinity, the achievement of which can never be taken for granted:

> Masculinity is something that we have to be constantly trying to prove. It isn't anything that we can feel easy or relaxed with because we have to be constantly vigilant and on guard to prove, for instance, we are not 'soft' or 'sissies'. (Seidler, 1997, p.39)

In this section I read four students' talk about their experiences of mathematics as performances of masculinity in the face of the constant threat of its loss (see Redman and Mac an Ghaill, 1997, for a fascinating Lacanian psychoanalytic theorisation of this threat). Three of these students are male and one of them female. How the impact of this threat of the loss of masculinity (or of the unattainable phallus in Lacanian terms) is affected by one's daily existence as a woman or as a man is the central question considered in this chapter. In the mathematics education literature it is commonly argued that the masculinity of mathematics makes it more problematic for girls and women to choose and succeed at the subject than for boys and men. However, my aim here is to use this unusual theoretical approach to imbue this idea with new meanings and new understandings.

6.2.1 Simon's story

Simon's mother is an English housewife. His father arrived in this country "on a boat" from Hong Kong and then worked in nightclubs. Simon is studying business, geography, information technology (IT) and mathematics at Grafton. Simon's interview was the longest individual interview that I did, he appeared very relaxed and discussed all the topics I asked about at length, needing very little prompting from me. In this story I look at the way he positions himself as a business-oriented representative of 'commonsense' in his views on mathematics teaching, and his subject choices, performing a masculinity tied to the new vocationalism within the curriculum.

I begin with his views on mathematics since these mark-out clear differences for him between it and his other subjects. Simon's favourite mathematics lessons are those where "you go in there knowing nothing and you go out knowing much more about that" topic. He enjoys the buzz of understanding. His experiences, more than those of any of the other interviewees, resemble those of the girls in Boaler's (1997) study who found their 'quest for understanding' frustrated within procedural mathematics lessons:

> They wanted to locate the rules and methods within a wider sphere of understanding. Thus they wanted to know *why* the methods worked, *where* they came from and *how* they fitted into the broader mathematical domain. (Boaler, 2000, p. 33, original emphasis)[3]

Simon wants, "to understand like, not just the answer's this because it's this, or *e*'s infinity because of this, whatever yeah. It's better to understand why it is like that. 'Cos when you understand why it is like that, not just know that it is that, then you can learn easier."

He links this explicitly to the pace of the lessons, and the way one topic rapidly becomes another and then another. He insists, "you've gotta make sure that everybody understands yeah, the whole topic yeah, before you move on, because when you move on and people get left behind yeah, I think that's when you start getting problems."

He has a very clear agenda about how to improve mathematics teaching and speaks authoritatively about it. His agenda, which is also reminiscent of the girls Boaler interviewed, includes not just a slower pace to lessons but also more participation and connection to real life. This latter point comes out most strongly in his response to my question: "What do you think other people, not doing maths, think about it?"

"They think to themselves that it's a really boring, pointless subject...But to be honest you won't never use it in your life, like if you're gonna be an accountant after maths,

[3] See also the discussions of the 'quest for understanding' in sections 3.3.2 and 4.5.2.

you might do a bit of maths but it's not gonna be nothing near the stuff, like there's a lot of pointless stuff...I reckon people view...maths being really difficult. And that's why they think it's boring, because they don't understand it. That's why they've got a lot of bad experiences because the teacher just said '3+3=6' and that's it...and 'the sum of the triangle,' I mean 'Pythagoras' theorem is a plus b equals c squared.' And they, they just don't know why, why you're doing that. You know what I mean? Does it work in real life have you checked it out or got a real life example? Have you got a triangle that you've actually measured and that you can tell that it's actually right?...You could be lying. 'Cos generally a lot of what the maths teacher says you don't understand anyway, so they could just go on and on yeah something that's completely lies, and they will think to themselves it's maths, 'obviously I don't understand it 'cos it's hard.'"

Simon clearly wants many shifts in mathematical pedagogy including a move to a more democratic classroom in which the students can challenge the teacher's statements. The changes he wants to make suggest he holds an epistemological position that sees mathematical truths as less absolute than most people's. However, this is complicated by his belief that discussion is inappropriate in mathematics classrooms, because, "well you do the discussion, but if you know the answer you know the answer, and then there's nothing to discuss." He feels this even though he finds discussion a productive approach to learning in other subjects, as he puts it "when you're talking with someone else you get ideas so it's better." So for Simon, introducing real life and 'commonsense' into mathematics classrooms will displace the power and authority of the teacher but not of the mathematics itself.

Thus Simon feels there are fundamental things that mark out mathematics from other forms of knowledge and hence affect the way it is best communicated. Looking in more detail at the way he speaks about these differences, he describes geography as "not really a hard intellectual subject", while of business, he says: "It's not that much, it's not that really demanding, I think, I think maths is more really demanding. It's more, you can either get it right or wrong, but in other subjects, it's more of a grey area, you know what I mean...[Business] is not something that can be put in a textbook, I don't think. You couldn't teach someone how to be a good businessman." He connects studying geography and business, the subject that he enjoys the most and his intended career, to the kind of person he is. With geography, "it's the way that I think, it's really straightforward...because it's more like real life." While business is like law, which he wishes he had taken, because "I can understand that stuff...I understand why it's gotta be there and why, I don't know, I just find it's interesting and I just wanna know about it." It is clear from his interview that it is what Simon reads as the 'commonsense' aspects of business and geography (and law)

that enable him to identify with them, and conversely their absence from his mathematics lessons that seems to prevent him from identifying with the subject.

The tenuous nature of his affiliation with mathematics is evident in the extrinsic motivation for his choice to pursue mathematics: "I chose maths because I think it sounds good when you say you're doing maths. And also because it's, it's the most challenging subject...that and physics I reckon, and chemistry. They're like the most challenging subjects and," he pauses, "generally if you can do something like that you are an intelligent person...Also because in maths, when you're applying for jobs, if you say you got maths, they always automatically assume that your commonsense is good and that you're generally smart. Not just that you know how to work out an equation or whatever. They generally think you're smart and they think you're hard working 'cos they know that maths is a hard subject. So I thought that, in terms of getting a job, that it would be a good idea to take it."

It is clear that Simon is constructing himself as a doer rather than a thinker; someone concerned with the concrete rather than the abstract. As such he fits a pattern identified by Mac an Ghaill (1994, p.63), in his study of masculinities and schooling, that he named the 'New Enterprisers'; "working within the new vocationalist skilling regimes of high-status technological and commercial subject areas, the New Enterprise students were negotiating a new mode of school student masculinity with its values of rationality, instrumentalism, forward planning and careerism". What is interesting is the way that Simon works geography and mathematics, both traditional academic disciplines, into his story. In the former case Simon reads geography as vocational in almost the same terms as business and IT, something that I think can be attributed to the very dynamic and practical ways in which it is taught at Grafton. However, with mathematics, something that Simon clearly sees as disconnected from real life, it is the earning power in the labour marketplace that he will get by succeeding at it that enables him to tie it to his view of himself. This pattern of the discourse of the possibility of economic empowerment through studying mathematics, overriding discourses of mathematics as irrelevant and uninspiring, recurs in a slightly different form in James' story.

6.2.2 James' story

James is in the second year of his post-compulsory education at Grafton. He is repeating his mathematics AS-level and is also in the second year of his A-levels in physics and sports studies. This year he has supplemented his original subject choices with a fourth subject, performing arts. James is white, his mother is not engaged in paid labour and his father is a fire engineer. From his interview it seems that James takes a highly pragmatic approach to life. The centrality of this to his identity is demonstrated by his answer to my

question: "What do you think other people who are not doing mathematics think about the subject?"

"Yeah, a lot of people ask me, um, like 'oh what A-levels are you doing?' and I sort of say maths and physics and they go 'ooh, tough' sort of thing...You must be clever' sort of thing. So I mean I think there's a general consensus that it's very hard. But I don't actually think it's that hard. I mean it's just, if you listen, take the notes, and just make sure you learn everything and revise a lot, I mean it's not that hard. And I think that's the same for most subjects, as long as you listen, do the work and revise, then, then you can probably do any subject." Here he describes other people's views of mathematics as being very different from his own; he rejects an academic identity based on being **clever** in favour of one founded on **hard work.**[4] There is no mystery to doing well at mathematics for James. That it is just a matter of application is something he demonstrated in his GCSE approach. This consisted of getting the notes in class and then working through past papers, "I mean I had a folder like that fat basically of past papers," he is holding his hands horizontal, one above the other and separated by about ten centimetres as he says this, "of every question that had ever come up sort of thing and I just gone through every single one."

James' pragmatic approach is very different to the 'laddish' behaviour that researchers (for example, Epstein, 1998; Francis, 2000; Jackson, 2002, 2003) have found in their studies of compulsory schooling. Within this boys' anti-school culture, hard work, far from being extolled as a virtue, is equated with effeminacy. Status is gained through a range of competitive and aggressive behaviours tied to sport, particularly football, and disruptive behaviour; a studious identity becomes a difficult one for a boy to occupy, carrying with it the risk of being labelled as a 'boffin', as 'gay', or as a 'girl'. The only acceptable way for a boy to succeed is through "effortless achievement" (Mac an Ghaill, 1994, p.67). However, Mac an Ghaill also found a small group of boys, whom he labelled the 'Academic Achievers', who had a "positive orientation to the academic curriculum" (p.59) and were "in the process of equipping themselves for social mobility and a middle-class post-school destination" (p.62) based on a traditional working-class work ethic.

Moreover, the work done on masculinities in post-16 education suggests that such positions become more secure for boys who continue beyond compulsory education, since the move from year 11 to year 12 "marks a key cultural transition that involves young people in new social relations (in particular those of the labour market) and requires new

[4] The contrast with the discursive performance of 'effortless achievement' in Graham's story in section 5.2.3 is striking.

forms of identity to handle them" (Redman & Mac an Ghaill, 1997, p.169). Power et al. (1998, p.143) also relate this to an evolution in the lived relationship between school and work; "it may be that, at this level, as career aspirations begin to take on more substance and significance, 'hard work' is an acceptably masculine attribute because it becomes more closely connected to entry to male professional status". Connell (1989, p.295) explicitly connects this shift to the way power operates within society, since hegemonic masculinity, the type of masculinity that is the repository of social and economic power, is not aggressive, anti-institutional and macho, but is tied to rationality and technical/scientific knowledge. Technical expertise is central to advanced capitalism, and men, through "the mechanism of academic credentials" (Connell, 1989, p.296), can invest time and accept a subordinate position within training, in return for a secure employment future.

I think that James' investment in technical rationality and achieving qualifications is apparent in his commitment to working hard. It also helps to explain his preference for 'traditional' chalk and talk methods of teaching, when "we talk about a topic and then the teacher does, works through an example on it, and then you've got a worked example that you can apply to every other question, sort of thing. I like that." And for learning individually: "I always work by myself. I mean if I'm stuck I talk to someone else, and then and talk through it, and, but generally I just work on my own. I find it easier that way." For James, "the central themes of masculinity here are rationality and responsibility rather than pride and aggressiveness" (Connell, 1989, p.297). Connell's (1995; 1989) work suggests that this is the default position for middle-class boys who construct their life-course through their family's relationship to the educational system (work such as Plummer, 2000; Roker, 1993; Walkerdine et al., 2001, demonstrates that these class differences also apply to girls). However, such an identity is less secure for working-class pretenders, such as James, than it is for the middle-class boys who inhabit it. This perhaps explains why his investment in rationality and qualifications translates into subject choices based on instrumentalism rather than enjoyment. I conclude my story of James by looking at these in greater detail.

Academic studies, with perhaps the exception of sports studies, do not seem to be a locus of pleasure for James. When asked for a mathematics topic, lesson or anything that he has enjoyed this year, he selects, after a long pause and a prompt from me, that morning's lesson, because "it's just that everything seemed to click, I seemed to remember everything and it all just went really well." Subjects seem to be almost entirely a means to an end for James. This is clearly demonstrated in the explanation he gives for his decision to take physics and mathematics: "My form tutor basically said to me a good A-level to take would be physics. It's really hard but it's sort of it's, if I come out of it and I pass, I would think that like I worked really hard to get that pass 'cos it's so hard. So he said it's quite

rewarding, so I thought OK. But he said it would be wise to take maths with physics because there's so much overlap and it would be, it would just be very helpful." As a result of this James had to drop the more vocational media studies in favour of the more academic mathematics since they clashed. When I ask him how he felt about leaving media studies, he recalls: "I was happy in the subject but I was looking at more in the long run, as in I'm not interested in the media either anything like that, so I thought maths. And maths is more sort of, you can apply it to more than you can with media. Maths is sort of used everywhere like sort of thing, whereas media is really specific. I thought maths it's more of a benefit in the long run."

Although James speaks of mathematics being more applicable and widely used than media studies, he combines this with a strong dislike of questions that require him to apply his knowledge to 'realistic' contexts. The following is part of his explanation as to why he prefers mathematics to physics: "I don't like the real life situations 'cos it clouds your judgement. You think about irrelevant things and you, you're talking about bridges and whatever. Clouds, clouds your brain really and you can't really think. Whereas maths you just," he pauses, "do maths." This could represent a rejection of the very contrived nature of what passes for a 'realistic' context in examinations (see the examples in: Boaler, 1994; Cooper & Dunne, 2000; Verschaffel, 2002). However, his interview does not contain any criticism of this, simply a statement that "they'll relate it to a real life situation," while his use of phrases like "physics they'll give you a shape, but indirectly" and it "clouds your brain" lead me to think it more likely that he dislikes the way these contexts make it more difficult for him to recognise the specific piece of technical knowledge being tested. As a result I think his reference to the wider applicability of mathematics than media studies indicates the way that mathematics can guarantee access to a wider range of careers, rather than a sense that he will have greater opportunity later in life to use the actual mathematical skills he is studying. This orientation around the future even affects his selection of sports studies as his favourite subject, because "that's obviously what I want to do most, so that's what's my favourite."

James has built a masculine identity project around considerations of what is "more of a benefit in the long run" and around his participation in the traditional goals of schooling, working hard and following an academic trajectory. However, this is a path that, as mentioned earlier, is far from a perfect fit; mathematics did not work out for James the first time around and in fact he did not return to Grafton after the summer holidays, having found himself a job with training. The way in which working-class boys and girls attempting complicity with the goals of a middle-class educational system often experience failure is also a theme of Michael's story.

6.2.3 Michael's story

Michael, a working-class African-Caribbean Grafton student, is studying for AS-levels in IT, geography and mathematics, as well as re-sitting his GCSE in English in order to improve his grade D. Michael has struggled with mathematics this year and plans to repeat the AS-level course next year rather than progress to the A2 modules as he had previously planned to do. He has had problems making the step up from GCSE (where he obtained an intermediate grade C) to AS-level. He highlights particular problems with the pace of the work, the amount of material that has to be memorised, and with negotiating the variety of methods available for tackling each problem. When I ask him what he has enjoyed least about mathematics this year, he says, "only just loads of writing and equations and having to remember most of it and copy it." Here, as elsewhere in the interview and in my classroom interactions with Michael, I get a strong sense of how frustrating Michael has often found the process of learning mathematics. This is a frustration that he nicely captures in his explanation of the connection between 'learning what' and 'understanding why' in mathematics: "you have to learn what you're doing before you can understand it, but if you learn it and don't understand it there's no point, so it's just a catch 22."

He has very different feelings towards mathematics than towards geography and IT, differences that illuminate the nature of his identification with mathematics. For Michael, geography and IT relate more directly to his experience of everyday life, there is "just more thinking about normal situations than with maths...But maths, more," he pauses, "it depends what you're going into after school with maths, but when you're actually doing it you don't think you're going to need it further on. So that's why, it's just different." I ask if this makes mathematics more difficult or less interesting. Michael opts for the latter, seeing the disconnection of mathematics from everyday life as very de-motivating, "it's probably just that that makes you lose your interest and, which makes you wanna just give up and stop working." Another difference that Michael raises in his interview relates to why he chose these subjects. While he speaks of enjoying geography and IT, his motivation for selecting mathematics is more extrinsic: "It's 'cos GCSE, throughout all of my lessons I was on the C/D borderline so I had to work hard to get my Cs and I thought if I could do A-levels, like I could even prove more that yeah I've done maths, something that's really hard and no-one likes doing, and passed it, so it would be like I've achieved something. And it hasn't happened, but at least I tried, I know I have tried, so it's not that bad." So, while Michael speaks of enjoying the challenge of doing mathematics, this is very different from enjoying doing mathematics. This is evident when I ask: "So did you prefer doing GCSE or do you prefer doing A-level?"

Michael pauses before replying, "probably A-level 'cos it's much more of a challenge. Although that's a problem, the challenge can be too great and you fall behind, like in the other class [the original class before the setting was introduced] that's what happened to me so. It's just a good challenge, that's why I chose it, I thought it would look good first, in my CV, or anything to have A-level maths, and also it'd be a challenge to prove everyone wrong." Certain aspects of Michael's identification with mathematics are apparent in this answer. He is aware that mathematics has a reputation as a difficult subject and it is this that leads him to identify it as a challenge; he is using this status of mathematics as 'hard' as a way of gaining personal power, providing him with the external validation of his 'ability' that he needs to prove wrong those who do not believe in him (this hard/easy opposition is hetero/sexualised, gendered and classed, see section 4.4.1). Thus it is the societal valuation of mathematics that makes an A-level in the subject the object of Michael's desire. It will enable him to prove himself. When I ask for whom this proof is required, he says "everyone" and then elaborates, "most of the time some of the teachers, some of my friends, 'cos some of them think you know I'm not too bright at some subjects," and "even my parents sometimes just to say I've tried, well I've tried it. Just showing that you can have tried something, even though I haven't done it I've tried and know, you see, I can try something else."

"Is the omission of yourself from the list of people to whom you are proving yourself significant? Are you also proving anything to yourself?"

"Yeah, I am proving it to myself, as," Michael pauses, "I'm trying to build up myself more, but, sometimes I think I have to prove it to myself, but sometimes I know say, 'yes, I may not be good at it but I know what I know.' But people don't know what I know, so it's to really, it's like, um, if you know it all in your mind and you don't have the," he pauses, "GCSEs and A-levels then people don't think you are that bright, so it's really having it down on paper that counts so that's what I was trying to prove to them. And once again it didn't work."

These passages conjure up an image of Michael against the world. Competition, as Seidler (1997, p.173) argues, is a central part of many men's masculinity projects:

> The competitive institutions of advanced capitalist societies mean that men are locked into competitive relationships with each other. Often we can only feel good about ourselves at the expense of other men.

However, the deep way in which Michael internalises other people's views of himself, transforming them into action, is perhaps also a response to his experience of racism and

the objectification and othering that are a part of racism's psychic assault on black people (Fanon, 1986). I return to this aspect of Michael's identity work in section 6.4.

In what follows I break Michael's struggle down into three aspects, highlighting the identity work that he engages in through each. First, Michael constructs himself as aware that he is not academically brilliant but that he is confident and comfortable with his own understanding and 'ability'. This sense of 'knowing his place' surfaces when I ask how he felt about the 'ability' setting that took place at the start of the year: "I can understand why they split us up in the first place. Because, um, they either work at a different pace to us or not or try more challenging, because they got higher grades...it's really commonsense really to have the brighter people doing much harder work than us, even though we are going for the same thing, if we're doing different methods then we'll probably get the same, so it's really no biggy to me." However, beneath the happy contentment that Michael expresses here there lurks a quiet resignation. This resignation is clearer in this next statement where he reflects on his future: "I was hoping to go onto university but that looks like a grim outlook right now. So I'll probably just start working."

Second, there is a dissonance between his and other people's views of him; Michael believes strongly that he is better academically than all his significant others-friends, family, teachers-think he is. This is manifest in his transformation of the question, 'what do other people not doing maths think of the subject?' into 'what do they think of you for doing the subject?'

He replies, "they think it's one of the most difficult lessons that you can do in A-level and what makes it worse is that when they hear what I got in GCSE, they go 'oh you're mad for doing it 'cos it's so hard.' So people's impressions of maths A-level is just, a subject you don't wanna take 'cos it's so hard." The way he personalises the issue of the public image of mathematics further demonstrates how important it is to the way he is constructing himself. Finally, he has a passionate desire to gain the kind of external validation necessary for other people to see Michael as he sees himself.

