

**Exploring the biographies of high-achieving students:  
how do social environments and classroom experiences  
enable them to identify as ‘good at maths’?**

D. C. H. Pomeroy

Supervisor: Diane Reay

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## **Abstract**

School students are more likely to enjoy and succeed in the compulsory, high-stakes subject of mathematics if they are able to identify as ‘good at maths’. This study investigated the manner in which students’ social and classroom experiences regulated how easily they could adopt this learner identity. According to previous research, historical and popular discourses portray mathematics as cold, rational, and masculine, and mathematicians as socially incompetent ‘geeks’. Therefore, identifying with mathematics can conflict with femininity and sociality. Furthermore, mathematics is often perceived as a subject that puts intelligence, or lack thereof, on public display, inducing anxiety, shame, and a protective distancing from mathematics.

Semi-structured interviews with seven postgraduate students at an elite British university, from a range of disciplines and nationalities, explored the processes by which the participants came to see themselves as (not) ‘good at maths’. All but one had achieved very good or outstanding mathematics results at school and identified as ‘good at maths’. Using open coding and cross-case analysis I identified two themes. Firstly, the participants were members of peer groups in which academic achievement was highly valued, contrasting with studies which report students downplaying their achievement to avoid being seen as a ‘geek’. Secondly, the participants derived a strong sense of pride and satisfaction from doing well in maths, and this emotional reward was reinforced by the perception that mathematics was ‘either right or wrong’ and therefore displayed their intelligence ‘objectively’.

This study highlights the need to explore ways of fostering a classroom culture which values achievement, and to identify pedagogies which make mathematical success less one-dimensional, especially for students less privileged than this study’s participants. The analysis points towards some ‘pockets of hope’ in existing schools which provide blueprints for a more equitable approach to teaching mathematics.

*I hereby declare that the sources which I have used have been stated in the body of the thesis and in the bibliography and that the rest of the work is my own. This thesis does not exceed 20,000 words in length.*

## Table of contents

<b>Abstract .....</b>	<b>ii</b>
<b>Abbreviations .....</b>	<b>iv</b>
<b>Acknowledgements.....</b>	<b>v</b>
<b>1 Introduction.....</b>	<b>1</b>
1.1 Identity and inequality .....	1
1.2 Research question .....	5
<b>2 Theoretical framework.....</b>	<b>7</b>
2.1 Ontology and epistemology.....	7
2.2 Ethical framework.....	9
2.3 Conceptualising identity.....	11
2.3.1 Academic and social fields .....	11
2.3.2 Fixity, movement, conflict.....	13
<b>3 Literature Review.....</b>	<b>14</b>
3.1 Discursive identity construction .....	15
3.2 Experiencing mathematics .....	22
3.3 Conclusion.....	25
<b>4 Methodology and methods .....</b>	<b>26</b>
4.1 Phenomenological multiple case-study.....	26
4.2 Methodological exemplars .....	28
4.3 From strategy to data .....	30
4.3.1 Planning the interviews .....	30
4.3.2 Participants .....	31
4.3.3 Interviews .....	33
4.4 Data analysis.....	35
<b>5 Results and Discussion.....</b>	<b>38</b>
5.1 Three mathematical biographies.....	38
5.1.1 Paula’s story.....	38
5.1.2 Amanda’s story .....	40
5.1.3 Peter’s story .....	42
5.2 Academically supportive friends .....	44
5.3 The sweet taste of success .....	49
<b>6 Conclusion.....</b>	<b>53</b>

6.1	Evaluation of the study.....	53
6.2	Looking to the future .....	55
<b>References.....</b>		<b>57</b>
<b>Appendices.....</b>		<b>63</b>
Appendix A:	Interview schedule Version I .....	63
Appendix B:	Interview schedule Version II .....	64
Appendix C:	Participant information and consent form .....	66

## **Abbreviations**

BERA	British Educational Research Association
GCSE	General Certificate of Secondary Education (England and Wales)
HAP	High achieving and popular
M.Phil.	Master of Philosophy
NZARE	New Zealand Association for Research in Education
OECD	Organisation for Economic Cooperation and Development
Ph.D.	Doctor of Philosophy

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# 1 Introduction

I have spent most of the last decade immersed in the world of mathematics learning, as an undergraduate mathematics student, a trainee teacher, a secondary mathematics teacher, and a postgraduate mathematics education student. Hearing this, people often launch into an account of their own experiences of learning mathematics at school, invariably including whether they are, or were, ‘good at maths’. “I was never good at maths”, “I was good at maths until I got to the sixth form”, “wow, you must be good at maths”, and so on. People who were ‘good at maths’ tend to have more positive memories of learning mathematics at school, although there are many exceptions. As the quotes around ‘good at maths’ suggest, the idea of being good at mathematics needs some deconstructing before it can be used productively. I will argue that *identifying oneself* as a competent mathematician has powerful consequences and is not simply an index of some innate cognitive capacity which relates in a predictable way to school mathematics attainment.