There seems to be an odd combination of success and failure within Michael's account of his mathematical career. He seems to have a sense that his scheme for proving himself based on achieving success in A-level mathematics has failed, but that, despite this, it does not affect what he knows about himself, and also that it was being brave enough to make the attempt that really mattered and what he has learnt about himself through it. However, his earlier conflation of examination success with 'ability', his morphing of people with "higher grades" into "brighter people" quoted above, suggests how difficult it is for people like Michael who accept the terms of the conventional schooling project,

along with its definitions of success and failure, to maintain confidence in themselves when, in those terms, they fail. It is in stories like Michael's that the structural failure of schooling to meet the needs of working-class and African-Caribbean boys is individualised; the political is made personal.

6.2.4 Toni's story

The final story in this section is Toni's. Although she is female, her relationship with mathematics has much in common with those of Simon, James and Michael. In this story I look at this and then consider the impact of her being female on this pattern of identifications. First I discuss how she labels herself. Before we start the formal interview, while we are waiting for her Sunnydale classmates to leave the room, Toni considers the different names that she can take on within my research writing, but without coming to any conclusions. She would ideally like the name of a Black female scientist or doctor.[5] I have settled on Toni after the Nobel prize-winning African-American writer and feminist, Toni Morrison. Attaching a label to her ethnicity is also complicated and involves much discussion. She ponders my question thus: "Me? Well, well, well."

"She is [a] mixture of every country in the world", explains Natasha, her Nigerian classmate, who is also a participant in the interview.

Toni was "born here. But then I moved to America when I was like five. So I came back in June and my mum is from Africa, in Gambia. My dad is half Jamaican. So I don't know what to really call myself. And my mum is half Nigerian and half Gambian. So it's all kind of mixed up. But I was born here so I guess I'll just call myself a British."

After a short discussion I suggest, "Mixed heritage?"

Toni sounds pleased: "There you go. All right there you go. It's really mixed."

Mixed heritage young people like Toni are often unhappy with a simple classification as black (Alibhai-Brown, 2001; Dewan, 2003). Toni lives with her aunty, her brother and her sister. Her father died nine years ago and her mother is a flight attendant. "My mum comes like always. She was just here like last, last two weeks or so. She always comes and go[es] anyway. Always flying."

Toni is studying for AS-levels in biology, chemistry, mathematics and science for public understanding. She explains to me that she took this last one because: "It's just the key skills I guess." The other three, of which biology is her favourite because "it deals with cells and you know the human body and all them things," were chosen because of her

[5] It is awful that I cannot think of any.

desire to be a doctor, "I just like curing people you know" and "prescribing things, you know. Telling them: 'take this and you'll feel better!'"

"Yeah, she does that all the time," agrees Natasha.

"Basically I just wanna be the person that knows everything. Like when you're sick yeah, I wanna be the one to tell you that 'OK take this thing yeah and when you take it you'll feel better and stuff.' I just like, just helping people I guess...Just helping people, that's what I want to do. And I like working with kids also." Toni mentions several reasons for wanting to be a doctor in this passage, but her desire to control others seems to be the central one (the more traditional feminine roles of helping others and caring for children seem to be afterthoughts). She wants the status, respect and influence that come with medical qualifications. The presence of these motivations in her relationship with mathematics led me to include her among the students who chose the subject to prove something to others rather than among those who selected it for career purposes.[6] I now look at this relationship.

Toni has little to say about a typical mathematics lesson, she mentions only the length of the lesson and the grades that she got: "It was great. Besides the timing was really short. I mean it was really quick. You know that was the only thing. But it was all right. I mean I had good grades anyway so, I was OK." One way in which Toni uses mathematics to position herself as powerful is through obtaining good grades. Within the interview she displays a strong orientation around getting the qualifications necessary for her future plans. This is the reason that she gives for studying in England rather than in America: "When you have like your, um, degree or certificate that you get for taking your AS, it's really good when you go back to America because you can easily get a university...That's why I'm here." Just a few weeks into her AS-levels, she already knows the grades that she needs to secure a place in her chosen course at her chosen university.

However, it is not just the good mathematics grades that Toni gets that enable her to use the subject to feel powerful. That she is using the status of mathematics as a signifier of intelligence is evident in the discussion of what other people, not doing mathematics, think of the subject: "they think maths is so hard. And whoever's doing maths is so brainy. That's what everybody thinks."

We then go on to talk about subject stereotypes more generally and I ask, "Where do you think they come from?"

"Experience," suggests Natasha.

[6] Now and at other points within this chapter I am aware that my happy categories of the Interlude (between Chapters 4 and 5) are dissolving into a mess of complex and contradictory motivations (probably as they should).

"Some of them don't even come from experience," says Toni. "I think they come from when people, OK someone like me I'll go and I'll be, 'I want to be so smart' or 'I want them to think that I'm so smart' and I'll go 'Oh my god, maths was so hard! You should see, look at this x, x, x.' Just to make them think that I'm so smart you know. And then they'll be like 'oh my god she's smart!' You know, something like that."

As with the other students discussed in this section, Toni's recognition of the power of mathematics is coupled with scepticism about the subject's utility. In the interview she asks: "What's the use of maths?" She explains, "when you graduate or when you get a job, nobody's gonna come into your office and tell you: 'can [you] solve x square minus' you know...it really doesn't make sense to me. I mean it's good we're doing it. It helps you to like crack your brain, think more and you know, and all those things. But like, nobody comes [to] see you and say 'can [you] solve this?' The basic things I think you have to know about maths is like," she pauses.

"You have to calculate and stuff," interrupts Natasha.

"Yeah, and subtract, divide."

"That's why they provide calculators."

"Yes. Exactly. So why do we have to go to all this? What was we doing today?"

"Differentiation."

"Differentiation: $x\,dx$. What's all this? I mean really, come on. I just don't, I don't know, I don't see the use of it...It helps you to think definitely, but apart from that."

The account above demonstrates that Toni's identifications with mathematics have many similarities with those of Michael, James and Simon. I have read all these students' stories as evidence that they are using mathematics to do masculinity, where masculinity is understood as something that is simultaneously desired and unattainable. However, this is something with which I have more difficulties and discomforts in Toni's case because she 'is' female[7] and I want also to argue that these performances of masculinity are not ones that are unaffected by the side of the gender binary on which their 'actors' live. There is some evidence that people who make non gender-traditional subject choices, in general, have more conservative views on other aspects of gender roles (for example, Thomas, 1990; Whitehead, 1996), as if their "gender category maintenance work"[8] (Davies, 1989)

[7] This female-ness is produced through reiterative performances, in such a way that it appears to precede these performances, and so is experienced as authentic/natural by the performer/possessor.

[8] "Gender category maintenance work" is a term devised by Davies (1989, p.29) in order to make sense of children's actions, including "what adults often see as incomprehensible nastiness on the part of small children", to maintain the categories of male and female against deviancy and to confirm the social competence of those doing it. She explains their thought processes running: "I may feel sorry for you, I may even have a fascination with the way you are doing your masculinity [or femininity], but my aggression is essential in defining what you do as a transgression and clarifying for myself that I have got it right. One

demands such conformity to compensate for their transgressions in other areas. In order to begin to explore the tensions between doing masculinity and 'being' female, I end Toni's story with her contradictory experiences of femininity.

Although Natasha's experiences in male dominated sports studies give her a unique take on the effects of the gendered patterns of subject choice, Toni has more to say about gender when I broaden the issue out and ask, "Is there any other ways in which being female affects your life apart from the ones you've told me?"

"No, not really. I love being female. I love being me," says Natasha.

"Sometimes I wish that I was a boy," begins Toni. "'Cos you know why? Boys are really easy going. They, like basically I say that because like, girls are really, they take too much time first off, like making their nails doing their hair...Like for example, if I was going to a party tonight, I would've been planning it since last week or even last month talking about 'oh what dress shall I buy? You know that silver one?' Or talking about 'oh my nails, my hair.' You know, boys just cut their hair, take some trousers, any kind of trousers, some nice shirt, it don't even have to be nice, some (full) shoes, and they are gone. Nothing else. Nothing else. But us it's just too much work, sometimes."

Natasha provides another example, "when my aunt was doing my hair" her uncle said "'god you spend too much time doing that, why can't you just like, just pull your hair in a bunch?' and she was going like 'well you've got to look good' and he was like 'well, what's the point?'"

"If you think about it," begins Toni, "there's no point to it, because like, OK you just want to feel good, you know. But it's not like you coming to school to attract anybody. So somehow it doesn't make any sense, you taking your time dressing, but you know, trying to look good. But in some other way, you're trying to just feel good about yourself. So it's really different. It's two different things. People dress for boys, some girls, and some girls just dress because they feel like dressing that way and some people just wanna look good. But some people say, 'oh she ain't got no money' or something like that 'she's poor' or something."

Toni describes the huge amount of time she devotes daily simply to getting ready for college. She finds this draining and questions its necessity but seems to feel obliged to continue. This is reminiscent of the white working-class female college students who were

might say that the 'deviants' are necessary for making stronger boundaries. Thus deviation does not change the category, but is used as an opportunity to shore the category up." My use here is thus a little different from (but in the spirit of) Davies' in that I apply the term to adults' (as well as to children's) behaviours and think of it as applying to the policing of one's own actions as well as to those of others.

the focus of Skeggs' (1997) research, who found their physical presentation constrained by the powerful notion of 'respectability'. Skeggs (1997, p.4, original emphasis) describes how:

> They operate with a dialogic form of recognition: they recognize the recognitions of others. Recognitions do not occur without value judgements of real and imaginary others. Recognition of how one is positioned is central to the *processes* of subjective construction.

Along with one of the women in Skeggs' study, Toni evokes "a sense of being caught up in something which is beyond her control". Perhaps, as Skeggs suggests, the risks of getting out are too great, hazarding "cultural stigmatisations in her local situation; a challenge to all her friends who collude in femininity; a sign of difference" (p.102).

In this discussion we see that, while being masculine carries an appeal for Toni, she is also (understandably) heavily invested in producing herself as female, both in her own eyes and in other people's. In order to do this she draws on the discursive practices that produce people as masculine or feminine. The tension in these passages between wanting to dress recklessly like a boy and wanting to be recognised through her dress as a girl, suggest that we could understand there being similar tensions contained in her desires for control and for mathematical success (discussed earlier). The stories in section 6.3 further explore such tensions. First I draw together the stories in this section.

6.2.5 Doing mathematics/doing masculinity: theorising the stories of Simon, James, Michael and Toni

Simon, James, Michael and Toni show us how they negotiate their educational choices, using the available discourses on mathematics and other subjects to construct identities, in such ways as to feel powerful. For these young people (and the others in this group: Mika, Jean, Lee and AJ, see Interlude) mathematics is a powerful choice because its social construction allows it to function in their identity projects as a way of proving their 'abilities' to a range of others, from friends to future employers. This raises three questions:

- Why is mathematics a more powerful proof of 'ability' than other subjects?
- How is this need to assert one's intellect and forge a high status employment trajectory gendered?
- And, what are the implications for mathematics teaching and learning?

Below I look at the first two, while the final question is addressed in Chapter 8.

Taking a post-structuralist approach, the power of mathematics as a subject and hence its authority in saying something about oneself, is not something fixed and natural but is a contingent product of the discourses through which it is constituted. These

discourses produce it as objective, absolute, abstract, hard, a means of controlling our environment, and an essential prerequisite for entry into the economically lucrative fields of science and technology. This builds on my work in Chapter 5 where I argue that mathematics, through oppositional discourses that associate it with pure rationality, social incompetence, challenges and heroic quests, is gendered as masculine. This, together with the discourses that relate mathematics to wage earning potential (examplified in McGavin, 1999) and the continued gendering of participation in paid labour in contemporary society (Witz, 1997), help to explain why this group of students is male dominated.

However, such arguments can tend to oppositional and/or essentialist thinking on gender difference. As argued throughout this thesis, this can be avoided by seeing gender as a social practice rather than an individual trait. These students' behaviours are gendered because different social contexts elicit different behaviours and men and women have differential exposure to these contexts and so the system becomes self-perpetuating (Bohan, 1997). In other words, both boys' and girls' subject choices represent attempts by young people to occupy powerful subject positions but their gender/identity projects make available different ways of being powerful. As Nazima persuasively puts it:

> *Nazima: This is also what I think it is. When you study English, right, you somehow have power [pause] you do. And I think, a lot of girls [laughs] I'm sounding really feminist here aren't I? I think a lot of girls tend to have, like power, 'cos when you, when you know English you have power over virtually anything, even boys, men. Like when I, when I do English now I say things to boys and they're like [whispered] 'what's she talking about?'... So it's power, I mean English gives you more power in stuff like that, whereas technology just gives you the brains to do this and to do that. It's not that girls aren't interested in money we are, but we just like the power side of everything.*

Moreover, while this group of mathematics students is male dominated, it does include both girls and boys. When I talk about masculinity and femininity I use them in the relational way that Connell (1995; 1987) does to refer to configurations of practice within a gender regime. This stresses both that the discursive construction of masculinity and femininity is tied to the reproductive arena via a system of binary thought and 'compulsory heterosexuality' (Butler, 1999; Rich, 1983), and that this can be powerfully replaced by a fluid understanding of gender. An understanding in which dichotomies become continua and differences overlaps. Thus masculinity can be found in the actions of girls and women, like Toni, just as femininity can be found in those of boys and men. The boys' stories here provide many examples that are best read through such an anti-essentialist lens, such as:

- Simon's 'quest for understanding'.
- James' conscientious and hard working approach.

- Michael's sensitive internalisation of other people's views of him.

All of these characteristics are commonly located within the academic literature as feminine. The stories here (and those in Chapters 4, 5 and 7) also provide evidence for the way other factors such as class, race/ethnicity and dis/ability intersect with gender. This further undermines claims for the utility of a binary model of gender difference in understanding the complexity of social life and raises questions about what is made visible and what invisible when we work within such a model.

Summing up, I have argued that:

- All of these students, male and female, are using the social power of mathematics as a way of doing masculinity.
- Access to the different available masculine and feminine subject positions, while complex, remains highly dependent on a person's assigned gender.

Through Toni's story I asked questions about the tensions this creates for girls doing mathematics. It is my aim in telling the stories in the next section to develop answers to these questions.

6.3 Students' stories: using/being used by mathematics to prove something about oneself to oneself

The girls whose stories follow are using mathematics to prove something about their 'abilities' to themselves. As well as providing further illustrations for and extending the arguments in the last section, the three stories in this section share something else. All three students associate feelings of both pleasure and pain with mathematics. This is in contrast with the stories of Simon, James, Toni and Michael, which contain much about the pain of doing mathematics and not much about the pleasure that it can bring, something that they share with the mathematics education literature generally. Bibby (2001, p.67-68) asks:

> What picture of mathematics does pleasure develop? How does it shape those 'rational' bits?

These are questions that are helpful to keep in mind during these stories and to which I return in Chapter 7.

6.3.1 Julie's story

Julie is a white working-class girl who is studying art, geography and psychology alongside mathematics. Although she stayed at Grafton in the transition from compulsory to post-compulsory schooling, she found this process difficult: "I got really stressed out

and cried a couple of times...I was just going mad," but now "it's not so bad." Julie was one of the five students mentioned in section 5.1 as self-identifying as 'good at maths'; she is the only girl in this group. This identification happens in her account of why she chose mathematics: "It wasn't anyone pressurising me, I just in my, in myself, I knew that if there was any lesson that I'd take that was gonna, that was gonna give me like maybe a better chance in the future and that I was quite good at it was maths...I don't know, I just, it's a challenging subject without being boring I think."[9]

However, Julie's self-positioning as 'good at maths' is not consistently maintained. This becomes evident at the start of the interview when she responds to my request to "just describe a typical maths lesson, what you do in it, how you feel" with laughter. "Why's it funny?" I ask.

"Because like there's three people in our class[10] that are really, really clever, and even though I feel like I shouldn't be in that class I should be in another class, 'cos like, the work's quite difficult anyway and then when they get it really quickly and it's, I dunno." She knows that her grades dictate that she should be in the 'top' set but still says that she feels that she does not belong there. As with Ling and Rachel (see section 5.3.1), despite claiming to be "quite good at maths," the myth of mathematical genius prevents Julie from thinking that she is '**really** good at maths'.

It could be for this reason that although Julie enjoys doing mathematics, she also finds that "sometimes I really don't want to go to a maths lesson."

"How do you cope with that?" I ask. "That's quite interesting."

"Um, I make myself go, I think it's because like a Tuesday morning I have to get up really early anyway. It's just the thought of having to go in, and sit in, the first two hours of maths go really slow, and," Julie pauses, "especially if you don't understand something, you get really frustrated. But I usually, I usually walk out of maths feeling a bit better, and usually smiling, 'oh I understand that'. But then when I get home again it's a bit like 'oops!'"

Julie lacks confidence in her mathematical 'abilities'. This is also apparent in her reliance on other people's, rather than on her own, estimation of these 'abilities'. For example, when she got a grade E in her first module she was visibly upset. "A lot of people noticed, going 'are you alright?' and I was like 'no, not really', 'why?' "cos I got an E.'" Julie needed external validation to help her cope with her mark of 48%: "I was quite upset 'cos I

[9] Julie's reasons for doing mathematics concern, as do those of Simon, James, Michael and Toni, the possibilities it gives her for the future. So I could have included her in the grouping 'to prove something to others'. However, because of the way she wants to conceal her success from her friends and to keep her achievements private, I have included her here in the group 'to prove something to themselves'.
[10] Salvador, Zia and Jane.

thought I did OK on the paper. But the thing is the last question which was 12 marks, I didn't do 'cos I didn't get to it so I basically lost 20%, and me and Salvador were talking about it and that means that I got most of the paper that I did answer right...I got about 90% of what I did answer right, which really gutted me because if I'd done that question I wouldn't be on an E." Salvador, acknowledged by his peers and teachers as the best mathematics student in the year, seems here to function as an authority on mathematics examinations for Julie. In the rest of this story I am going to argue that Julie's lack of confidence is gendered.

When asked about the difference that being female makes to her life, Julie chooses to speak about the intimacy that she experiences with her female friends: "I think emotionally girls are probably a lot more, they're better off because they can talk to their, like it's easier for us, to say talk about sex with our friends openly. 'Cos like me and my friends are really open with anything we have to say. Maybe with boys, they wouldn't be able to admit it if like they were still a virgin, they'd get bullied, or they'd get stick for it, whereas a girl wouldn't. It would be like, 'oh well that's your decision.' And I think...that's why a lot of men turn out the way they do like butch and masculine, 'cos they can't show any emotion, 'cos then they look like a girl." This answer suggests an open communication with her friends that Julie values greatly.

So it is not surprising that Julie takes 'others' to refer to her friends when I ask: "What do you think other people who are not doing maths think about the subject?"

"They think I'm stupid, for doing it. Because it's really hard," she begins. Typically she is clear that her friends think mathematics is "really hard." However, this is her second statement on the matter, and she uses it to explain her first. Her first instinct is to personalise the question and to see it as being about what people think of her. Julie continues, "and a lot of the people I know didn't do as well in their, the people that I know that did well are in the maths class, so it's, kind of like the people that I do talk to, they'll say, 'oh why did you take maths I think you're really silly.' Or if they look at [your work they] say 'what the hell is that?' and 'that's too complicated for me, why did you take it?' But I, um, I used to say 'I don't know really' just because, because a lot of them take lessons that ain't so complicated." In this passage, she vividly recaptures instances of her friends telling her she's "really silly" and asking her why she chose mathematics. Her answer to them is the highly equivocal "I don't know really." This contrasts with the answers of many other students interviewed who use the divergence of views as an opportunity to position themselves as more knowledgeable about mathematics, to say, for example, that while 'others' think it's hard it's not because really it's about the way it's taught or about how you apply yourself. Julie's resolution of the difference through a performance of ignorance

seems to contradict the openness she claims for her friendships, for it is clear from her talk elsewhere in the interview that she does know why she elected to do mathematics. Her answer (which I quoted earlier) when asked directly about this is suggestive both of a clearly considered decision and of a quiet determination to choose the subject.

Perhaps Julie censors these reasons in conversations with friends in favour of "I don't know really" in order to erase the differences between herself and her friends, by positioning herself with them, also at a loss to explain why she has opted for such an impossible subject. The paradox of female friendship is that beneath the smooth surface of pretended equality there lurk suppressed differences. Hey (1997, p.65, original emphasis) captures the psychic costs of this for the girls she studied:

> One outcome of the pressure on girls to convert the wider loyalties of friendship into the exclusivities of best friendship is an implosion of individual power. It is not that girls...did not experience differential *feelings* of power through their ability to access other dimensions: being clever; being pretty; being good at games. They did. It is more that all of these other forms of cultural capital were incessantly evaluated within the domain of their friendships. Importantly therefore, in setting their alliances girls had to position themselves very carefully, lest their success in these other dimensions was perceived as disadvantaging one's peers.