## 1.1 *Identity and inequality*

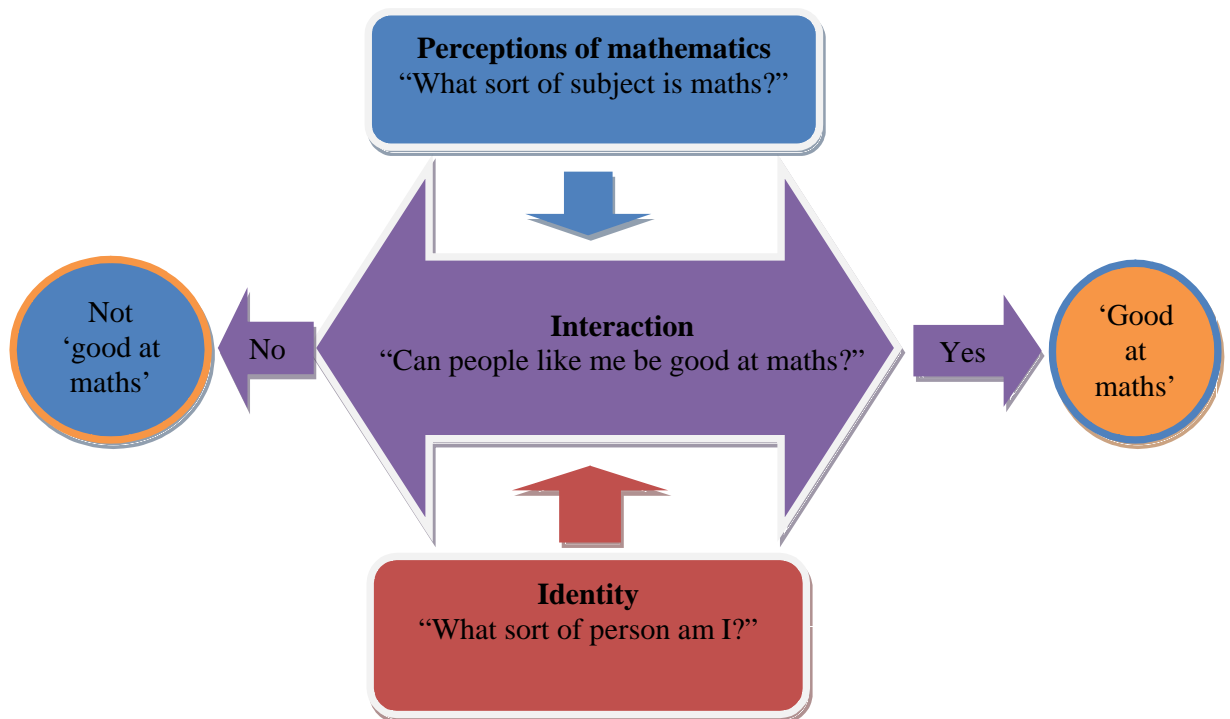
In this thesis I argue that it matters at an ethical level whether students consider themselves to be capable mathematicians, that is, whether they identify as ‘good at maths’. This is not to deny that mathematical success can be *partially* attributed to cognitive practices in a fairly commonsense way (Nash, 2005), rather, that cognition only tells part of the story. The story that I attempt to tell views students within their complex social worlds; worlds in which students vie for popularity in hierarchical and competitive peer groups; in which opportunities to succeed are mediated by social class, ethnicity, and gender. The language I will draw on to help me tell the story comes from the academic tradition of sociology, which has developed theoretical frameworks that facilitate a nuanced analysis of the opportunities different people really have.

My motivating assumptions are that:

- identifying as ‘good at maths’ has powerful material consequences for the opportunities that students have to flourish in life;

- access to the identity ‘good at maths’ is regulated in complex ways that involve the interaction between how students perceive *themselves* and how they perceive *mathematics*;
- students’ perceptions of themselves and mathematics are shaped by their social environments and classroom experiences;
- therefore it could be fruitful to gain a better understanding of how social environments and classroom experiences shape the process of students coming to see themselves as ‘good at maths’, a process I will sometimes refer to as their mathematical *identity construction*.

The empirical investigation reported here investigates the nature of the interaction between how students perceive themselves and how they perceive mathematics, with a focus on interactions that make it harder or easier to identify as ‘good at maths’ (see Figure 1).



**Figure 1.** Diagrammatic representation of how perceptions of self and mathematics regulate access to the learner identity ‘good at maths’.

The problem that motivated this research is inequality in school students' outcomes and experiences of mathematics, in New Zealand, England, and elsewhere. *Inequality* is used here to refer to differences in experiences and outcomes that are related to specific student characteristics, such as gender or social class, not simply to the existence of variability. *Inequality* has a purely descriptive mathematical meaning (i.e., not the same), but should be read here as both descriptive and evaluative (Sayer, 2011), referring to things that aren't equal but *should* be, ethically. This problem, of course, has been researched extensively and over a long period of time, particularly within the sub-discipline of sociology of education. It has been documented statistically (Boaler, Altendorff, & Kent, 2011), described in terms of lived experience (e.g. Reay, 2006a), and debated philosophically (e.g. Corlett, 2010; Herman, 2007). Despite the seemingly intractable nature of educational inequalities, the situation is not static. For example, the last few decades of the twentieth century saw a reduction and then reversal of some gender inequalities in education in England and elsewhere (Moore, 2004). The nature and extent of educational inequalities are much debated and rehearsed (e.g., Goldthorpe, 2010; Moore, 2004; Reay, 2006b) and will not be addressed here at the level of 'educational inequality'. This study focuses on how inequality plays out in the process of mathematical identity construction.

Both England, where I currently live, and my home country New Zealand have significant inequalities in mathematics, although these are slightly different in nature. New Zealand's main inequalities are socio-economic and ethnic; it was one of a minority of Programme for International Student Assessment participant countries that did *not* have gender differences in mathematics attainment (Organisation for Economic Cooperation and Development [OECD], 2010). New Zealand's *socio-economic gradient*, which represents the magnitude of the correlation between socio-economic status and attainment, was one of the highest of all participating countries, and higher than England's. England has a slightly different pattern of inequality in mathematics, including lower participation by girls than boys past the compulsory age of 16, but the clearest inequalities are associated with social class (Boaler et al., 2011; OECD, 2010). The upshot of this is that there are very high levels of socio-economic inequality in secondary mathematics in England and New Zealand.



In England and New Zealand mathematics is a compulsory element of the most basic secondary school-leaving qualifications<sup>1</sup>. Universities recommend taking mathematics to a high level in order to be well-prepared for courses as diverse as sciences, economics, and psychology, all of which have mathematics or statistics in their course structure. Thus the stakes of attainment in mathematics are high compared to most other subjects. Furthermore, it is common practice in New Zealand secondary schools for mathematics and English to be allocated more lesson time than other subjects, and mathematics is compulsory in Year 11 (age 15-16). Recent government rhetoric in the United Kingdom conveys the message that mathematics is highly valuable for individual life chances and the strength of the national economy, and there is high-level debate around mathematics becoming the only school subject to be compulsory until age eighteen (BBC, 2011; Vorderman, Porkess, Budd, Dunne, & Rahman-Hart, 2011).

The compulsory status of mathematics makes students' *experience of learning mathematics* central to their experience of school; if it is causing anxiety students simply don't have the option of switching subjects. The high-stakes nature of mathematics makes students' *mathematical attainment* particularly important because, more so than any other subject except for English, it has a relatively high impact on students' objective opportunities for further study. Furthermore, there is evidence that many students see mathematical attainment as a proxy for how intelligent they are (Bibby, 2002; Mendick, 2006), therefore mathematical attainment has quite a strong relationship to self-image. For all these reasons it is crucial that secondary mathematics teachers do all that is within their power to ensure that students *enjoy* the many hours of mathematics learning that they experience (Noddings, 2003), and that they *learn mathematics* to a high standard. The systematic inequalities in the experience and outcomes of secondary mathematics learning are the central problematic of the research project comprising the current Master of Philosophy (M.Phil.) dissertation and my proposed Doctor of Philosophy (Ph.D.) thesis.

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<sup>1</sup> General Certificate of Secondary Education (GCSE) in England and Wales and National Certificate of Educational Achievement Level One in New Zealand.