There is a sense here of how a position has to be negotiated between the individual and the collective, a process in which Julie must act to silence feelings which in other contexts she can express. (Similarly the young people in Brooks, forthcoming-a, avoid talking about their higher education choices with their friends.)

The interview contains other instances of this, for example in Julie's description of her choice of geography. This was a subject that Julie speaks of having always enjoyed. But, as she says: "There was another reason behind me choosing it which was I was doing physics and having physics and maths wasn't a good idea. I couldn't, I couldn't cope with it. And the teacher as well, I couldn't, he, it was like I couldn't, he would not let me leave the lesson and one of the ways I could get out of physics was by doing geography. By taking up geography and I, because there wasn't a geography course available first, and everyone wanted to do it. So they started up a course during like, into like the first month, and so we started doing geography and dropped physics, 'cos I couldn't do 5 AS levels." The conflict here is between Julie's opinions and those of the teacher, an authority figure who has taught her since she was thirteen, and whom she describes as being very strong-willed: "If he believes in you then he will not let you disbelieve in yourself...And he would say 'you're doing physics', not 'oh are you gonna choose physics next year?' He's 'you're doing physics next year ain't you?' and it was intimidation to say yes."

Julie was clearly in a difficult situation. She was unhappy in physics lessons, something she elaborates on later in the interview. Again it is her resolution of this that is interesting. She escapes physics by taking geography. In this way she avoids confronting her teacher and removes from herself the responsibility for the decision. This is reminiscent of Gilligan's (1993) Amy who is given the moral dilemma of whether Hans, whose wife is dying, should steal the drug he needs to save her but which he cannot afford. Instead of reasoning abstractly as traditional moral philosophy demands, Amy searches for a solution based in relationships. She refuses to accept the problem as it is presented, asking whether Hans cannot persuade the druggist to give him the drug more cheaply on humanitarian grounds, and considering the possibility that should Hans steal the drug, he may be found out, and end up in prison, leaving his sick wife alone. Julie, like Amy, seems to be interested in solutions based on connection.

However, such instances can also be read as an expression of Julie's lack of confidence in and ambivalence about her experiential knowledge. This is exemplified when she says "I think that I learn best, especially at like at home, when I've got music on. But it's been proven by my psychology teacher, that that's wrong, and it's a distraction, and you should do it in silence. And I can't do that. But I think I learn better with something in the background." Her own assertion of embodied knowledge is disturbed by her teacher's assertion of her proof of the converse. Shaw (1995, p.118-119) nicely summarises how, in her more recent work with Brown (Brown & Gilligan, 1992), Gilligan describes a crossroads that girls traverse during adolescence, at which:

> Young teenage girls appear to lose the feisty, self confidence and directness of their middle childhood years and replace it with a self deprecating, assumed and false ignorance. They fear being outspoken lest the knowledge that they have of relationships, themselves and other people, which comes from their experience to date, wrecks the idealised relationships that they are beginning to want above all...Swept up in this ideal image girls lose confidence in their own bodies, and what they really know, including the evidence of their own bodies and become disconnected.

Lucy, in the next story is older than Julie, and presents herself as having now acquired the confidence that Julie lacks. I use her story to look at the problems created by her struggle for autonomy.

6.3.2 Lucy's story

Lucy is a working-class student who was born in England to an Irish mum and a Turkish dad. She is the only mature student in her AS-level mathematics class at Sunnydale. She was allowed into this group because of the closure of the corresponding evening class.

She started AS mathematics in the previous academic year but after three months "I fell ill. And I really sort of lapsed with the work. And I'm back again. I'm mad." At school she tells me that she was "just very, very, naughty," and we both laugh. But since leaving school she has spent a number of years studying. She explains that "when I grew up...well matured should I say," she thought, "'I need to educate myself,' not, for me, it's for me, not for the rest of the world, or you know getting a job...I'm realising at the moment. This is all for me."

Her journey to AS-level mathematics has been a long one. She originally took GCSE mathematics twice and got an E both times "and I was not impressed at all." She then started a new course, an introduction to computing, and was persuaded to do City and Guilds mathematics. "And again I wasn't impressed with, like 'no, no, no, I want to do GCSE.' And they was like 'no, no, start on the City and Guilds again and there'll be things that you've not learnt and you can go from there.' So I was like 'OK' 'cos it was part of the unit for the course that I was taking." She progressed from there to the BTEC which included units on calculus and quantitative methods and recalls "it was like 'this is great' you know 'I like this.'" She adds, "I've always wanted to do an A-level maths and that, just wanted to do it. Even though I think it's bloody hard. I've just always wanted to do it."

The reason for this is contained in Lucy's discussion of the reputation of mathematics. Laughing, she tells me that people think "you're just very, very intellectual when...you've got maths degrees and everything. Everyone's like 'wow!'"[11] She is clear this reputation is justified: "'Cos it's hard work. It's really, really hard work. Maths is very, very, very hard. And you have to be really, really committed. Not that you don't have to be committed to other subjects and everything, like chemistry, science, and physics and all them. But when it comes to things like, erm, I don't know, this is really, really hard and heavy, English, geography, and everything, you don't, I don't think you have to be that committed, you know...I'm not saying this [to be] nasty, because again if I was to take sort of French or German...they may be really, really hard subjects. But again, when it, when it comes to maths, maths is, it's hard work. It's literally really, really hard work. And you know anyone that actually deals with maths will tell you like 'whoa, you know, this is deep, this is deep'...Whereas with English, I'm not saying that, at the end of the day you're writing essays and you, you have to do a 5, um, 10,000 essay, like of 10,000 words you

[11] Perhaps her laughter here functions to cover her embarrassment about what such a claim implies about herself (or even as part of a denial that it implies anything about her).

know like. Then of course it's gonna, it's using the imagination and that but it's not hard. To me that wouldn't be hard."[12]

Lucy tells me that this image of mathematics as "hard" and "intellectual" lay behind her initial decision to take it: "I wanted to prove to myself, not to anyone else, but to myself, that I could do it. That there was something better inside me. And that's how it started but now I enjoy it for some sick, unknown reason." In explaining this enjoyment she reminds me of a mathematical discussion we had during one of my earlier classroom observations. This was an 'Aha!' moment for her, when "all of a sudden you get, you like, 'ah yes.' It's great! It's a great feeling. It's great to think 'yes I've done it!'"

This obvious pleasure, in her sense of power, combines with some pain in Lucy's relationship with mathematics. This is evident when, immediately after this exchange on what she enjoys about mathematics, I ask: "What about what you haven't enjoyed about learning maths?"

Lucy hesitates, "um, ah, what haven't I enjoyed?" Then, laughing, she jokes, "everything, I've not enjoyed."[13] Lucy then gives a serious answer to my question: "I can literally do the whole work" and then a few weeks later "it's difficult to remember it" and, above all, in the pressured situation of the examination "I just go completely blank...and it's trying to defeat that." The strategies that she has developed "to train my mind to that sort of level" are based on effort. For each topic "I will literally go home and I will break it all up into literally tiny, tiny segments. And I'll write each segment down so it's got an understanding to it."

There is a parallel between the change, from doing mathematics entirely for the challenge it provides in order to prove something about herself, to also doing mathematics for the pleasure that challenge provides, and a change in Lucy's relationships with her teachers. This is illustrated in her talk about Alex, one of her current mathematics teachers, who is "absolutely ace". She explains "I've had him for a couple of years and he's absolutely great, because you're not scared of him. Well I'm not scared of him. I know that at the end of the day he's not actually looking down his nose at me. He never, never did. I s'pose when I was in a vulnerable position, then you know, I can sort of explain from there."

"OK."

[12] Unusually Lucy conflates 'hard' and 'hard work' in these passages. It is not important for the argument here, but it is interesting to compare this with other students' talk where I argued that maintaining a distinction between these terms does key identity work (notably, Graham in section 5.2.3 and James in section 6.2.2).

[13] Freud (1991a) claimed that jokes, along with slips of the tongue and other parapraxes, can reveal things that we would normally keep hidden and give clues to the contents of our unconscious.

"Um, when I was in a more vulnerable position...Alex was cool, calm and collected, and 'alright, fair enough, yeah, yeah.' And you could say to him 'no, no, I don't understand, no, no, no, I don't understand' and he'd just go over and over and over it again. Whereas now I'm not afraid to actually say to a teacher, whether or not he's gonna look down his nose at me or not 'oh god you stupid cow' or whatever, in his mind. I'm not afraid of that no more...So I'm free like that."

These changes are indicative of the way Lucy is constructing herself as having shifted from a position as dependent on (male) others' views to one as independent of them, and having grown in confidence and maturity. Lucy's emancipatory account can be disrupted if it is read in the context of Rose's (1999a, p.ix) discussion of neo-liberalism's insistence that "each individual must render his or her life meaningful as if it were the outcome of individual choices made in furtherance of a biographical project of self-realization". These new forms of regulation can neither be understood as freedom, since "the self is not merely enabled to choose, but obliged to construe a life in terms of its choices" (p.231), nor as repression since they "do not crush subjectivity. They actually fabricate subjects-human men, women and children-capable of bearing the burdens of liberty." (p.vii)

Key features of the ideal neo-liberal subject are autonomy and individuality. Lucy performs these in her denial that external pressures affect her choices. For example, when she tells me that she "wasn't impressed with" her computing teacher she adds, "that's not the reason why I didn't" continue with computing. She agrees with me that teachers do have an effect but qualifies this, explaining "not that he made my choices. Because at the end of the day I'm, you know, I know what I want." Similarly Lucy denies that her choices are affected by the social construction of gender. She points out that there are now more women going into mathematics because it is no longer a "male-dominated world...And this is maybe a suggestion and a theory that at the end of the day women actually pick maths because they actually enjoy the subject more...Whereas with males, they might [be affected by] the macho [image]" suggesting that men's, but not women's, choices are constrained by gender.

Then I ask whether "thinking more generally, do you think that being female has made differences to your life?"

"No. Because it's, to me it's, I'm a female and that's it. I've not thought of nothing else I suppose. It's just a natural thing."

Despite this definitive answer, Lucy brings the subject up again, at the conclusion of the interview, when I ask her if there is anything that she wants to ask me: "No, yeah,

the woman issue. You said, um, about, just now, the, um, question about being a woman. Where did that come from?" I explain and she tells me that she asked, "because it's like to me a strange [question], but, 'Whoa! I'm a female but that's it.' I can be feminine. I sometimes can't be feminine, depending [on] the situation and that. But to me that wouldn't matter. Personally, you know that would not matter to me...other people, and that, other women, you know, they sort of shy away from the male dominated areas. But to me it wouldn't matter."

Lucy's story illustrates one damaging impact of the fiction of the autonomous self through which she is writing herself. At the end of the academic year in which I interviewed her, she failed her AS-level mathematics and she looks likely to do so again at the end of this year. Within such a story of her actions she cannot look to class and gender to help her to understand this failure and so has no alternative but to understand it as the result of personal pathology. This dark side of the neo-liberal vision of self, this time for middle-class girls, is a theme of Claudia's story.

6.3.3 Claudia's story

Claudia is an ambitious young woman who is interested in becoming a barrister. Her family moved from Algeria to Scotland when she was four and a half years old and then later to London. In her interview she distances herself from her childhood, for example, through her absence from phrases such as, "my mum and dad are from Algeria" and "they lived there till I was four and a half." She is doing five AS-levels, instead of the four that is the norm at Westerburg. She tells me "if you could do six, I'd be doing six" because "I don't feel alright, if I'm not doing, if I know I'm not doing the hardest thing possible I'm not really exerting myself, I don't like it." When I ask about why she thinks she always seeks out challenge she describes how she coasted along at the top of her class in primary school and the early years of secondary school. Then, in year 11 and now, "I'm feeling the need to actually" and here she impersonates a teacher "achieve my potential". Her five subjects cut across the whole academic curriculum: sciences, arts and languages. They are chemistry, English literature, French, history and mathematics. Claudia explains, "I don't like sort of narrowing down my options." They represent her desire for challenge as well as her self-presentation as sophisticated (as mentioned in section 4.1, she prefers to sit at the back and is disdainful of those who are eager to answer questions in class), "defiant" ("I don't [take] things as they're told to me") and determined. That she also jokingly describes her chosen programme of study as "self-torture" suggests that her academic work carries some pain with it as it does for the middle-class women in

Walkerdine et al. (2001, p.175) trapped on an educational "conveyer belt...they must be kept to that path at all costs".

> What we found in our study was that the middle-class girls' educational lives had been rigidly circumscribed by the expectations of academic success, often to such an extent that quite outstanding performances were only ever viewed as average and ordinary. (Walkerdine et al., 2001, p.179)

I think that this ambiguity can be read into her subject choices. For example, with French she clearly wanted a challenge: "I did French to GCSE and I went to France last year, in the summer sorry, and I realised I wasn't quite as good at French as I always thought I was, so I thought I should take it up." There is a determination as well as a sort of stubbornness here; she is trying to prove that she is as good at French as she thought she was and clearly thinks she ought to be. However, because of the way that she keeps raising the targets she is aiming for academically, I have doubts as to whether she will ever be able to do enough to prove herself to herself. As such this continual challenge-seeking may be destructive as well as productive. This double edged-ness is clearer in her talk about mathematics.

Claudia employs a militarist metaphor to explain why she is doing mathematics: "I like the fact that I've got to conquer these numbers." However, as well as her evident pleasure in the power she gets from such conquests, she explains, "sometimes I dread going into [maths], 'oh now I've got maths' but I think that's just because of the, what do you call it stigma, stigma attached to maths. It's like, 'oh, maths, numbers, er.' I don't dislike it. It's not my favourite subject. I'm doing it, I'm doing maths sort of because I know it will be a challenge to me and it's useful and it's good. I think it's good for your brain to do maths." These painful aspects of Claudia's identification with mathematics are also manifest in the way that she froze in her GCSE mathematics examination: "I was so scared of not having done enough maths revision." So when "I went into the exam, for the first few minutes I was just really scared stiff, I couldn't do anything. I just kept staring at the first page and just reading it and not taking it in at all."

The terror in these passages is reminiscent of some of the experiences described by Buxton (1981) in his case studies of maths anxiety and panic. He related these feelings to: the time pressure and competitive performances that are part of the early school mathematics curriculum[14] and the right and wrong nature of school mathematics which mean that questions in the subject carry with them a moral authority. The concentration of work on maths anxiety (for example, Evans, 2000; Isaacson, 1990; Tobias, 1978) on those

[14] Walls (2003) contains evocative analyses of the effects of such activities on what she calls the 'sociomathematical worlds' of children in New Zealand.

who fail at mathematics or who drop out early creates the false impression that it is only such people who experience such feelings towards mathematics. In looking for an explanation of Claudia's "dread" of mathematics, her account of when she was sent to special mathematics classes in year 8 is important. "I was like always top in the class, top in the year, and, and," she pauses, "myself and a couple of other students were selected from the year to go to these advanced maths classes...And they were really, really hard." We laugh. The classes covered "really super, super maths for really clever people, stuff you'd see on sort of Open University or whatever and so me and my friend would just sit there and sort of draw, doodling and so, I think, there's often been times when I've like been inclined to be scared of maths 'cos of not understanding it." Claudia's fear here seems to relate both to the myth of mathematical genius explored in Chapter 5 and to the constant threat that exists of just "not understanding it," and so of being judged inadequate/wrong.

Her experience of mathematics can be read as gendered in two further ways. First, she tells me that while she has always been "good at mental arithmetic" and "just thinking in numbers comes quite naturally to me," it is the "harder maths" with which she has problems. This distinction draws on the gendered discursive opposition between reason and calculation discussed in Chapter 5, and contrasts with the positions adopted by Graham and Peter in their stories as self-consciously bad at tables (see sections 5.2.1 and 5.2.3 respectively).

Second, in spite of her negative feelings, she did choose mathematics. The status of the intellectual challenge that mathematics represents is central to this, but so are the teachers she has had. Her version of mathematics is a relational one: "[Mathematics] really depends on the person you have teaching you." She tells me about how, in GCSE mathematics, "the first teacher I had I didn't really gel with him so in the first year, year 10, I didn't feel I really achieved anything," but in year 11 a "really good" teacher took the group over.

"What made this person really good at teaching maths?"

Claudia hesitates, "I don't know, actually. Um," she pauses, "what made her good? Odd coincidence was that the teacher who I had for years 7 to 9 was a lady, and the teacher who I found to be good was also a lady...I think it was sort of, I don't know, a sense of authority."[15] She laughs, "not a sense of authority over her, but the way she treated us, the way she spoke to us, especially like my little group, was really, it was more personal. The

[15] It is unlikely to be a coincidence that both these teachers are female. Shaw (1995, p.62) describes the gendering of the cultural fantasy of the ideal teacher, with "the male notion of the good teacher [being] less personal than the female one". She accounts for this by arguing that buried deep in the psyche is the equation of teaching and mothering. Thus it is in "seeking to remain in the merged unindividuated state that women are led to mothering and to substitute mothering, that is, to teaching".

last teacher, it was just like 'you haven't done your homework, why? Detention' and 'you don't get it. That's because you haven't been listening. Why?' Blah, blah, blah."

"So what sort of things did she say that were, that you describe as 'more personal'?"

"She'd talk to you about, like at the time when we were choosing, sort of thinking about A-levels and she was telling us all, 'cos she, she'd had a lot of experience teaching maths, like fifteen years, seventeen years, or something, and so she would tell us about different situations she'd been in and about things that universities would want, things like why maths would be helpful later on and, it was more like, it made maths more sort of accessible."

However, despite her relational version of mathematics and her feelings about the influence of the teacher's gender, Claudia, like Lucy, is reluctant to read the influence of gender into her educational choices. After she has talked briefly about the possible physiological and sociological reasons for the gendered pattern of subject choice I ask her: "So do you think that being female makes a difference to your life in any other ways, apart from in subject choice?"

"I read something about if you're a barrister, female barrister, you have to accept that men will go further than you, which I think is a bit 'er, no they won't!' I want to be the best." We laugh. "Obviously men still get better pay, don't they? Erm, I don't know, I'm not really a feminist. I don't think that, I don't know all about that equality thingy and stuff."

I pursue this, asking, "What do you mean?"

"Um, I don't know, I don't think I have understood the question very well".

"Um, what I'm trying to get at is just to see whether people, what effect people think their being male or being female has had on their own life, and is going to have on their life in the future, and has on other people's lives. That's really what I'm trying to get at."

"Oh, OK. Mm, mm, mm."

"Yeah, it's not easy."

"No it's not." Claudia hesitates, "Um, I think if you're male then you have more of a chance of being more career orientated and even if you're not career orientated, 'cos well women produce children, funnily enough, um, it's sort of split between the two. So men are more likely to become leaders and more important people, have more jobs, and so it becomes a man's world really. And women are still, um, second-class. I mean I've heard that said a lot but I don't know how true it is."

"How true do you think it is?"

Claudia pauses before replying, "It's becoming less and less true, but I think it is, it is true in sort of, in terms of the hard facts it is. Like figures and stuff. Who has what jobs, who earns what, who owns what, who has power, stuff."

In these passages Claudia, like Lucy, is reading herself through the fiction of the autonomous self that compels her resistance to connecting being female to lacking power and to disadvantage within her own life. Instead she attaches these to generalised others and to the impersonal realm of reports, statistics and theories.

6.3.4 Doing mathematics/doing masculinity/being female: theorising the stories of Julie, Lucy and Claudia

Like Simon, James, Michael and Toni, Julie, Lucy and Claudia show us how they use/are used by their educational choices to do their identity work. Once again, mathematics is a powerful choice because its discursive construction allows it to function in their identity projects as a way of proving their 'abilities' not only to a range of others, but, above all, to themselves. The reasons why it can do this were discussed in section 6.2.5. However, I have further argued within their stories that this creates tensions for them because, while mathematics is discursively inscribed as masculine, their bodies are discursively inscribed as feminine, and it is this latter label that they are invested in producing as 'natural'. There are three questions that arise out of these analyses:

- Why is this group of students all female?
- How are the tensions they speak about gendered?
- What is the role of mathematics in constructing these tensions?

I address these briefly below.

That these three students are all female could be a coincidence. This is a study that has sacrificed breadth for depth and so I am cautious about generalising. Throughout the thesis I have tackled this limitation by combining the detailed reporting of interviews and observations with the continual relating of these to other empirical and theoretical work, so that readers can assess the relevance of this study's findings to other contexts (Boaler, 1997). In this case the many studies that demonstrate that boys and men express greater confidence in their mathematical 'abilities' than do girls and women, suggest that the female dominance of this grouping is not simply a coincidence (see sections 3.2.2 and 3.3.2 for critical discussions of some of these).

In the stories, the reasons that I offer for the gendering of the need to prove to yourself that you are good enough to do mathematics, are based on a range of experiences-for example, of friendship, of teachers and of bodies-that, in general, differ for girls and

boys. I relate these to the way that, while both girls and boys are required to produce themselves as autonomous subjects, these patterns of differential experiences make this more problematic for girls.

> Now that girls can, in principle, take the place previously accorded to their brothers, their production as the bourgeois subject is a huge struggle and is never simply or entirely achieved, and certainly not without terrible penalties for body and mind. This view of what happens to the girls is in complete opposition to a simplistic notion of a genderquake as a freeing feminist triumph! (Walkerdine et al., 2001, p.175)

Generally the interviews support the idea that gender is experienced as more problematic by the girls than by the boys and was talked about in more personal terms by them (although it could simply be that the boys find it more difficult to discuss their feelings about being male). The tensions involved are particularly pronounced in the case of mathematics because of its key role in producing rational subjects and the ways that it is constructed as absolute and abstract and so as dis-embodied and dis-connected.

6.4 Conclusions

This chapter demonstrates that gender is a project and one that is achieved in interaction with others and that opting into or out of mathematics is part of this project. One of the main tensions that I have experienced in thinking and writing about gender in this chapter is that between equality and difference. Difference or women's specialness is the base of feminist political struggle, but it always has a "double face" (Snitow, 1990, p.14), being prone to political misuse. As discussed in Chapter 3, explanations based in gender difference so easily become self-perpetuating and indeed when I have presented work from this study I have met the view that work such as mine, which seeks to explain gender differences, is actually part of the problem. Perhaps my readings produce differences between boys and girls because that is what I 'want' to do.

On this issue, Michael's response, when I asked him to help me to respond to a reviewer's comment on an earlier version of the first part of this chapter that I had submitted for publication, is revelatory. I asked him to explain in what way his need to prove himself differed from the similar sentiments expressed by Julie. He was unable to explain this difference but was angry about the question and adamant that there was a difference. There are two possibilities:

- That this difference is 'true' and relates to the way that Michael's desire is for public recognition of his 'abilities' while Julie's is more private and she wants just to prove something for herself.

- That this difference is 'untrue' and it exists only in Michael's subjective constructions of his and other people's motivations (and perhaps in the subjective constructions of Julie and some other young people).

However, this dichotomy is misleading for if 'true' is understood not in terms of an idea's power to describe the world but in terms of its power to produce effects within the world then the latter version is at least as 'true' as the former. And the difference is gendered because for Michael this is something that he experiences and performs as masculine. So, while each person performs both masculinity and femininity, only one of these will be felt and **need** to be felt as authentic.

Moreover, stopping feminist research on gender differences is not going to eliminate cultural stories about them, it is just going to further restrict the range of stories through which gender difference is understood. If progressive social theories ignore difference, there is the danger that students' "awareness of differences...lends plausibility to those theories which do base themselves on difference, but explain it in ways which have more pernicious, because determinist, implications"[16] (Henriques, 1984, p.89). Gender differences have material consequences, and we need to acknowledge this if we are to make decisions that promote equity. For example, since dyslexia is between 75 and 90% male, "any organisation which campaigns for more awareness of dyslexia is effectively campaigning for a better deal for boys" (Shaw, 1995, p.66); in fact, boys' dominance of the 'special educational needs' category means that they have always had more resources (Hey et al., 1998). Connell (1987, p.18) makes this point with great force:

> The habit of mind that treats class, or race, or North-South global relationships as if gender did not matter, is obsolete-and dangerous. For the facts of gender do not go away. Aid programs to Third World countries, by ignoring gender in principle, in fact give resources to men rather than to women. Industrial and nationalist militancy that ignores questions of gender reinforces men's violence and the patterns of masculinity that lie behind it. The question of human survival, in the face of a global arms race and widespread environmental destruction, requires us to understand a play of social forces in which gender has a major part.

As Scott (1990) explains, post-structuralism offers the possibility of deconstructing the binary of:

EQUALITY/DIFFERENCE

[16] Henriques' comment is taken from a discussion of 'race' not gender, but the parallels are clear.

Two ideas are particularly fruitful. First, it is questionable whether there is not such great contrast within each term of the opposition as to render meaningless the idea of describing feminist positions in terms of either 'equality' or 'difference':

> Equality, for example, can mean anything from the mildest liberal reform (this is piece-of-the-pie feminism, in which women are merely to be included in the world as it is) to the most radical reduction of gender to insignificance. Difference can mean anything from Mary Daly's belief in the natural superiority of women to psychoanalytic theories of how women are inevitably cast as 'the Other' because they lack penises. (Snitow, 1990, p.26)

Second, while difference may be thought of as the opposite of sameness, politically equality has never meant sameness (see Young, 1990). In fact:

> Demands for equality have rested on implicit and usually unrecognized arguments from difference; if individuals or groups were identical or the same there would be no need to ask for equality. Equality might as well be defined as deliberate indifference to specified differences. (Scott, 1990, p.142)

As feminists we need **both** difference, "our most creative analytical tool", **and** equality, "to speak to the principles and values of our political system" (Scott, 1990, p.142). No work takes place in a political vacuum and feminists must be aware of this. I believe that we each need to find where our work lies and assess "how powerful that political decision is as a tool for undermining the dense, deeply embedded oppression of women" (Snitow, 1990, p. 29). This is the project that engages me within this thesis.

That people whose bodies are socially marked as feminine do things that are socially marked as masculine and vice versa is not surprising and is clearly evidenced in the stories told here. However, that the marking of the body as male or female impacts on one's possibilities for acting, is also apparent; not all positions are equally available to all people. Given the generally greater social valuation of facets of masculinity, it is not surprising that these hold out greater appeal for boys and girls than do facets of femininity. This has social justice implications.

I end this chapter by arguing that making a wider range of subjectivities available to a wider range of individuals would be a way of tackling educational inequity. This carries implications for mathematics pedagogy. In Chapter 4 I looked at the limited range of identifications with mathematics that were available to students through the practices within their mathematics classes. To widen these possibilities for being, we need mathematics reform work that shifts the discursive invention of mathematics from that of a subject of abstract rules and absolutes to that of a more relational and collaborative discipline. This is something that may also help stem the tide of students rushing away

from the subject at the first opportunity. The students discussed in this chapter form temporary identifications with mathematics; for them mathematics is a popular choice but not a popular subject. We also need gender reform work that rejects the fashionable polarised 'Mars and Venus' versions of gender that naturalise dominance as difference, and that does not dictate to girls or try to change them, but works with both boys and girls acknowledging the complexities of their lived identities. However, these two cannot be separated since, as this study demonstrates, mathematics and gender are mutually constitutive, mathematics reform work is gender reform work. While the focus in this chapter has been to undermine the binary constructions of gender, my focus in the next is to undermine the binary constructions of mathematics.

Chapter 7 Objective subjectivities, subjective objectivities and guilty pleasures

7.1 Introduction

This chapter is about mathematical pleasures. It builds on previous chapters, particularly the two that preceded it, so I begin by reiterating the main arguments in these. Chapter 5 looked at the way that young people make sense of mathematics and construct their relationship to it through a series of binary oppositions. The ones discussed in that chapter were:

MATHS PEOPLE/NON-MATHS PEOPLE

MATHEMATICS AND SCIENCES/LANGUAGES AND ARTS

ORDERED AND RULE BASED/CREATIVE AND EMOTIONAL

NUMBERS/WORDS

THINKING/WRITING

FAST/SLOW

COMPETITIVE/COLLABORATIVE

INDEPENDENT/DEPENDENT

ACTIVE/PASSIVE

DYNAMIC/STATIC

NATURALLY ABLE/HARD WORKING

REAL UNDERSTANDING/ROTE LEARNING

REASON/CALCULATION

REASONABLE/CALCULATING

MASCULINE/FEMININE

REALLY GOOD AT MATHS/GOOD AT MATHS

OBJECTIVE/SUBJECTIVE

HARD/SOFT

MIND/BODY

SEPARATION/CONNECTION

THEORY /EXPERIENCE

READING BOOKS/LIVING LIFE.

Although I derived this list through making sense of the talk of a select group of students who both enjoy mathematics and are academically successful at it, the inscription of mathematics into binary patterns is more widespread, as the stories in Chapter 6 made clear. Those too are full of talk about what makes mathematics different from other subjects, what makes the ways of knowing in mathematics different from other ways of knowing, and what makes people who are good at the subject different from other people.

I have argued throughout that, whilst there are important historical continuities in the ways that individual entries are organised in this list (see section 5.4.1), these entries are also in a continual state of flux. New ones are incorporated, for example computing, the recent addition to the curriculum, has fallen in with mathematics and sciences rather than languages and arts; and some entries have changed sides, for example Latin was once on the masculine side of the divide and has now crossed over. Thus it is not the existence of particular binaries that matter but their underlying logic and pattern, dependent upon polarisation and hierarchy, the valorised against the degraded, the masculine against the feminine. This logic structures our thoughts and feelings and marks out the limits of what it is possible to think, and to feel, and to be. In Chapter 6 I went on to develop the main argument of this thesis. I explored how this binary patterning combines with the socio-culturally inscribed opposition of masculine to feminine, and male bodies to female bodies, to make identification with mathematics more difficult for girls and women than for boys and men. Hence they are less likely to choose, enjoy and succeed at the subject.

In looking at gender in this thesis (see particularly section 3.4.2 and Chapter 6) I work with a particular model. This model both acknowledges the Background (see section 2.6) of gendered oppositions with and against which we think, and simultaneously tries to shift this Background a little, in directions that I hope will be more productive for social justice. Importantly this model breaks with the dominant pattern of research in the sociology of gender that maps masculinities onto men and femininities onto women so that the binary division of sex is preserved and reinforced:

> Research on gender should not be exclusively concerned with the differences between males and females (thereby perpetuating these), but should also look to the contradictions and possible cross-gender overlaps within each position. (Pattman et al., 1998, p.130)

Overlaps are excluded within a very particular way of seeing the world that homogenizes male and female experience and disappears practices that do not fit. For example, Pattman et al. (1998, p.128, original emphasis) criticize Seidler (see Seidler, 1997) for reifying masculinity:

> Representing men as the homogeneous Other of women. He writes as if the experience of masculinity as a kind of estrangement from emotion is common to all men...by apparently *describing* a universal masculine experience he actually constructs it as an *ideological* product.

It is not that such work is never useful but that it should carry a health warning, perhaps:

> WARNING: BINARY THINKING DAMAGES GENDER REFORM

My model of gender and my use of masculinities and femininities are drawn from the work of Connell (1995, p.71):

> 'Masculinity', to the extent that it can be defined at all, is simultaneously a place in gender relations, the practices through which men and women engage that place in gender, and the effects of these practices in bodily experience and culture.

However, while stating clearly here and elsewhere in his theoretical writings that masculinities and femininities are practices/places that are done/occupied by men **and** by women, even Connell includes only men in his detailed empirical studies of masculinities (for example, Connell, 1995; Connell, 1989). This emphasises the impossibility of completely escaping our Background of gender oppositional facts, beliefs and language games.[1] However, it also emphasises how important it is to keep trying.

This chapter continues this project. My aim is to further undermine our Background of binary thinking by focusing on the ways in which mathematics is constructed, since the project of changing the relationship between mathematics and gender involves undermining the interlocking pattern of binary oppositions in which both are inscribed. Many people have argued that there are separated and connected ways of doing mathematics and it would be better for us all if we moved towards the connected ones (for example, Becker, 1995). This seems to me both a valuable intervention and one that is limited because of the ways that it feeds the Background binary patterning of our thinking:

> The affirmation of the value and importance of 'the feminine' cannot of itself be expected to shake the underlying normative structure, for, ironically, it will occur in a space already prepared for it by the intellectual tradition it seeks to repudiate. (Lloyd, 1993, p.105)

What I want to do instead is to deconstruct the two related oppositions:

SEPARATED/CONNECTED

[1] This point is compellingly argued in Halberstam's (1998, p.14) study of female masculinity: "Even when the need for an analysis of female masculinity has been acknowledged, in other words, it seems remarkably difficult to do."

I do this by dispelling the myths that the 'cognitive' is not always already affective and that 'separated' mathematics is all the things that it claims to be: rational, abstract and objective. The stories in this chapter build on those in Chapters 5 and 6 and are used to demonstrate that mathematics must be made to look separated by producing stories of it that exclude its Others-the emotional, the relational and the subjective. I carry out this deconstruction through looking at stories of mathematics and pleasure.

7.1.1 Welcome to the pleasure dome[2]

I have decided to focus on pleasure for two reasons. As I commented in section 6.3, this is a neglected area and if we want to make mathematics look, sound, feel, taste and smell[3] different from how it does now then absences are a good starting point. Additionally, before focusing, in the concluding chapter, on the ways that mathematics might be different it is helpful to think about those who, like myself, do and have gained immense pleasure from the current version/s of mathematics as a prelude to considering what would happen to us if mathematical practices, and so mathematics, re-formed.

Over half of the student participants in this study spoke of enjoying mathematics. Some of these were featured in earlier chapters. They are Julie, Lucy and Claudia, whose pleasures combine with pains, and Peter, Saldon and Graham, whose pleasures in mathematics are less overtly ambiguous and are inseparable from their self-identification as 'good at maths'. Looking again at these stories, the students talk about deriving pleasure from some combination of four aspects of mathematics:

- That it provides opportunities to do new stuff that they would not have thought of otherwise.
- That it is/represents a challenge and so provides an opportunity to test oneself.
- That they are good at it/can do it, and they enjoy the feelings that accompany success.
- That it is certain, and often related to this that it is 'narrower' than other subjects and involves less writing.

[2] This subtitle comes from the title of the paper *Welcome to the pleasure dome: taking pleasure in the university* (Quinn, 2003) that was scheduled in the same session as mine (Mendick, 2003c) at a conference called Discourse Power Resistance, held in April, 2003, at Plymouth. The presenter of that paper and most of the audience for the session felt that mathematics had little to do with pleasure. (Quinn, I assume, in turn borrowed her title from Frankie Goes to Hollywood.)

[3] I include all five senses here because of Applebaum's (1999) argument that the metaphors used in mathematics education are dominated by the visual and the tactile at the expense of the aural, olifactory and gustatory. He argues that this helps to maintain the dominant view of mathematics as an external thing that is separate from the self and disembodied.

The first two of these can be seen as potentially threatening to one's sense of self, while the latter two speak more of safety and refuge. This tension perhaps contributes to the combinations of pleasure and pain in some of the student stories about mathematics.

In the next section I supplement the stories of pleasure in Chapter 5 and section 6.3 with others drawn from the group of students who chose mathematics, at least partly, because they enjoyed it. I construct stories about what lies beneath the perfectly logical and rational reasons for liking mathematics that I have listed above. The arguments that I develop through these stories build on those in previous chapters in two ways:

- They consolidate the arguments made earlier. My examination of 'mathematical pleasures' offers a case study demonstrating the potential of the approaches to choice, mathematics and gender developed so far. The four stories, of Analia, Jonathan, Phil and Maryam, in the next section provide more provocative examples of the ways that the dominant discourses about mathematics impact differently on girls and boys.
- They extend the arguments made earlier. I look at how human relationships, and emotional investments in these, impact on young people's experiences of mathematics. All the interviews contained some mention of the influence of other people. However, while such relationships feature in the other stories in this thesis, they are not my main focus there, as they are here. In the stories in this chapter, I examine the significance of family members, teachers and peers; nationality and race/ethnicity intersect with these relationships in complex ways.

Before the stories themselves I briefly explore the connections between these two aims through a discussion of the literature on affect in mathematics education.

7.2 Emotional and relational mathematics

Emotions are integral to the learning of mathematics, but this is something that it is rarely acceptable to acknowledge. Surveying the field of research on mathematics education, Breen (2000) notes that in the proceedings of the annual conferences of the International Group for the Psychology of Mathematics Education, or PME, the P for psychology is usually interpreted cognitively rather than psychoanalytically or therapeutically. In general, work on affect in mathematics education is largely atheoretical and based on 'commonsense'. Its domain is different from that of cognitive research; it does not focus "on the direct interaction of student or teacher with the mathematical object that characterizes cognition studies" (Cabral & Baldino, 2002, p.170; see McLeod, 1994, for a survey of the research on affect in mathematics education). This disappearing of

emotions creates a problem that we can understand using Bibby's (2001, p.68) argument that "in relation to mathematics, people split off their 'bad' emotional feelings from their 'good' rational knowledge"[4]. This is a process whose impact on learners can be read throughout this thesis.

Breen's (2000) work is part of a small body of research on maths anxiety that explains dislike of and failure at mathematics in emotional terms and works with the same basic material as cognitive studies. He draws on incidents and student diaries to explore his students' emotional responses to mathematics. The stories are very traumatic and he compares them to tales of abuse, with mathematics in the role of the abuser. Mathematical success and pleasure are even more exceptionally described in emotional and relational terms.[5] The few exceptions include Early's (1992) work on experiences of mathematical challenge. He encouraged his students to record their phantasies of challenge and then conducted a Jungian analysis of them. Looking for timeless and universal themes, he read their phantasies in terms of alchemical processes, through which they were trying to turn ignorance into gold. One particularly memorable student phantasy was: "I felt as though I was jumping rope on a razor blade, and with each jump blood trickled onto the blank paper below me." (p.15). Other exceptional examples of work on the emotional and relational pleasures of mathematics are Burton's (forthcoming) work on professional mathematicians (although this does not adopt a psychoanalytic perspective), Walkerdine's discussion of the desire for certainty (see section 3.4.1) and Cabral & Baldino's Lacanian readings of students' engagements with mathematics and of the place of desire in these (Baldino & Cabral, 1998, 1999; Cabral & Baldino, 2002).

I have been inspired by these and other psychoanalytic material to produce the stories that follow. Most of all in constructing these stories I have been influenced by Pimm (1994). He looks at unconscious elements in the learning of mathematics by studying the metonymic/metaphoric associations and slips that are ever-present in mathematical discourse. These links are often denied but add to 'meaning' in mathematics. He argues:

[4] "The psychoanalytic concept of splitting, like that of repression, has a narrow, technical use as well as a broader metapsychological and metaphoric meaning. Just as repression became a paradigm for a larger cultural process, so might splitting be suggestive not only for individual psychic processes but also for supraindividual ones. Technically, splitting refers to a defense against aggression, an effort to protect the 'good' object by splitting off its 'bad' aspects that have incurred aggression. But in its broader sense, splitting means any breakdown in the whole in which parts of the self or other are split off and projected elsewhere. In both uses it indicates a polarization, in which opposites-especially good and bad-can no longer be integrated; in which one side is devalued, the other idealized, and each projected onto different objects." (Benjamin, 1988, p.63)

[5] Interestingly such descriptions are more common outside of the field of mathematics education research, in fictional and biographical accounts of mathematicians (for example: DeLillo, 1991; Doxiadis, 2000; Hoffman, 1999; Nasar, 2001).

> The looseness and gap between symbol and referent, regularly exploited for mathematical ends, also permits such slippage to a far greater extent than in other disciplines. 'Circumscribed' is very 'close' to 'circumcised' and the connection is not arbitrary. Teenage girls working on the period of a function can and do make overt connections with menstrual periods.[6] Adolescents can become preoccupied with freedom and constraints upon themselves, and geometry can offer them the possibility of working with the same material as well as the same terms. (p.46, footnote added)

Pimm focuses on an example where a girl misremembers the word infinity as fidelity. He reads this as having both a sexual association in the discourse and one relating to romantic dreams of never-ending love. This is another approach to coming to understand doing mathematics as working on the self. It is one which adds a further psychic twist to the central theoretical engine of this thesis that the choice to do mathematics and the ways in which one engages with the subject can be read as ways in which young people do identity work. The stories that follow are attempts to understand mathematical pleasure as the pleasure of engaging in the different kinds of work on the gendered self that happens through mathematics.

7.2.1 Analia's story

Analia Kasersoze chooses her pseudonym to be a postmodern mixture of the exotic and popular culture (the surname belongs to the mythical underworld presence in the film *The Usual Suspects* (McQuarrie, 1995)). She is a Turkish Cypriot and a Muslim "but only up to a certain point, 'cos I don't wear a headscarf and all that." Her mum is a housewife and her dad a civil engineer and architect. At Westerburg she is studying biology, chemistry, history and mathematics.

In her interview talk and in my observations of her, Analia appears determined and highly motivated. Her "motto is: 'if you fail to prepare then prepare to fail.'" At the start of the GCSE history course her teacher wrote this on the board, adding "'I can only give you the resources, I can only give you the knowledge, whether you choose to take it or at what point you choose to use it to, it depends on you.'" Analia has a second "motto" for "when it's coming up to exams: 'now or never.' I pin it up right in front of my desk: 'now or never.' So you gonna do it now, or you gonna fail?...You know, if something's gotta be done, you've gotta do it." Analia works hard and, aware that it makes her different, she speaks about it ironically: "I enjoy my work. It gives me something to do at home." She laughs, "takes your mind off things...Homework's good. Lots of it!" She also enjoys answering questions in class: "I like it. It gives me a chance to show off that I know something. 'Yeah, I know that!'... You prove yourself, don't you? That's good. I enjoy

[6] I did when I was a teenage girl.

that." Given the status of mathematics as a proof of self (explored in Chapter 6) it is not surprising that the subject is central to Analia's intellectual identity project.

Mathematics represents a wanted and needed challenge to Analia. It "will always keep my mind on tiptop...condition...there are times when it's difficult, but what's even more rewarding than being difficult is to find out where the difficulty lies. That's the biggest reward. If you give up, then yeah you've lost a challenge...you know, you're gonna look back and [say] 'I didn't do that in my lifetime.'" Mathematics is "self taught...you can find out your errors and even work out your own method," and "you get satisfaction if you find out the methods. Once you can do it, you can always do it. And that's, like, the biggest reward." These comments suggest that her pleasure derives from a sense of her power to create mathematics, from the ownership that she feels once she has **mastered** something, and from the certainty that things, once mastered, stay mastered forever.

Analia connects her pleasure in mathematical certainty to the nature of mathematics and the ways that it differs from humanities subjects. "What I enjoy about maths is the fact that you can sit down and open up a page of exercises and...you wouldn't have to write a long essay, you'd have symbols, it would be, like, quick into it, find out the solution, work out the method, use it over and over again, if you get it wrong the first time, if you practise you'll improve, and it's all about how your mind works. You start focusing onto a question. You see...in history or English there are several answers to one question, but in maths there's only one answer."

Analia's attachment to certainty and her individualistic and competitive approach to academic work resemble the performances of masculinity discussed in sections 5.2 and 6.2. As with Toni (see section 6.2.4), Analia's feelings about gender suggest that the fact of her femaleness produces tensions with these performances. Although this is evident in what follows, my purpose in telling her story is different. I generate a relational story about what it is that attracts Analia to mathematics. To do this I set what she says about her academic self alongside what she says about her gendered self in order to make sense of Analia's earliest memories of doing mathematics:

> *Analia: I remember how I learnt to do my multiplications. My dad told me to bring my marble box and do multiplication, and he had some marbles and he showed me it, and I remember I used to go to the shop with him and he used to find these little subtraction and, um, adding books, you know, they would be like thick and they'd have like five questions on every paper, 2 + 4, or something. You know, you used to get, you used to do them and take them up to him and he'd go 'oh, well done! And those others, well done!' and you'd think 'wow!'*

Analia tells me that gender has "made a big difference to my life." She laughs, "Right, I'm gonna be a bit honest here. Like being a girl in my family. I'm the only girl in

the whole family. I have no girl cousins, I have no girl aunts or whatever, well I do have aunts that are married to uncles, but you know no family type, you know the same blood...Of course, I'm gonna study, I'm gonna go to university here and of course I'm gonna get a job...But I know that when I come through that, I'm gonna get married as well and that, and I will most probably give up my job and I will be at home and I will look after the kids...So that's why I think a girl loses out, whereas a boy, he, he'll go to work. And I know it's a bit traditional and all that, but I'm OK with that, I don't think it's, um, a big problem, I'll accept that yeah. So I'm, I'm perfectly happy sitting at home all day, so," she laughs, "not doing any work." Analia's imagined future here stands in stark contrast to the Analia who is concerned earlier in the interview that "if I didn't do maths for a month, I think I might become really lazy."

Analia goes on to discuss the gendered policing of sexualities: "boys can do certain things and like it won't give them a reputation but for girls it will give you a reputation. For example, me, I don't go out with any boys. Um, er, I am very flirtatious, but...I think that's because I don't go out with any...Like I'm trying to keep my purity to me because I know that the man I wanna marry isn't going to be someone who would like a wife that's been about." Here Analia acknowledges the tension that this double standard creates for her (one that seems disturbingly similar to that described over 20 years earlier by the girls in Lees, 1986). These tensions around her sexuality are found in her reasons for not doing physics. She first gives me a reason when we are discussing her subject choices, explaining this in terms of her need for variety, "'if I chose to take physics as well, then that would just be three sciences and maths, and...that might tear me down too much, yeah. 'Cos consistently [working] in the same sort of methods, and stuff."

Later when we are talking about gendered subject choices Analia gives me a different, less 'rational' reason: "I was thinking of taking up physics, but I thought a class full of boys might distract me a bit too much." She laughs.

"That's the reason?"

"Yeah, I thought physics, too many guys and so I thought 'no!' My hormones might start playing up or something, I thought best to leave it."

In another example Analia recalls, "I've had a guy that I've liked for a year and then after about a year he noticed me as well, and he started to like me as well, and then he came to ask me out and I looked him in the face and said to him 'I can't, I'm sorry, I know I really like you, but I can't go out with you 'cos I won't feel like going home at night and looking at my dad, who's got like, starting to have grey hairs and you know, seeing his face you know, all crinkled,' beginning to get crinkled, because my dad's not ninety," she laughs.

"'I can't sit at the table and eat with him you know it just won't feel right to me, because like I carry a name, I represent something, I represent my family,' and I feel that, um, if I did do anything bad, which sometimes I'm very tempted to do as well," more laughter, "I know that it will not only damage me, but it will damage them far more. And that's why. So, but I think it's right, although it's difficult, but it's right, so I have to be stronger...And I accept that. I ain't got a problem with that. I'll just carry on being really saucy and flirtatious and then reject everyone." Again she laughs, "It's fine with me and I think it gives me character as well, it makes up who I am...I enjoy being who I am."

Analia draws here on 'traditional' discourses in which the woman is seen as custodian of her family's, in other words her male relatives', status. Her honour is their honour. Yuval-Davis (1997, p.45) explains that many ethnic identity projects depend on a notion of 'authenticity' which:

> Assumes fixed, essential and unitary constructs of cultures, identities and groupings. 'Authentic voices' are perceived as their true representatives...Women especially are often required to carry this 'burden of representation', as they are constructed as the symbolic bearers of the collectivity's identity and honour, both personally and collectively...A figure of a woman, often a mother, symbolizes in many cultures the spirit of the collectivity, whether it is Mother Russia, Mother Ireland or Mother India.

This position seems to be more critical for Analia because she is the only girl in her family, and perhaps also "because of the rigidity and 'freezing' of cultures which takes place in diasporic communities" (Yuval-Davis, 1997, p.46). The understanding here, of her academic choices as collective acts, contrasts with their inscription as individual ones within her "mottos" discussed earlier.

However, Analia connects her emotional and sexual restraint not just to her 'public' role as a representative of her family but also to her 'private' feelings for her father. Her earliest memories of doing mathematics (quoted earlier) are also associated with her father, particularly with gaining his approval. As a child, Analia remembers that she was rewarded with love and respect from her father for success at mathematics. This leads me to conjecture an alternative reading of her attachment to mathematics. In this reading what she works on through doing mathematics is her imagined relationship with her father; within this work, she wants certainty from mathematics and finds pleasure in this because it gives her certainty in this relationship. Clearly such a reading is speculative and my connections are not ones made by Analia (although this could be said of all my readings and she did nothing to object to it after I e-mailed it to her). I use it to open up possibilities for looking differently at what students are enjoying when they do mathematics. This is a project that I continue in Jonathan's story.

7.2.2 Jonathan's story

Jonathan lives with his mother who works as a "specialist nurse." He has spent the last two years in Uganda, "my country of origin," interrupting his GCSE work and taking O-levels instead. He is now at Sunnydale studying A-levels in art, mathematics and physics. As with Analia's story, I begin by discussing what Jonathan tells me when I ask him how he feels about mathematics and I then read these feelings as tied to the work on his self-in-relation that he does through mathematics.

It is evident from Jonathan's interview that he takes pleasure in mathematics. During his O-level "I enjoyed all the topics that I studied," but he most enjoyed the work on trigonometry, "I found it easy and it was a challenge to me...Trigonometry's just really about the manipulation of data, which you already have and that's something which I like to do so it's something which appealed to me. That's why I think I found it easy because it did appeal to me." The idea of applying material that you already have is central to how Jonathan characterises mathematics and to the pleasure that he gets from the subject. He first introduces this theme, in terms of the manipulation of known and unchangeable rules, when I ask him whether he thinks that mathematics is about learning rules or understanding why rules work: "I see mathematics as, as learning the rules and then applying the rules. And that's the way I see mathematics. That's why, um, I think that's one of the reasons why I do like mathematics more than other subjects because...it is about applying stuff that you already know."

Jonathan uses this idea to compare mathematics with other subjects. In his opinion mathematics is similar to physics because the latter "is also about learning rules and applying rules." However mathematics is different from the humanities, "there's subjects like history and geography and that's just about memorising what you're told. And I don't really like that, I like, um, technical subjects where you have to really think and apply." Art too, which "is about learning [the] rules of drawing and stuff like that and then learning how to break the rules," is very different from mathematics where the rules are fixed. Jonathan returns to this idea when he is explaining to me why art is taught in a different way from his other two subjects: "Art is a totally different subject from mathematics. The rules which are applied in art are, are not mathematical rules. Well some of them are. And, but generally they're not mathematical rules. They're rules on perspective and stuff like that. So it is taught in a different manner."

As well as arguing that different teaching styles are appropriate to different subjects, Jonathan tells me that he adopts a distinctive learning style for mathematics which "is the only [subject] which I really like working by myself in." In mathematics, "I really tend to

work individually but I don't have a problem sharing my work with other people...But, I really prefer to work on my own." He prefers this way of working in mathematics because "I can concentrate fully on what I am doing, I can focus my mind. 'Cos if I'm working with other people my mind is always distracted by other little things what people are saying and what's going on. But when I'm on my own it's just like, it's just me and the work and there's nothing else left." He again draws on discourses around applying rules to explain why he likes working in groups for physics but not for mathematics: "because physics is, is like, um, you're given a statement or a set of rules and you're given a situation and you have to see how those rules work within that situation. And it's like there's many ways that the rules can work, so it's like there's, there's lots of room for discussion and everybody can have like a different idea. Some ideas do make a lot of sense and it's like you, you might think it's working, it works only in [one] way, but then someone else might come along with something else and you can see, yeah that, that also works. And it's just like you've got all these different rules that work that can be applied to the same situation." Here Jonathan is arguing from his experiences that mathematics is learnt and taught in different ways from other subjects not just because there is only one right answer but also because there is only one right method.

Jonathan seems clear and confident about what he is doing throughout our interview. One example of this is his approach to answering questions in class: "It depends really on the topic, if, if I'm really sure about the topic then yeah...I'm up for being asked questions and I enjoy it. But, if I'm not really sure then I'm just scared that I'm gonna be embarrassed if I get a wrong question. Then...if the teacher's asking people to, to give answers in front of everyone else, I'll usually just hold back and let other people answer. So if my answer's correct then I'm just happy in myself but if it's, if it wasn't correct then...I'm just glad that I didn't give my answer to the class." Another example is his sense of ownership over his choice to engage with mathematics at O-level compared to GCSE: "When I did GCSE mathematics it's just like I wasn't really interested in it, I just did it because my parents wanted me to do mathematics. They wanted me to get good grades. But I wasn't really interested in it."

However, Jonathan left Sunnydale before taking the first A-level module in January. In what follows I look for an answer as to why he dropped out so early. I argue that O-level mathematics, for Jonathan, was a way of re-working his relationships with adults, notably family members and teachers, and shifting from a dependent position relative to them to a more equal and autonomous one, and that this kind of work was no longer possible in his Sunnydale mathematics class. This is a shift that is evident in the last quote, a move from doing mathematics for his parents to doing it for himself.

Jonathan's time spent in Uganda is central to how he constructs this shift in the space of the interview. The reasons for his move to Africa were "personal [ones] between me and my mum. My mum and myself were having some problems, and she just decided it'd be better for me if we spent some time apart." Going to Africa thus marked a move away from parental authority towards a different relationship with his cousin. Jonathan made the subject choices he did because of his interest in pursuing academic studies and a career in architecture. His initial explanation as to what appeals to him about architecture is that "it's just the creative side of me just designing buildings and making things that look nice." However, when I ask when he first wanted to be an architect he speaks of an additional motivation: "I think that was around '99, something like that. 'Cos when I went to Africa I went to live with my cousin, he's an architect. So I was staying with him and it's just like he influenced me."

Parallel to Jonathan's changing relationships with his family, his move to Africa and experience of different teaching styles marked a change in student/teacher relationships. Jonathan feels that there were real differences between the teaching and learning styles used and encouraged within his O-level mathematics lessons in Uganda and those associated with his GCSE mathematics lessons in England. While he frames this as a contrast between GCSE on the one hand and O-level on the other, I read it as a contrast between the teaching styles in the two countries with no necessary connection to the examinations. He describes a typical mathematics lesson in Uganda, "you go into class. The teacher would come in. He would tell us what we're gonna study in the lesson and, um," he pauses, "give us a couple of examples on the board, just give us the basics of what we're supposed to learn and then he'll give us a couple of questions to try out." The way the teacher presented only the basics of each topic meant that students were expected to display a great deal of independence in their study habits. Jonathan contrasts this with the dependent attitudes that he saw cultivated in his GCSE classes: "O-level maths is, is really about, um, studying by yourself, learning the things by yourself, and GCSE maths is just really like studying in the class. The teacher tells you something and you just write it down. And that's what you're supposed to remember. But O-level maths is like: you're told something and then you're told to go and do your own research on it and find out some stuff about it…I enjoyed the way I was taught the O-level maths more because it focused me more." This teaching pattern made it possible for Jonathan to occupy a new and more responsible position relative to his teachers and to mathematics.

Jonathan thinks that his current teaching is more like that of the O-level than it is like that of the GCSE. However, when I ask him to compare the A-level and the O-level he comments: "The only difference that I can really say is just that, um, the A-level maths

does not go into as much detail as the O-level maths and the subjects covered are not as wide as the O-level maths syllabus." He is happier with the way that he is being taught art than with the way that he is being taught mathematics: "'cos the [art] teacher does encourage me to do the work in the class. Meanwhile...with mathematics I'm just used to doing the work on my own so in class I don't really pay attention I'm just like racing ahead doing the work and then if I get stuck, that's when I, I call the teacher over." Thus although, as I discussed earlier, elsewhere in the interview Jonathan explains the different teaching styles in his A-level mathematics and art lessons in terms of the nature of the subjects, what he is saying here appears to contradict this. Here it seems like his O-level mathematics lessons have more in common with his A-level art lessons than with his A-level mathematics lessons. This suggests that the space that was there for working on autonomy is lost and this is perhaps why he left the course. Maryam's story is also about the loss of possibilities for particular kinds of identity work accompanying the transition from compulsory to post-compulsory mathematics.

7.2.3 Maryam's story

Maryam is "half English, half Egyptian, my dad's Egyptian and my mum's English." Her mum works as a classroom assistant in Maryam's old primary school, and her dad owns two businesses. She is studying for AS-levels in economics, mathematics, psychology and sociology at Westerburg. She is interviewed with her friends Nabil who is working-class and Bengali and AJ who is middle-class and Indian. Of the three Maryam displays the strongest identification with mathematics in the interview. When I ask her about her subject choices she explains, "maths was my first, [the] first one that I knew definitely that I was doing [was] maths, but the others I didn't know if I was gonna do them or not. It took me ages to decide. Maths because I do love maths...I just think it's, it's like everyone has a subject that they, not even that they like, it's just that, not hmm, not good at either, it's just," she pauses.

"What about your other subjects?" AJ interrupts.

Maryam continues her previous train of thought, "it's just natural."

"Is it something you feel comfortable," I begin to ask.

"Yes, it's something I feel comfortable with. Maths was my subject. And everyone knew that. I just love maths, sad, but true!" (The gendered implications of this comment are discussed later in this story.)

The assurance with which she speaks about her choice of mathematics contrasts with the doubt in her discussion of her other choices. She is unsure of what career she wants to pursue. She has abandoned an earlier plan to be a primary school teacher because

she now considers teaching "the most stressful job." She expresses some interest in business and in law, and then adds "I wanted to be a psychiatrist at one point 'cos they make enough money, but I'm still not sure." The uncertainty is also clear in the reasons Maryam gives for selecting her other subjects: "I picked economics because I done business GNVQ in year 11 but I didn't want to do business studies at AS, but I wanted to do something similar;" "I just think [psychology's] one of the best subjects you can do and it's really popular here...and we've never been taught anything like it in GCSE;" "if you learn about sociology you learn about...why people are doing that and you live in a society so you need to know these things, 'cos we never got taught that at GCSE either." So mathematics is Maryam's only continuity between her studies at GCSE and her sixth-form studies.

However, her relationship with mathematics is complex. She "loves" mathematics but also "think[s] that it's generally not that interesting, like to, even to me, it's generally not really that interesting, but it's just, but I enjoy it, if you get me, I know that seems to contradict myself." There are two ways of making sense of this apparent contradiction. The first is to look at the context. This comment comes immediately after Maryam explains that mathematics "doesn't show your creative side at all it just shows...your understanding and how to apply things." This makes it different from her other subjects: "With psychology it's more like activity work and group work, and sociology as well, and maths, you can't really do that. You've got to work as an individual. There are some times when you can like look at new topics and research them in groups or something like that, the majority of the time you're working alone and that's just the way it's got to be. 'Cos you've got to have your own understanding." Maryam summarises what characterises mathematics in distinction from her other subjects: "It's either right or wrong. There's no two ways about it." So the 'contradiction' arises because mathematics is both Maryam's favourite of the subjects that she is doing and the one that does not fit with her pattern of preferences for ways of working and subject matter that generally stress the creative and the collaborative.

Second, it is even clearer in Maryam's story of mathematical pleasure than in either Analia or Jonathan's, that what she is enjoying is not the subject matter itself. So the 'contradiction' in her account can be understood as arising because of how difficult it is to talk about enjoying mathematics for any other reasons. I speak about what it is that Maryam is enjoying in the rest of this story. I look at the pleasure that Maryam found in GCSE mathematics and at why she no longer finds this in AS-level mathematics. Up to now mathematics has been a place of safety for Maryam, a transitional object or 'security blanket' (see section 3.6.1), and this is disrupted by her experiences of AS-level. There are other stories of loss in this study, in the participants' accounts of their relationships with

mathematics (such as Jonathan's), but Maryam's was the most striking because of the dramatic nature of the change. In a few months she went from a lifelong "love" of mathematics to a position in which she is eagerly awaiting being able to drop it after the first year modules.

Maryam's memories of GCSE mathematics are dominated by her final year when, as a result of the group being behind schedule, her teacher imposed an unusual pattern of teaching and learning on the class. "The class was split up into two [mentors and mentees] and then the mentor would have to sit next to their mentee and then they'd have to make sure that they did their homework and everything, and like that they're understanding the work. And then the mentors would go to extra class on Saturday mornings and we would learn the topic and we would have to teach it to the class on Monday." It is clear within Maryam's discussion of this scheme that she gained a lot of pleasure from it. She says that she was "flattered" to be chosen since "our teacher just picked the more cleverer people to be mentors." Being a mentor was a powerful position for Maryam and this is evident in her talk about what she has enjoyed most about mathematics: "You know, I was saying like how we used to get up and teach the class. I, I always really enjoyed it, 'cos out of English, maths and science, anyway, my best subject was maths, and it's always been my best subject...and I used to be the best at explaining to the class, I'm not being bigheaded [to Imran and AJ who are being sarcastic] but I was, I was, you can even ask Shakilah and everyone used to call me, like, 'second teacher' and everyone used to say to our teacher how I'm gonna take her job...And I really enjoyed it 'cos everyone understood." Maryam's role as a 'sub-teacher' (Walkerdine, 1998) gave her access to a power that few students have within mathematics classrooms. She took pleasure in this and in the caring aspect of her role, making sure that "everyone understood" (Gender and Lifelong Learning Research Group, 2003). Her use of the word "always" here suggests that this powerful position was consistent with ones she had occupied in her previous experiences of learning mathematics.

The contrasts, between Maryam's feelings at GCSE and her feelings at AS-level, are stark. When Imran mimics her saying "'I'm the best'" her response succinctly captures this change: "I am! I used to be, sorry." The sense of loss that she is feeling, even after only three weeks of the course, is evident in this extract: "I used to be the, like proper, like the best. I'm not being funny, I used to be the best in my class and now I've come here...I was the closest to an A* out of everyone. But I didn't get it by a few marks." At Westerburg she feels stupid: "it's like, I'm at like the bottom of the class." I now look at what Maryam says about her new group in order to explain this change.

Maryam begins talking about how she feels in her AS class when I ask about whether the gendered composition of the group bothers her: "It does actually, because like most of

the guys there are like really, really clever and I think if there was more girls to balance it out, then it would be...less tense 'cos at the moment it's quite tense 'cos all the boys, especially boys they like to compete with each other, and I think that...most of the people on the back row, anyway, are competing with each other and like, which makes them go faster, which makes you want to go faster because you feel like you're behind." Maryam projects both 'ability' and competitive spirit onto the boys in the back row. This is a process that does not seem to be based on the actual 'abilities' or behaviours of the boys in question but one that is made possible by, among other things, the gendered discourses discussed in Chapter 5.

This has negative effects on Maryam's ideas about her own 'ability' and confidence at mathematics. "It makes you feel a bit like: 'well, why don't I know about this?' But it's not like you're low, it's just that they're really, really high...And if the majority of the class is understanding it better, then the class will go faster. But, but I do enjoy the maths lessons and I do think our teacher's good and I think she does like, she does go through it on the board...all the time and she's making sure that we understand. I know she knows that there are people that are high, that are faster than us and some that are slower, and she's trying to like get the balance, but still I think it's like the class is divided whether people are like on the just normal starting AS-level and some are really higher...It's quite intimidating sometimes...I feel sorry for them 'cos like, if we're, I feel bad that we're holding them back and I don't want to hold anyone back but at the same time I don't want to be left behind."

Again Maryam is projecting feelings onto the boys in the back row. She imagines them as unhappy with her for slowing the group down. This is in contrast with her mentoring experience where her class was divided and she did not feel held back by helping others to understand but indeed identified this as what she most enjoyed about those lessons. In addition to the gendering of the current divisions, there are two important differences between the divisions in Maryam's GCSE class and those in her AS class. First, in her GCSE class Maryam was positioned on the knowing side as an authority and a helper rather than as unknowing and helpless. Second, the discursive practices surrounding the divisions are different. In section 4.4.1 I discussed in detail the motivational practices encouraged by Mrs. Sawyer, such as her stress on working quickly, the public reading out of test marks, the active encouragement of within and between group competition, and the constant talk about some members of the group being more 'naturally able' than others and some being 'badly prepared' by their schools. These explain some of Maryam's distress and help to explain what she has lost in the transition from one mathematics environment to another.

Maryam, AJ and Imran's discussion of the competitive dynamic of the group in the interview, ends with a defensive strategy. All three agree that a sort of social deviance attaches to being too good at mathematics and project this onto the boys in the back row. They conclude that they are happier not being as mathematically brilliant as these "nerds" (an excerpt from this discussion is given in section 5.4.2). Bibby (2001, p.128-129) suggests reading such presentations of the 'mathematically able' as part of a psychic defence on a social scale:

> The existence of a level of mathematics which is 'other' generates dissonance and discomfort: I feel that school maths should give me direct access to academic maths but I fail to make it do so. As a result mathematics and mathematicians become a cipher for difficulty, complexity, and incomprehensibility, feelings which disconcert and lead to dis-ease. A defence against this discomfort might be to belittle or mystify that thing that can not be engaged with and so the mathematics of mathematicians is laughed at (Professor Branestawm), dismissed as freak (Dustin Hoffman's 'Rainman', Stephen Hawking), or mystified (Numerology).

Most young people, like Maryam and her friends, are keen to distance themselves from the 'nerd' stereotype. However, some actively locate themselves within its boundaries, as does Phil, the subject of the last story in this section. I use his story to explore the identity work involved in such positionings.

7.2.4 Phil's story

Phil, a working-class Chinese Grafton student, is studying English literature, physics and Information Technology alongside mathematics. When asked what he has enjoyed most about mathematics, he is among a few participants who select a specific topic and speak about a fascination with the subject's power rather than about the ease with which they can do mathematics: "It's quite interesting as well and stuff, stuff that you never thought of, you use mathematical methods...I liked integration...the fact that you can work out the area under a curvy graph...it's just stuff that I'd never thought of before." His rejection of ease as a source of enjoyment is explicit in his comparison of GCSE with A-level mathematics: "Well probably [I prefer] the GCSE 'cos it's easier, but A-level, actually I prefer the A-level 'cos it's more thinking." He later reiterates his intrinsic interest in the subject; "I find maths quite interesting the way numbers and things just link up with each other." Phil prefers mathematics to English whose GCSE examinations he disliked because they involved "too much writing and there was no set answer."

This position is not one that many people occupy relative to mathematics. As has been demonstrated, this study and similar ones of A-level mathematics students (for example, Burton, 2001) suggest that the majority of people identify with the subject via

extrinsic properties, factors that relate to how it is valued, for example, as difficult and hence a challenge, as a source of future earning power, or as a necessary stepping stone to a future career. Even for those who take pleasure in mathematics itself, there is normally an elision of ease and enjoyment. As in the three previous stories, here I want to read Phil's pleasure in mathematics as pleasure in the identity work that he does through it. In the passages quoted so far Phil frames his attachment to mathematics and its certainty as cognitive and rational. However, in what follows I deconstruct this reading of his mathematical pleasure by looking at the affective and the emotional and, in particular, how, through Phil's claim to enjoy pure mathematics, he also claims an intellectual maturity and a cultural identity.

Moving into the sixth-form seems to have been an important transition for Phil. He explicitly links this to the way the more immature 'laddish' elements have left: "It's a nice comfy atmosphere. There's no immature people mucking around like you get in GCSE, you just get your lesson." Phil attaches importance to being able to joke around, as distinct from muck about, in class. What he enjoys least about mathematics is "when it's getting a bit too serious. We have the odd joke, now and then, which lightens the atmosphere." Phil's construction of himself as intellectually mature is gendered. It is reminiscent of Redman's (Redman & Mac an Ghaill, 1997) account of his own experiences of schooling, where at 16 he became aware of the possibility of a masculinity based, not on aggression or sporting prowess, but on a "muscular intellectualness" or being able to push people around with your mind. Redman acquires his muscular intellectualness via history and Phil via mathematics.

Mathematics with its intellectual status is an important part of Phil's construction of himself as mature within the interview. He positions himself as self-disciplined in mathematics lessons, "I tend to concentrate a lot when its maths compared to other lessons anyway and I always pay attention in my maths lessons." When asked about what other people not doing mathematics think of the subject, Phil says: "They see it as it's pointless, because you're not gonna use maths in the world, but I don't think they know what maths is about, it's about, if you've got a good grade in maths it shows that you've got a good analytical mind and employers look for people who can do that." As well as being a claim to intellectual maturity, this statement sees Phil leaping to the defence of mathematics, against people ignorant of what it is really about. He positions himself as knowing the truth about mathematics.

Phil's sense of himself as mature also links to his expressing feelings of being out of place in Grafton: "I find sixth form quite depressing...the fact that I haven't met anyone new it's just the same old people...It's a sixth-form but it's in a secondary school and when

you walk round the school...you feel out of place, everybody else is doing GCSE." His identification with mathematics enables him to establish an 'imagined community'[7] (Anderson, 1983) of like-minded individuals beyond the sixth-form's boundaries. I look at this community next.

Phil has acquired a certain amount of notoriety in Grafton's sixth-form for having written a detailed account of the fundamental and mystical role of fish within our culture. One of the things he cites as evidence for his position is the way that the mathematical symbol for proportion bears a striking resemblance to a fish. He suggests founding a new religion based on this fundamental and fishy insight. With his friend Salvador he has written a series of humorous texts about the organisation JFC. The first, quoted from below, is framed as an e-mail manifesto sent to potential customers:

> Being divinely funded by God, JFC is able to establish itself on very firm territory with extremely stable foundations. Once more, our headquarters is very flexible and is constantly on the move in the form of Jesus Fucking Christ himself...
>
> Our very stable capital (funded by God) is able to provide several different commodities.
>
> Firstly, as our very analytical sales department (located in the main area [the head] of Jesus Fucking Christ, in the upper right area of the holy brain), has spotted a gap in the fast food industry in that we believe we can do better than other companies currently on the market. After careful consideration, we have decided to imitate a well-recognised name in the fast food industry, and turn it into a very original and somewhat witty title. There will be two fast food chains, with each specialising in different meat products.
>
> The first would be titled: 'Jesus Fucking Chicken' (or 'JFC' for short). This would be backed up with a TV advertising campaign starring Jesus Fucking Christ himself advertising Jesus Fucking Chicken with cheesy music being played in the background, advertising our main product, which we believe would launch our name as a heavy weight in Fried Chicken fast food chains.
>
> The product to be advertised is our special St. Peter's Feast with a free bottle of Holy water, together with 8 pieces of Fucking Chicken and 4 fries, complete with side dishes of Bread and Wine for only £9.99, with 5% of intakes donated to the Catholic Church. Alternatively, customers could go fuck and order the St. Peter's Fucking Feast for an extra £2 and receive a special JFC big bottle of Red Fucking Wine complete with a practical tub to vomit in, with 10% of intakes donated to the Catholic Church of YOUR CHOICE.
>
> The next fast food restaurant would be titled 'Jesus Fucking Cows' (or 'JFC' for short) with a slogan of 'Now there's an image'.
>
> The commodity will of course be beef cooked in various different ways from our highly trained secondary school students.
>
> We strive to offer complete variation and choice in our products, with beef products ranging from 'Common British', 'Savoury', 'Organic' and our

[7] Anderson (1983) develops this term to theorise nationhood. However, as he and others have recognised, it has wider utility since all communities beyond primordial face-to-face ones are imagined because most members "will never know most of their fellow-members, meet them, or even hear of them, yet in the minds of each lives the image of their communion" (p.6).

> special 'Foot and Mouth infected' beef. If you are not satisfied with British Beef and prefer exotic foreign meat, we also have a wide range of imported 'French Foot and Mouth' beef.
>
> Once you have chosen your beef, it's now time to choose your meal (for further details, contact Jesus Fucking Christ).
>
> Our next commodity lies in the trading industry. We have decided on opening a shiny branch of Fucking banks located somewhere in Central London. Our trading company will be ingeniously named 'Just For Capitalist' (or 'JFC' for short). We believe that with such an appealing name, we would no doubt attract many consumers, employers and traders. Our trading industry would mainly lie in American Churches and Evangelist TV shows, and also the Catholic Church...

I have quoted from this extensively to demonstrate that there is a very particular form of satire operating here. The content and style of the text are reminiscent of Douglas Adams' *The Hitchhikers Guide to the Galaxy*, a cult radio series/"trilogy" of five novels/TV series that, although enjoyed by many, is a marker of identity for many mathematicians and computer scientists. In fact, Phil wants to study computer science at university and mathematics is his favourite school subject. For Phil his identifications with mathematics and computing can be read as being not with these subjects' abstracted activities, but with concrete social practices and their associated cultural objects-such as books, films, games, modes of dress and talk-and with other people who share these practices.

Such identity work can provide safe spaces for many young people, particularly boys (for a discussion of the gendering of this see section 5.4.2). Through the responses of others, it can supply them with intellectual validation as well as allowing them to opt out of specific social expectations. The nomadic asexual life of the mathematician Paul Erdos (described in Hoffman, 1999) provides an interesting, if extreme, example of these processes at work, as does the reaction to Jon Tickle, ex-resident of the 2003 Big Brother house. The latter escaped four eviction votes and was swept back into the house on a wave of public enthusiasm in week 8, through his use of this pattern of identity work and the way that the 'general public' read this as signifying authenticity, originality, intelligence, and lack of emotionality.[8] The Westerburg further mathematics group also contained a group of four boys (Peter, Graham, Will and Jacob) who fit into this pattern and who one of their teachers called "the techies." In one of my lesson observations I saw Peter and Will, two members of this group, pass the note in Figure 3 round the classroom. This is striking in its difference from the notes that are normally passed around classrooms (see Hey, 1997) and substantiates my argument that to understand 'nerd' stereotypes we need to look at

[8] Examples of Jon Tickle fan-sites (accessed on 18th June, 2003) are:
Jon Tickle-the Big Brother legend at http://www.rabid.oneuk.com/jontickle.html
Save Jon Tickle at http://www.geocities.com/sarahabannister/jon_ticklesab.html

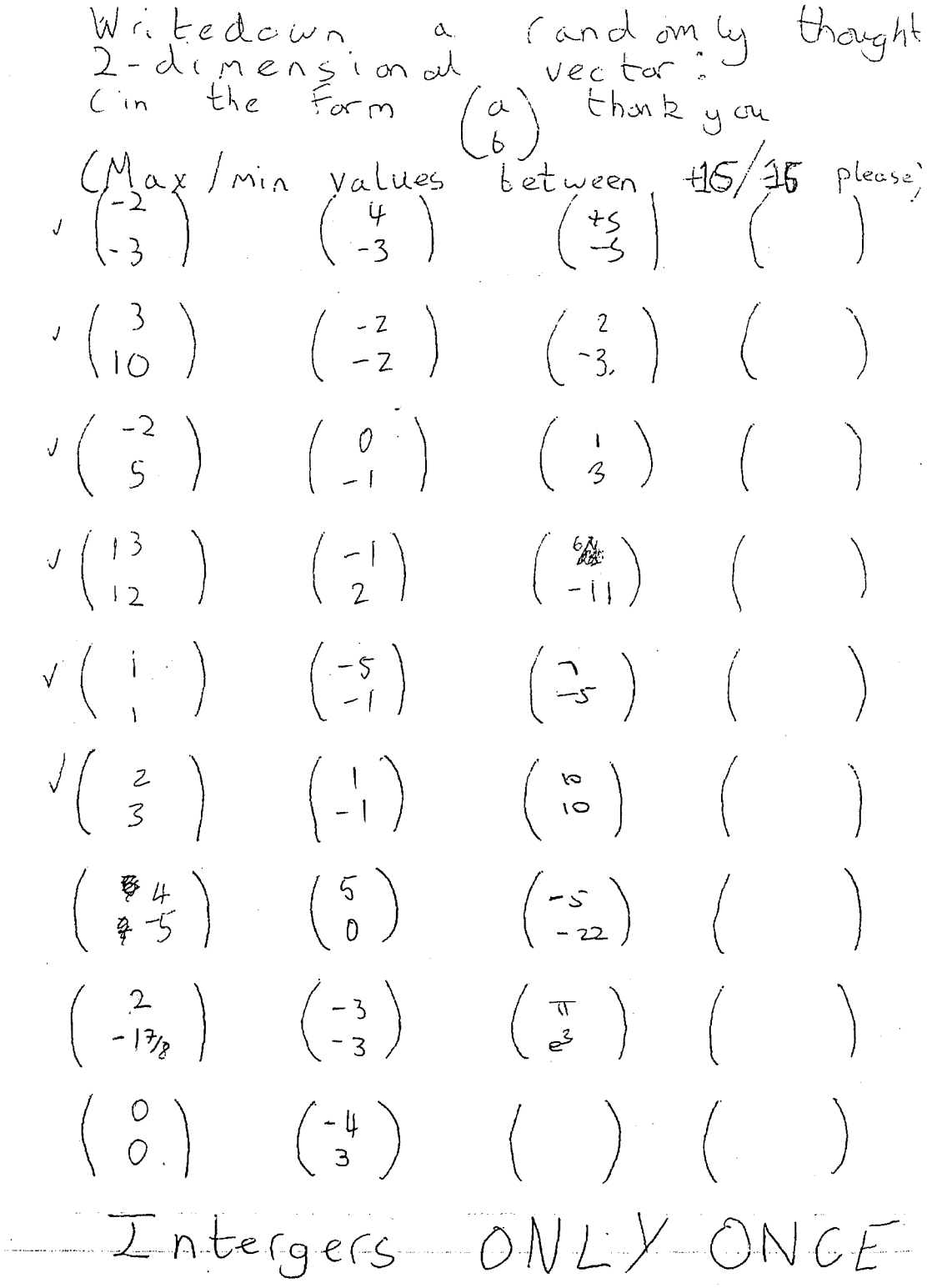


Figure 3: A note passed around the Westerburg further mathematics group.

elements of both ascription and self-identification, that is at the identity work that these stereotypes do for those who construct their boundaries from without and from within.

Thus I finish Phil's story by suggesting two further things this identity work does for him. First, his identification with mathematics enables him to appropriate a particular form of 'cultural capital'. He does this in order to mark his distance from those he classifies as younger and less mature, as discussed earlier, and also from his ethnic and working-class self. Asked about his ethnicity Phil says he was born in this country, but his parents are from somewhere in Asia, "China probably". He agrees that it would be OK to identify him as Chinese. I ask what his parents do for a living. He slurs the word "takeaway," the place where his father works, and, when I ask him to repeat it, adds "shop" as a descriptor. Perhaps Phil, like many of the participants in Parker's (1995, p.103) study of British Chinese identities, is using academic success in order to break away:

> The generation that arrived and grew up here in the last twenty-five years is increasingly viewing the [takeaway] counter as a hurdle to be leapt over as they work on it to secure their escape.

Second, Phil has clear beliefs in the naturalness of differences between people. This is evident twice in the interview regarding differences in 'ability' and in gender. He shows a very clear sense of his own and other's 'abilities' when he discusses collaborative work: "if you have the same ability then it's good to work with other people, but if you have people who are of a higher ability than you or lower, they'll either get frustrated or you'll get frustrated." When I ask him about gender differences in subject choices, Phil says, "I think girls and boys have different abilities naturally" because "the way we develop our brains" is different with girls, in general being more verbal and boys more numerical. This is something that Phil shares with the other five participants who strongly identified with mathematics in their interviews (see Interlude). This is evident in the talk in section 5.2 where Peter, Saldon and Graham construct the differences between maths people and non-maths people as natural and in the views of two of the three, Saldon and Peter, on gender. This suggests that the epistemological certainty of mathematics may have consequences for how young people who strongly identify with it think about knowledge in other areas and that this may provide them with security.

7.3 Conclusions

The stories above consolidate the arguments made in previous chapters of this thesis. They further demonstrate how young people use/are used by the various discourses

on mathematics in doing their identity work and the ways that these processes are gendered. So, for example:

- Analia's story demonstrates (with those in section 6.3) the gendering of the requirement to produce oneself as the ideal neo-liberal subject and the tensions between doing mathematics and being female.
- Jonathan's story demonstrates (with those in section 6.2) how mathematics can be used as part of a young man's intersecting masculine and national identity projects to prove his independence and his employability to others.
- Maryam's story demonstrates (with those in section 5.3) the distinction between being 'good at maths' and being '**really** good at maths' and the gendered effects of this.
- Phil's story demonstrates (with those in section 5.2) the way that some young people use discourses about mathematicians as heroes and geniuses, set apart from the rest of humanity in their masculine identity projects.

However, in this conclusion I want to concentrate on looking at what these stories add to earlier arguments.

In this chapter my main focus has been the question: **For those who enjoy mathematics, what is invested in their identification with the subject?** The four stories that I have used to explore this read young people's pleasure in working with mathematics as a pleasure in working on their psychosocial-self-in-relation. In these readings of mathematical activity:

- Analia works on her relationship with her father and takes pleasure in the certainty in this that she gets from mathematics.
- Jonathan works on his relationships with adults and takes pleasure in moving to independence from his parents and teachers through mathematics.
- Maryam finds a safe space in mathematics, a refuge from the anxious world and one through which, previously, she built peer relations from a position of power.
- Phil finds a security in mathematics that enables him to construct himself as intellectually mature and as distant from his working class, minority ethnic self.

Thus, I have argued that what these young people get from mathematics are opportunities to develop relations with others and to re-make themselves. My aim in telling the stories in this chapter (and thesis) has **not** been to tell the 'truth' about this study's participants. Although these stories are firmly grounded in my data, they could all have been told differently. My purpose has instead been to open up possibilities for multiple ways of being

in the mathematics classroom. So the main conclusion from this chapter is that, in understanding what is happening when people are learning mathematics, we need to be sensitive to all the varied things that students may or may not be doing when they do mathematics.

Of course, it goes almost without saying that identity work is not all people do when they do mathematics. They can also, for example: prove things about abstract algebraic structures, calculate what the shopping bill comes to, program computers, or pass examinations. My aim in relegating to the margins these normally centralized outcomes is to stress that these aims are **never** separate from other less 'logical' ones and so to deconstruct three binary oppositions that give mathematics meaning:

OBJECTIVE/SUBJECTIVE

RATIONAL/EMOTIONAL

ABSTRACT/RELATIONAL

When we locate mathematics as objective, rational and abstract we are not impartially describing it. We are telling historically and culturally specific stories about mathematics. These are hegemonic stories and ones that, I have argued in this thesis, have inequitable effects. These are oppositions that maintain a distinction between separated and connected ways of doing mathematics and between the cognitive and the affective realms in mathematics learning. It is apparent from the stories in this chapter that while the language students use to describe mathematical pleasures is understandably drawn from these dominant discursive repertoires, very different readings of that pleasure can be constructed when their interviews are taken as a whole and read psychoanalytically. In this sense too, this chapter both consolidates and extends the earlier ones, for this applies not just to the stories of Analia, Jonathan, Maryam and Phil but also to all the stories in this thesis including my own in Chapter 1.

By focusing on finding the subjective, the emotional and the relational in the actions of students who often talk explicitly about being drawn to the objective, the rational and the abstract, in mathematics, I do not hope to switch halves in the above binaries but to move beyond them. This would contribute to a re-figuring of mathematical reason expressed well by Povey (1995, p.202):

> It is a reason which permits, for example, metaphoric thinking, that acknowledges that knowledge is contextual and not universal (see Walkerdine 1988, especially p183-201, for a discussion of these attributes and 'western rationality'); a reason that is interwoven with emotive thought (Belenky et al 1986, p134) rather than distanced from it; and, crucially, a reason that attempts to integrate personal knowledge with the knowledge of others. It recognises and embraces the need for negotiating shared meaning and for constructing

> 'argument' in a multiplicity of ways, attempting to interrupt the objectification, the formality and combativity of 'Reason' and helping one remain 'paradoxically aware of one's complicity in that which one critiques' (Lather 1991, p10).

In the concluding chapter I focus on some of the implications of working with this re-visioned reason.

Chapter 8 Conclusions

Only connect. (Forster, 1941, p.3)

In this chapter I draw together the ideas raised in my explorations of the words and actions of this study's participants. First, I summarise my answers to the research question: **how is it that people come to choose mathematics and in what ways is this process gendered?** Second, I consider directions for future research. Along the way I discuss both what my research has to offer and its limitations.

8.1 How is it that people come to choose mathematics and in what ways is this process gendered?

This question is important because of the persistence of gendered patterns of participation in mathematics, and because, at its centre, is a particular instance of a general phenomenon, that as society becomes more individualised (Beck, 1992; Rose, 1999a), choices are increasingly seen as asocial acts. My starting point for asking this question in Chapter 1 was the desire to investigate the way in which unjust social relations are reproduced through individuals', but not individual, choices. My starting point for answering this question was the argument that what matters is the position you occupy in relation to it. I made this argument in Chapter 2 and in the *Prelude to Chapter 3* and then, in Chapter 3, I described the advantages and disadvantages of various ways of positing this question from different theoretical locations. This analysis built to a discussion of my own particular theoretical lens that draws on feminist, post-structuralist, and psychoanalytic work. The four subsequent chapters of the thesis strengthened the argument for the value of this particular theoretical location by applying the analysis to my empirical data. In this section, I review the answers I have developed to my research question by examining three ideas that are central to this theoretical way of seeing. These ideas run through this thesis, interweaving theoretical and empirical work. They are:

- Choices are identity work.
- Doing mathematics is doing masculinity.
- Mathematics is a social practice.

In what follows I link these ideas to existing literature and point out the contributions that my own research makes.

8.1.1 Choices are identity work

My approach to choices starts from the idea that they are inseparable from our 'identity', that is identity is something that we are constantly producing in and through our choices. Using Butler's (1993a, 1997, 1999) work I argued that this process turns everything around so that it feels as if it is the self that produces our choices. My study is thus part of the growing body of work on post-compulsory educational choices that critiques rational choice theory by emphasising the parts played by serendipity, the unconscious and the 'irrational' in determining young people's educational careers. For example, Ball et al. (2000, p.40), critiquing the dominant vision of the technically rational chooser implicit in government policy, write:

> Identity work is hard. 'Being yourself' and 'becoming somebody' is troublesome, troubled and on-going...False starts seem the norm, set-backs are common, and the social and domestic aspects of 'choice-making' are often more important than the educational.

In this literature, the focus on identity work is accompanied, as it is in this thesis, by attention to how social factors such as gender, class and race/ethnicity influence choices. Even 'luck' and the workings of the unconscious are understood as being constructed by the very particular socio-cultural contexts in which they operate. In other words, while choices may be experienced by young people as independent of class and gender, qualitative and quantitative research attest to their continuing impact on educational careers (Furlong & Cartmel, 1997). My thesis adds to this contemporary literature in two key respects, one empirical and the other theoretical.

Empirically, my research provides data that enhance our understanding of how subject choices happen. The current literature on post-compulsory educational choices is dominated by material on the pathways and directions taken by young people and, in particular, on:

- Choices of academic vs. vocational routes (for example, Ball et al., 2000).
- Choices within the vocational education and training framework (for example, Bloomer, 2001; Bloomer & Hodkinson, 1999, 2000; Hodkinson et al., 1996).
- Choices within the higher education marketplace (for example, Brooks, forthcoming-b; Reay, 1998).

Within it, subject choice has been dealt with only peripherally. In contrast, subject choice at post-16 is at the centre of my research. Given the recent increase in the numbers studying for A-levels, the introduction of the AS-level qualifications and the fall in demand for mathematics, the analysis in this thesis is particularly pertinent.

Theoretically, my approach to identity also adds something new. The work discussed above has generally taken its version of the self from Bourdieu (see Bourdieu, 1984) albeit influenced by Foucault. Bourdieu's ideas of habitus and field attempt to move beyond the social/individual dualism but in fact, I would argue, over-stress the impact of social structures (Jenkins, 1992). Seeing the social within the individual and the individual within the social is at the heart of the theoretical approach to choice used in this thesis. It has enabled me to draw on the best of other approaches in order to look at the ways that young people make themselves in conditions not of their own choosing, focusing on the contradictions and conflicts involved in successfully producing oneself as male or female.

8.1.2 Doing mathematics is doing masculinity

This thesis is concerned with seeing how far the ideas on choice summarised above and discussed in more detail in Chapter 3, take us in understanding what goes on in mathematics classrooms, and further, what young people studying mathematics have to say about the subject. If choices are viewed as identity work then young people, in choosing or rejecting mathematics, are telling us stories about: who and what they are and are not like, and who and what they do and do not want to be like. In doing so they are drawing on what mathematics 'is'. For analytic purposes at least, post-structuralism holds that there is nothing beyond discourse. So when examining objects such as mathematics we must look at the discourses in which they are inscribed; mathematics is what the discourses say it is.

The application of this approach to my data has resulted in coming to understand certain discourses about mathematics and mathematicians as central to the way that students negotiate a relationship with the subject. 'Real mathematics' is different from other subjects; it is certain, rational and hard. 'Real mathematicians' are different from other people; they combine the flattering character of geniuses and heroes with the unflattering character of nerds. These discourses are oppositional and gendered; they inscribe mathematics as masculine. Based on this, and using detailed analyses of individual cases, I argued that boys and girls, and men and women, in doing mathematics are doing masculinity, and so it is more difficult for girls and women to feel comfortable with mathematics and so to choose it and to do well at it.

This is a central argument in this thesis and is the one through which I make sense of the gendering of the choice to study mathematics. That mathematics is masculine has been said before, using a variety of theoretical approaches, and will be said again. However, my study adds to this claim in two significant ways. First, the data presented here provide convincing evidence that the gendering of rationality and genius are not just historical phenomena but permeate the words, thoughts and actions of today's AS-level mathematics

students and teachers. Second, I have broken with the dominant pattern in work on gender and education of using masculinities to describe the actions of men and femininities to describe the actions of women. Since making this argument in Chapter 6, I have been thinking and reading about the implications of describing women as engaged in doing masculinity. The rest of this section discusses this innovative approach that has potential for helping us to break with binary ideas of gender.

The most detailed study of female masculinities is Halberstam's (1998) work that combines historical, "pseudo-ethnographic", pop-cultural and literary analyses. She points out that, while it is often said that it is easier to be a tomboy than a sissy, this is not something that carries through into adulthood. In fact, as she describes, in adolescence a great deal of work is done in drawing previously masculine girls back within the confines of femininity. Halberstam argues that, while "excessive conventional femininity often associated with female heterosexuality can be bad for your health" and "tends to be associated with passivity and inactivity, [and] with various forms of unhealthy body manipulations from anorexia to high-heeled shoes" (p.268), it is masculinity that is commonly viewed as dangerous for women and girls. She concludes that there is a need "to make masculinity safe" for us:

> Although it seems counter-intuitive to suggest that such a project should be necessary in the 1990s, it has been my contention that despite at least two decades of sustained feminist and queer attacks on the notion of natural gender, we still believe that masculinity in girls and women is abhorrent and pathological. (p.268)

My argument in this thesis that we need to make a wider range of subjectivities available to a wider range of people is congruent with Halberstam's argument. Although Halberstam's work is based entirely on lesbian examples of female masculinities, the sections quoted above make clear the wider applications of her work. I now turn to another study that supports Halberstam's and my own analyses of the difficulties encountered by women doing masculinity, but also suggests that there are some dangers for women in this approach.

Adkins (2001) looks at analyses of the feminisation of the workplace and of popular culture. Originally the term feminisation, as it applied to the labour market, was a socio-economic one, referring for example to the increased participation of women in the workforce and the decline in traditionally masculine manufacturing jobs. However, "it is now used to refer to a new sovereignty of appearance, image, and style at work, whose performance of stylised presentations of self has emerged as a key resource in certain sections of the economy, particularly in new service occupations" (p.674). Within this

framework femininity is a resource, deployed by both men and women, and this is seen as part of a progressive process of undoing gender binaries. A similar trend is apparent in cultural analyses of the feminisation of masculinity in TV culture. For example, daytime TV is analysed as inserting the private domestic space into the public realm; and men are now theorised as objects of the camera's 'gaze' in terms very similar to those applied to women's relationship to the 'gaze' in Mulvey's (1989) classic essay.

However, while both men and women can do femininity in the workplace, Adkins (2001) cites empirical work that provides evidence that there are two crucial differences between their performances. First, men and women differ in their gender mobility for "men workers may 'take on' (and be rewarded for) performances of femininity, yet women cannot unproblematically 'take on' (and be rewarded for) performances of masculinity" (p.687); women's gender mobility is restricted "*within* the genre of femininity" (p.687, original emphasis). Second, men and women differ in the ways in which their deployment of femininity is read. While men's performances are read as such, women's are not readable in this way. To explain this Adkins draws on Diawara's (1998, p.57) distinction between the transtextual position occupied by white actor John Travolta in *Pulp Fiction* (Tarantino, 1994) and the immanent one occupied by the black actor Samuel L. Jackson:

> Travolta has literal masculinity, in terms of coolness and language and dress code; no door can be closed to him. But Samuel Jackson has the coolness of his own-immanent-blackness. To me, Jackson, who's a great actor, appears to not be acting; he just appears to be 'a black guy.' Let me give you another example of this. In *Boys N The Hood*, the single mother of Doughboy and Ricky is acting, but she looks so much like a typical welfare mother that she couldn't even be considered for an award for a supporting actress.

Similarly, Adkins argues women are not eligible for the rewards that accrue to men for successful performances of femininity because femininity is immanent to them and so is not recognisable as a performance. (There are interesting parallels between Adkins argument and Lloyd's critique of de Beauvoir's work on transcendence and immanence, discussed in section 5.4.1.)

Adkin's (2001) ideas can thus be read as supporting the need for work such as my own and Halberstam's (1998, p.241) that re-claim masculinity for women-"masculinity does not belong to men, has not been produced only by men, and does not properly express male heterosexuality". They can also be read as highlighting some dangers of the flipside of this: making femininity safe for men. Perhaps "current moves toward the undoing of binaries may involve less of a feminisation and more of an arrangement of gender without women" (Adkins, 2001, p.692). This warning is important. However, it suggests a need for vigilance rather than a need to abandon the project altogether, a need to keep in mind

Butler's (1997, p.100) question (from the end of Chapter 3): "how can we work the power relations by which we are worked and in what direction?"[9] Another problem with the approach to masculinity in this section is that it has been largely uncritical. Yet, femininity and masculinity are not two symmetric sets of practices from which people should be enabled to select at will. Current gender regimes are profoundly unequal and men still secure their "patriarchal dividend" (Connell, 1995). However, I see the project of making masculinity safe for women (and femininity safe for men) as a way of transforming the current gender regime and the practices and ways of being that support the oppression of women. After all, it is partly the exclusion of women (and men) from certain practices that allows these same practices to function as part of a system of domination. Transformation, this time of mathematics, is also the theme of the next section.

8.1.3 Mathematics is a social practice

The idea discussed in the last section that doing mathematics is doing masculinity challenges both the binary construction of gender and the binary construction of mathematics. Throughout this thesis I have argued that in choosing mathematics students are doing gender, and doing class and race/ethnicity. Therefore, this implicates mathematics in preserving masculinity, and capitalism and white supremacy, as sources of power and control (see, Frankenstein, 1995; Shelley, 1995). So higher mathematics remains masculine, not only in the sense that it is numerically dominated by men, but also in the ways that the practices through which it comes into being serve to support the current gender regime, "the capacity of certain men to control social resources through gender processes-and the kind of society being produced by that power" (Connell, 1995, p.205).

These ideas are based in an argument for understanding mathematics as a social practice. My work thus contributes to other work that aims to build a sociology of mathematics (Lerman, 2000, contains a good review of the 'social turn' in mathematics education). In this thesis I have developed this work in several original directions. I highlight two here. First, I have made a sustained argument that relates young people's experiences of school mathematics to their experiences of popular culture. Such arguments are common for other curriculum areas but not for mathematics education. Second, I have used psychoanalytic thought experiments to deconstruct mathematical certainty. I will now consider what to do with this understanding.

[9] That post-structural versions of gender require vigilance is a point supported by McLeod's (2001, p.276) analysis of how "the exhortation to examine the construction of gender" within Australian educational policy has functioned as a disciplinary technology. However, while all policy interventions can be "understood as governmental, implicated in managing populations and inciting modes of subjectivity" (p.280), not all disciplinary technologies are the same.

In thinking about what futures may follow from a social theory of mathematics, Connell's (1987) discussion of possible futures, which can be built on a social theory of gender, is helpful. He sees two possibilities: the abolition of gender or its reconstitution on new bases. The first is a deconstructive strategy that is powerful as a direction but is impractical as an immediate goal. However, beyond these considerations it raises questions about whether our current gender relations have any value.

> What would be our loss if they went down the gurgle-hole of history?
>
> It has to be said that a great deal of our culture's energy and beauty, as well as its barbarism, has been created through and around gender relations. A gender-structured culture, and quite specifically sexist sensibilities, have given us *Othello*, the *Ring of the Nibelung* and Rubens portraits, to go no further. Much of the fine texture of everyday life, from the feel of our own bodies, through the lore of running a household, to popular songs and everyday humour, are predicated on gender. Our eroticism and our imagination seem to be both limited and fuelled by gender. To discard the whole pattern does seem to imply a way of life that would be seriously impoverished by comparison with the one we know. At best it would be so different from the world of our experience that we can hardly know whether it would be desirable or not. (p.288)

Returning to mathematics, here too the abolition of mathematics is not only impractical but it is also questionable whether a mathematics-free world is desirable. My own view is that it is not. It is clear to me that the social and historical practices of mathematics have resulted in a great deal more than oppression and inequality. A mathematically structured culture, and quite specifically absolutist and sexist sensibilities, have given us the Internet, the central limit theorem, and the Mandelbrot set, to go no further. Just as masculinity is not all bad (Halberstam, 1998) neither is mathematics.

This leads to the second option, the reconstitution of mathematics on new bases, the possibility of separating the cultural energy around mathematics from structures of inequality. I am attracted to this option not just because of the positive contributions that mathematics has made to society but also because of my positive relationship with the subject. As I discussed in section 1.3.1, for as long as I can remember I have enjoyed mathematics and I continue to do so; I value what my mathematical training has made possible for me, while simultaneously mourning the loss of what it has made impossible. This pleasure in mathematics is shared by many of the students in this study and was the main reason for choosing it for 16 of them and one of the reasons for their choice for a further 12. That pleasure was the subject of Chapter 7. I end this section with a brief discussion on the possibility of the reconstitution of mathematics.

I argued, in Chapter 5, that the starting point for change must be the myth of the certainty of mathematical knowledge, its epistemological status as absolute and untainted

by the corruption and messiness of daily life. It is this that gives mathematics its power and maintains it in its position as the ultimate intelligence test. Two metaphors, voice and narrative, have been useful for this purpose. By basing my analytic chapters around students' voices and stories, the 'objective' voice of mathematics has been put in its place so that other voices can be heard. As I argued in section 3.3 it is important to avoid essentialism here; there are no true voices. However, the idea of 'voice' is still a useful one. It enables me to acknowledge that we feel able to express some things in some places and not in others and that some of these processes feel authentic while some feel like silencing and that these processes impact on what we can do in different spaces. So an inclusive mathematics needs a wider range of student voices to be heard in classrooms by teachers, by fellow students, and by mathematics.

Hearing voices is not a neutral process. As the analytic work in this thesis emphasises repeatedly, it matters into which stories we insert the words we hear. Bibby (2001, p.27) argues that "school mathematics still lacks stories" and asks: "Is this one reason why some of us have such trouble understanding and relating to it?" I both agree and disagree with this. I disagree because, as this exploration has illustrated, there **are** stories about school and other mathematics and to make meaning in any field, including mathematics, is to tell stories. However, I agree in the sense that these inter-locking stories, about the people doing mathematics, about mathematical objects, and about the purposes of mathematics, are of very particular kinds and they are ones that create only limited spaces for learners (and teachers). As Plummer (1995, p.166) argued (in the rather different context of sexualities): "It is not an easy option to keep the pluralistic, polyvocal potential of proliferating stories open; but it is probably a very necessary one."

Many others have called for similar changes to mathematics (for example, Boaler, 2002; Burton, 1996; Cotton, 2001; Skovsmose, 1994). My work supports their arguments that this would be a more inclusive and socially just mathematics curriculum than the current one, and one in which more students than at present could come to think of themselves as what Povey (1997, p.332) calls author/ities in relation to mathematics:

> An author is one who brings things into being. Who is the originator of any action or state of things. Authority is concerned with power and the validity of knowledge. Linked together they lead us to the construction of an epistemology which recognises each of us as the originator of knowledge.

As Burton (1999b) argued, and my own analyses in Chapter 4 illustrate, this talk of stories is rather different from how mathematics is normally presented in classrooms. So now seems an appropriate point at which to consider the question deferred from Chapter 5: what would happen to students that seem happy with the status quo if school mathematical

practices were to change? This and other unanswered questions are subjects of the next section.

8.2 Directions for future research

The research findings discussed in the first half of this chapter suggest many directions that could be usefully pursued in future projects. In this section I do not try to collect together all of these possibilities but simply offer some thoughts on those that seem most pertinent. I begin with the unanswered question above about how those who currently strongly identify with mathematics would feel about a change to multi-vocal, narrative-based mathematics practices.

Although certainty is a facet of mathematics that appealed to many participants in this study, my data contain reasons to be optimistic about how young people would respond to such a change. Most young people told me that they appreciated the opportunities for discussion and group work in other subjects but felt these to be inappropriate in mathematics lessons. For example, Phil (see section 7.2.4) who strongly identified with mathematics told me that he liked the way in English "you can sort of have some room to find your own opinion." He felt that this was not possible in mathematics "you need to discuss stuff in English, but you can't really do a lot of discussion in maths." While initially he found the uncertainty of English, the way "there's never a wrong or right answer," difficult, by the time of his interview at the end of the second term of year 12 he told me, "I'm more comfortable with it now because I can deal with it better, before I couldn't." Young people cannot be shielded from the uncertainty of the world forever and an overemphasis on certainty in mathematics:

> Seems to rest on a misunderstanding about the sorts of knowledge and understanding needed for living well in our sort of society. It risks conveying to pupils a distorted picture of the possibilities and responsibilities of an adult human life. (Bramall, 2000, p.62)

Barnes (2001) also paints an optimistic picture of how students who are successful in a 'traditional' mathematical system and resistant to a new regime, respond to a change to a 'progressive' mathematics pedagogy. However, apart from this there is little research that directly addresses this question.

How young people's mathematical identities would be affected by living with uncertainty is just one of the questions that my investigations raise and about which they make some suggestions, but that they ultimately leave unanswered. Others, provoked particularly by the stories in Chapter 6, are:

- What is and should be the relationship between mathematics and 'real life'? (This question is discussed in Dowling, 1998.)
- Why learn mathematics? Should mathematics be compulsory after Key Stage 3? (This question is discussed in Bramall & White, 2000.)

Regarding the first, my student stories highlight how the perceived disconnection of school mathematics from everyday life makes it difficult for a large number of people to identify with it. Regarding the second, it is clear from my student stories that unless young people are able to incorporate mathematics positively into their identity work then compulsory mathematics will remain largely unsuccessful at getting people to enjoy it and to achieve. However, these questions are basically beyond the scope of this study and I leave a thorough treatment of them to other researchers. Another unanswered question that I have already informally started to pursue is:

- What makes people come to understand gender as a central influence on their educational choices and on their life more generally?

While the questions discussed so far are located at the edges of my study, other research possibilities arise from its heart, provoked by both its limitations and its strengths.

Although my research has produced a lot of information on mathematical identities there are several limitations of the study that future projects could seek to move beyond. I highlight four here. First, my research is entirely London based. It is important to acknowledge the "specificity of London" with its "several interpenetrating economies old and new, varieties of ethnoscapes…, changing patterns of opportunity and constraint" (Ball et al., 2000, p.21). Future research could look at mathematical identities in other settings. Devolution makes comparisons between the different countries that make up the United Kingdom a particularly interesting possibility. Another option is a study comparing London students with those from another city or with those in a nearby rural setting. This would help to theorise any part the capital's specificity might play within mathematics education. Second, due to the limited resources available, my research is not longitudinal. It would be interesting to observe and interview students on either side of the transitions from GCSE to AS-level, from AS to A2, and from A2 to university. In this way students who reject mathematics could participate in research alongside students who opt to continue with it. E-mail has potential, used in conjunction with conventional interviews, for the study of the development of young people's relationships to mathematics (Mann & Stewart, 2000). The use of e-mail data would overcome some of the ethical problems raised by young people's discomfort with how their spoken words look on paper (see the discussion in section 2.4.2). Third, as I commented at the end of Chapter 4, my study focuses on students at the

expense of teachers. It would be interesting to look in more detail at the way in which teachers construct both their own identities as students and as teachers of mathematics as well as the identities of their students as learners of mathematics and any connections between these. Finally, stories and thought experiments are at the centre of my analytic approach and if I were doing this research again I would aim to make my questions more biographical and less 'rational' so as to generate more of the kind of interview data that this methodology requires (Hollway & Jefferson, 2000). As well as moving beyond the limitations of this study, future research should seek to build on its strengths.

Each year fewer young people in England choose to continue with mathematics beyond GCSE, and fewer of those who do complete the AS-level progress to the A2 programme (Henry, 2002). This same pattern repeats itself in the transition from further to higher education (Times Educational Supplement, 2003). This increase in the number of people rejecting mathematics has been debated within the media and by policy-makers and educationalists. Concerns have been raised about falling 'standards', about the 28% failure rate at AS-level mathematics (Kirkman, 2002), about whether we are producing sufficient people with mathematical skills to service our economic needs, about giving people access to the skills necessary to participate in an increasingly technology and information rich society, and about the negative ways in which the culture of mathematics classrooms is experienced by the majority of learners. Yet, there is startlingly little research evidence on which to base interventions. This exploration of the gender imbalance in participation in advanced mathematics courses in England provides some such evidence. I hope that it will inspire more work (and indeed, I hope to carry out some myself) that can inform both teaching practice and government policy, including the current propositions based on 'commonsense' such as the proposal to restrict access to AS-level mathematics to those with a grade B in GCSE (Hayes, 2002), the suggestion that two modules be done in the first year and four in the second year to give students longer to absorb the ideas (Stripp, 2002), and discussions on the role of the shortage of mathematics teachers and of their training (Tarleton, 2003).

Social justice issues are absent from these media debates about participation in mathematics. One of the main conclusions of my research is how important the factors of gender and class are among all of the many influences on young people's mathematical careers. The contrast between the results in the largely middle-class Westerburg and those in the largely working-class Grafton and Sunnydale is stark (see tables 2, 3 and 4). We need to know far more about how such social factors impact on mathematical learning and this should be a focus of future research. Access to mathematics is about more than meeting the country's economic needs. If people are opting out of mathematics because of factors

such as class and gender, then it is also a social justice issue. Access to the skills and opportunities offered by mathematics education (Ernest, 2000; Huckstep, 2000) must be widened because of the roles of mathematics highlighted in this thesis: as a 'critical filter', a source of high earnings and status, a proof of intelligence, and so on.

I thus hope that my research will have an impact on educational practice. There is currently much debate about the nature of the relationship between educational research and practice. In particular, there have been voices raised for and against applying the medical model of 'evidence-based practice' to teaching (Hammersley, 1997; and Hargreaves, 1997, offer critical and supportive views respectively; Lather, 2003; and Oakley, 2000, do the same from within feminist perspectives). I will not rehearse these arguments here. The views I expressed in Chapter 2 and in *Prelude to Chapter 3*, put forward a very different vision of what educational research is about than that embedded in the idea of 'evidence-based teaching'. This involves a conviction that doing teaching and reflecting on it are inseparable activities:

> Since all practice is imbued with moral meaning and is the explicit exemplification of (someone's) implicit intentions, such a separation must of necessity be incoherent or, if intended, not honest. Teaching is not simply the aggregation of effective techniques: it is a moral activity which integrates practical, cognitive, interpersonal, affective and intellectual aspects of the teacher and requires recognising those aspects of the learner too. (Povey, 1995, p.264)

The epistemological position implicit in Povey's words is the one that I elaborated in Chapter 2, that there is no easy distinction between thought and action and so once we understand people's relationships to mathematics in the ways that I have within this thesis we cannot but do things differently in the classroom. This has certainly been the experience with my own practice.

I end by asserting that research on gender and mathematics, and on mathematics education in general, should be more open to engaging with ideas from other fields. The interdisciplinary nature of my work and the eclectic range of sources on which I have drawn, is the thing of which I am most proud. However, in mathematics education, despite the recent 'social turn' (Lerman, 2000), quantitative research remains the norm. Most of the qualitative research that is conducted remains either atheoretical or based in one of the three dominant perspectives on mathematical learning: radical constructivism, social constructivism and situated cognition. Exciting new theories from cultural studies, political philosophy, queer theory and so on, are largely ignored. This is a mistake. Making sense of the impact of gender on anything is complex. It requires imagination, innovation, and all the theoretical resources the social sciences have to offer. As a final reminder of this

complexity I close with Jonathan's (see section 7.2.2) response to my question: "Do you think that being male has made any differences to your life?"

"Yeah definitely. If I was not male then I wouldn't be who I am today. Um," he pauses, "but I can't really say how different I would be if I was female. I don't know if I would like the same subjects or if I would do the same things that I do."

Parting is such sweet sorrow

Language is part of an infinite semiosis of meaning. To say anything, I have got to shut up. I have to construct a single sentence. I know that the next sentence will open the infinite semiosis of meaning again, so I will take it back. So each stop is not a natural break. It does not say, 'I'm about to end a sentence and that will be the truth.' It understands that it is contingency. It is a positioning. It is the cut of ideology which, across the semiosis of language constitutes meaning. But you have to get into that game or you will never say anything at all. (Hall, 1991, p.51)

Meaning is an offer, not a claim. (Skovsmose, 1994, p.92)

To describe a formulation *qua* statement does not consist in analysing the relations between the author and what he (sic) says (or wanted to say, or said without wanting to); but in determining what position can and must be occupied by any individual if he is to be the subject of it. (Foucault, 1972, p.95-96, original emphasis)

Goodbye (Heather Mendick, personal communication)

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Appendix 1: Research participants

Table 6: Grafton School

My group		*Matt Delling's group*		
Ang	Mei Jin[1]	James	Simon	Jane
Edward	Nazima	Olu	Tang	Julie
Jean	Susan	Phil	Zia	Melanie
Michael		Salvador		Niamh
Vijay				

Table 7: Westerburg Sixth Form College

Alan Rudolff & Jason Dean's group			*Veronica Sawyer's group*		*Andy Rhodes' group*	
Ahmed	Jacob	Ling	AJ	Hina	Deji	Analia
Ali	Khalid	Rachel	Ben	Jo	Alvin	Carla
Apu	Mohammed		Brendon	Maryam	Craig	Claudia
Bart	Paul		Imran	Vicky	Hanif	Elaine
Darren	Peter		Kiriakos		Jagdish	Linda
Desmond	Petros		Martin		Karim	Kuljit
Gary	Saldon		Mike		Mark	Suki
Graham	Tom		Robert		Sam	Suzanne
Ishmael	Will		Saeed		Steve	Tania
			Sanjay		Vikram	
			Sven			
			Yasser			

Table 8: Sunnydale Further Education College

Alex Harris & Nick Bennett's group		*Abdi Kureishi & Alex Harris's group*	
William	Ashley	Jingki	Amy
Matthew	Avnee	Joe	Ji'in
Jonathan	Ella	Kanton	Joni
Emmanuel	Lili	Kenjin	Marsha
Julian	Lucy	Lee	Natasha
Ben	Julianne	Philip	Nefertiti
Chris			Priya
Shane			Rosie
There were 10 other boys in this group who I never knew well enough to identify by name			Toni
			Yemi

Table 9: Grafton Interviewees

Name:	*Class:*	*Ethnicity:*	*Gender:*	*Term:*[2]
James	Working	Anglo	Male	5
Jean	Working	African	Male	2
Julie	Working	Anglo	Male	2
Mei Jin	Working	Chinese	Female	2
Nazima[3]	Middle	African	Female	2
Melanie	Working	Anglo	Female	2
Michael	Working	African-Caribbean	Male	2
Niamh	Working	Mixed heritage	Female	2

[1] Underlined students were interviewed.

[2] This refers to the term of the current programme of study, although not necessarily the term they were in of their mathematics course.

[3] Students in the same row were interviewed together, apart from this entries are alphabetical.

Phil	Working	Chinese	Male	2
Salvador	Middle	Anglo	Male	2
Simon	Working	Mixed heritage	Male	2
Vijay	Working	Sri Lankan	Male	5

Table 10: Westerburg interviewees

Name:	*Class:*	*Ethnicity:*	*Gender:*	*Term:*
Deji	Middle	Somalian	Male	1
Analia	Middle	Turkish Cypriot	Female	1
AJ	Middle	Indian	Male	1
Imran	Working	Bengali	Male	1
Maryam	Working	Mixed heritage	Female	1
Claudia	Middle	Algerian	Female	1
Darren	Middle	Anglo	Male	1
Desmond	Middle	African	Male	1
Graham	Middle	Anglo	Male	1
Hina	Working	British Asian	Female	1
Vicky	Middle	Anglo	Female	1
Kiriakos	Working	Greek	Male	1
Ling	Working	Chinese	Female	1
Peter	Middle	Anglo	Male	1
Rachel	Middle	Anglo	Female	1
Saldon	Middle	Bangladeshi	Male	1
Sam	Middle	Mixed heritage	Male	1
Yasser	Middle	Iraqi	Male	1

Table 11: Sunnydale interviewees

Name:	*Class:*	*Ethnicity:*	*Gender:*	*Term:*
Ashley	Middle	Hong Kong Chinese	Female	1
Jingki	Working	British Born Chinese	Male	7
Kenjin	Working	British Born Chinese	Male	7
Jonathan	Middle	African	Male	1
Kanton	Middle	Nigerian	Male	7
Lee	Working	Vietnamese/Chinese	Male	4
Mika[4]	Working	British Chinese	Female	4
Nefertiti	Middle	African	Male	4
Lucy (mature)	Working	Mixed heritage	Female	4
Matthew	Middle	Black British	Male	1
Natasha	Middle	Nigerian	Female	1
Toni	Middle	Mixed heritage	Female	1
Priya	Working	Sri Lankan	Female	1

[4] Mika was in the A2 course but had been in the same AS group as Lee and Nefertiti in the previous year and they brought her along to the interview that I arranged with them.

Appendix 2: Interview schedules

Table 12: Interview schedule for Grafton

I'm going to start by asking you some questions about your EXPERIENCE OF MATHS LESSONS	Describe a typical maths lesson, what do you do and how do you feel? What have you enjoyed most about your maths lessons and why? Prompts: Specific topics/lessons, way you were taught What have you enjoyed least about your maths lessons and why? Prompts: Specific topics/lessons, way you were taught How do you feel when you are asked a question in maths lessons?
The next questions are about TEACHING AND LEARNING in maths	Thinking about yourself as a learner, can you say something about how you learn best? Can you say something about the learning approach used in maths lessons? Probe: Compare with other subjects, explore reasons for differences Do you usually work with other people or individually in class/on homework? Probe: Compare with other subjects, explore reasons for differences
Now I want you to think about the NATURE OF MATHS as a subject	Would you say that pure maths is more about learning procedures and rules or about understanding why the rules work? Repeat for discrete maths. Which of your other subjects is most like maths/different from it? Probe: Why and connect to the image of maths. What do you think that people not doing maths think about the subject?
Thinking about the CHANGE FROM GCSE TO A-LEVEL MATHS	Do you think that GCSE Maths was a good preparation for A-level Maths? Why? What do you think are the main differences between A-level and GCSE Maths? Which do you prefer? Prompts: Assessment, Teaching, Pace/Difficulty/Amount of work
CHOICES	What other A and AS-levels are you studying? Which of them do you like best? Why did you choose these? Prompts: Good at them/GCSE results, Enjoy them, Career plans, Pressure/advice e.g. parents, friends, teachers. What do you hope to do after you finish sixth form? Probe: University? Employment? Involvement of maths?
My research is also about GENDER and the last 2 questions are about that	Why do you think that more boys than girls choose to study Maths A-level? Do you think that being male or female makes a difference to your life generally in any way?
IS THERE ANYTHING ELSE?	Could ask about group allocated to and about module results here if they've not already come up.

Table 13: Interview schedule for Westerburg and Sunnydale

I'm going to start by asking you some questions about your EXPERIENCE OF MATHS LESSONS	Describe a typical GCSE maths lesson, what you did/how you felt? What did you enjoy most about your GCSE maths lessons and why? Prompts: Specific topics/lessons, way you were taught What did you enjoy least about your GCSE maths lessons and why? Prompts: Specific topics/lessons, way you were taught How do/did you feel when you were/are asked a question in maths?
The next questions are about TEACHING AND LEARNING in maths	Thinking about yourself as a learner, can you say something about how you learn best? Can you say something about the learning approach used in GCSE maths lessons? A-level? Probe: Compare with other subjects, explore reasons for differences Did you usually work with other people or individually in class/on homework? A-level? Probe: Compare with other subjects, explore reasons for differences
Now I want you to think about the NATURE OF MATHS as a subject	Would you say that GCSE maths is more about learning procedures and rules or about understanding why the rules work? A-level? Which other subjects that you've studied are most like maths/different from it? Probe: Why and connect to the image of maths. What do you think that people not doing maths think about the subject?
Summarising the CHANGE FROM GCSE TO A-LEVEL MATHS	What do you think are the main differences between A-level and GCSE Maths? Which do you prefer? Prompts: Assessment, Teaching, Pace/Difficulty/Amount of work
CHOICES	What other A and AS-levels are you studying? Which of them do you like best? Why did you choose these? Prompts: Good at them/GCSE results, Enjoy them, Career plans, Pressure/advice e.g. parents, friends, teachers. For maths ask about choice between statistics and mechanics. What do you hope to do after you finish sixth form? Probe: University? Employment? Involvement of maths? Why did you choose to come to Westerburg/Sunnydale College?
My research is also about GENDER and the last 2 questions are about that	Why do you think that more boys than girls choose to study Maths A-level? Do you think that being male or female makes a difference to your life generally in any way? How would you describe your class and your ethnicity/ethnic origin?
IS THERE ANYTHING ELSE?	Could ask about group allocated to/shift to college.

Appendix 3: Observation schedule

Sixth-form: **Date and time:**

Group: **Teacher:**

Focus of observation:

Lesson topic:

Resources:

Classroom plan:	Lesson structure with timings:

Classroom surroundings:

Classroom interaction:

General comments:

Specifics: be descriptive, note: time, setting, words used, paralinguistic features, body language etc.

Appendix 4: Research letters

Letter to gatekeeper

The Principal,
Sunnydale College,
London, SM6 G54.

Dear sir or madam,

I am currently studying for a doctorate in Educational Studies at Goldsmiths College. The title of my project is 'Gender and Mathematics: Choices, Teaching and Assessment' and I'm particularly interested in looking at how A-level maths students chose the subject, how they feel about maths and maths lessons, and the ways in which gender influences these.

There is now very little difference in the examination performance of girls and boys in Maths at GCSE and A-level. However, there remains a large gap between the participation levels of boys and girls in maths post-16. This A-level gap widens at degree level and again at postgraduate level. It is for this reason that I have decided to focus on subject choice. I also think there is a real need for research that looks at the impact of the changes in the sixth-form curriculum on students' learning experiences.

In my research I plan to follow a small number of students across three institutions, a secondary school, a Further Education College and a Sixth Form College, during the first 4 terms of their A-level course. I intend to interview participating students at 3 points during their course and observe them in lessons for 2 short periods during the study. I have enclosed a copy of the interview schedule for the first set of interviews to give you a feel for the way I approach the project.

I would really appreciate it if you would be willing to discuss the possibility of me conducting some of my research in the maths department at Sunnydale College. If you agree to take part, I will, of course, make every effort to cause as little disruption as possible to the work of the classes observed and the students interviewed. I will also explain the project fully to the staff and students directly involved so that they can make an informed decision as to whether or not to participate.

Before starting my PhD I worked as a maths teacher in secondary schools and sixth form colleges for 7 years, and I have continued to teach part-time this year. I taught everything from Foundation GNVQ to A-level Further Maths and am keen to use this experience to contribute to the work of the schools and colleges in which I conduct research.

I hope that you will consider participating. You can contact me at the address below, by 'phone on 020 8355 5843, or by e-mail at edp01hm@gold.ac.uk, to discuss the project further.

Yours sincerely,

Heather Mendick

Letter to student participants prior to interview

Dear ,

Thank you for agreeing to be interviewed by me. Your interview is part of my research for my doctorate in Educational Studies that I'm doing at Goldsmiths College. The title of my project is 'Gender and Mathematics: Choices, Teaching and Assessment' and I'm particularly interested in looking at how A-level maths students feel about the subject and their lessons.

At the interview I am interested in hearing your opinions about maths, for example we could talk about why you chose the subject and what you like and do not like about it. I will ask your permission at the beginning to tape the interview. **Everything you say will be completely confidential.**

The interviews will take place in:

And will last between about 30 and 45 minutes.

Your interview date and time:

If you can't make this time or have just changed your mind, please tell me.

Once again, thanks for your co-operation.

Yours sincerely,

Heather Mendick.

Letters to student participants accompanying their 'story'

Dear Mei Jin,

Thank you for supporting my research by being interviewed last year. I have been developing my project since then and have written a short piece on each of the interviews. I have enclosed the piece about your interview with this letter (you are referred to by a pseudonym in it). In this piece I am trying to combine your words with mine and with those of other researchers. The aim is to begin developing a series of stories about AS and A-level maths students that can help me understand what it is that makes some people enjoy maths and want to continue with it while others do not. These analyses will form the basis of my writing, for presentation at conferences, for publication in journals and, ultimately, for my PhD.

Thank you also for agreeing to continue being part of the project next year. The exact way that you are involved is up to you. You could be interviewed again either once or twice (perhaps at the end of the first term of your second year and then again nearer or after your A-levels), either individually or with one or two other students. Or, if you prefer not to be interviewed, you could write something about your experiences learning maths, or we could do the interview via e-mail even.

I will be in Grafton in the second half of term observing lessons and perhaps you could tell me then how you would like to be involved (or you can tell me if you have changed your mind about wanting to continue). In the meantime if you have any comments on what I have written about you, or would like to contact me about anything else, then you can get me by post at 35 Laurie Grove, London SE14 6NW, or by e-mail at edp01hm@gold.ac.uk.

Best wishes,

Heather Mendick

For Westerburg and Sunnydale the second and third paragraphs were changed to:

When I have shown such stories to other people who I have interviewed they are often bothered by the way their words appear in the sections transcribed from the tape. There are lots of hesitations, repeated words and ungrammatical sentences. As a result I considered editing what was said into a smoother form. However, I decided against this because it is often these aspects of the speech that I find interesting to analyse. I hope that you will feel that this decision is acceptable to you.

I am not sure whether or not I will be returning to Sunnydale this year so I would like to take this opportunity to wish you good luck for the future. I would also welcome any feedback you have on what I have written about you. So if you have any comments or you would like to contact me about anything else, then you can get me by post at 35 Laurie Grove, London SE14 6NW, or by e-mail at edp01hm@gold.ac.uk.