## 1.2 *Research question*

To put the current M.Phil. research in context I will briefly outline the aims of the wider project of which it is a part. The project's focus is the way real-world situations are used as 'contexts' for mathematical tasks such as word problems, a spectrum of approaches which fall under the general category of *contextual pedagogy*. The reason for this focus is prior empirical and theoretical work suggesting that contextual pedagogy can exacerbate educational inequalities; it can lead to working-class students (Cooper & Dunne, 2000) and possibly girls (Boaler, 1994) achieving inordinately poor results. However, the theory behind the attack on bringing 'everyday knowledge' into the learning of the 'powerful knowledge' of mathematics (e.g. Moore, 2004; Wheelahan, 2010; Young, 2008) is a long way ahead of the evidence. I wish to examine the purported *discriminatory* nature of contextual pedagogy in New Zealand and possibly also England. The overarching research question is: *How (if at all) does contextual mathematics pedagogy mediate students' access to abstract mathematical knowledge in relation to social class and gender?*

This M.Phil. project pursued one sub-question in the English context, by way of a pilot project. The provisional research question was:

***How do students' social environments and classroom experiences make it easier or harder for them to identify as 'good at maths'?***

In some respects this research question seems odd; it doesn't explicitly mention contextual pedagogy, and introduces identity to the research problematic, yet I would argue that introducing identity brings balance to the project. Most previous explanations of how gender and social class mediate the effectiveness of contextual mathematics pedagogy are framed in terms of cognitive difficulties students have when engaged in mathematical tasks. My own experience and, as we shall see, a good deal of research (see Chapter Three), indicates that student identity is a strong mediator of the extent to which students engage in learning mathematics. The role of identity needs to be explored; otherwise we only have part of the picture. In particular, I suspect that students' feelings of engagement with or alienation from mathematics are to some extent determined by the type of pedagogy they have experienced. Thus

the research question may potentially lead to contextual pedagogy, but the question does not use contextual pedagogy as a starting point.

To illustrate the role of identity in the wider project, and to further clarify what I mean by 'good at maths', let me contrast two activities that I do *not* identify as good at: playing chess, and rapping. I was never good at chess, and losing to my best friend was a constant source of frustration. I thought that, being a 'smart' child and 'good at maths' I should also be good at chess, but alas, this was not the case. Furthermore, I certainly don't consider myself good at rapping; whilst I have written a little poetry and enjoy singing, it's just not the kind of thing I would want to try. I don't enjoy listening to rap, and I couldn't hold a conversation about rap with someone who was interested in it. I am neither 'good at chess' nor 'a good rapper', but the senses in which I don't identify as 'good at' the two activities are completely different. My identity as 'not good at chess' arises from constraints imposed by my lack of ability; repeated losses made it impossible for me to consider myself 'good at chess'. Being 'good at rap' is not something that people like me (White, middle-class New Zealanders) do. In the current M.Phil. project I am concerned with shedding light on the process by which students don't see themselves as 'good at maths' in the same sense that I don't see myself as 'good at rapping'. This process is not so much exclusion from success on the basis of some 'cognitive lack', but a more personal distancing from the idea of mathematics as something that 'people like me' do.

## 2 Theoretical framework

This chapter describes and defends the theoretical framework that underpins this research, much of which derived from developments of *critical realism* for social science (Sayer, 2000). These form the “meta-theory” (Scott, 2005, p. 634) of the investigation, which I will explain with reference to my research problem (Section 2.1 and 2.2). The meta-theory will be followed by an explanation of theories that will be employed more directly in my data interpretation, drawing primarily on the work of sociological researchers who attempt to make theoretical sense of identity and emotions (e.g., Reay, 2006a; Sayer, 2005; Skeggs, 2004).

### 2.1 *Ontology and epistemology*

My ontological and epistemological assumptions align most closely to *critical realism*, a philosophy of the natural and social sciences founded by Roy Bhaskar (1975). Whilst *critical realism* “does not refer to any internally-coherent school of thought” its various articulations share much common ground (Siljander, 2011, p. 494). Critical realism’s ontological position is that the world, social and physical, exists whether or not we are aware of it. Critical realism clarifies this position by distinguishing between *intransitive* and *transitive* dimensions of knowledge, which refer respectively to the ‘objects’ we study, and the theories and discourses used to describe the objects (Sayer, 2000). A literature review, for example, operates at the transitive dimension of discourses *about* identity; there may be competing discourses, but this does not mean that they are talking about different things.

Critical realism’s ontology is stratified in that it distinguishes between the *real*, the *actual*, and the *empirical*. *Real* ‘objects’, like identities, people, and schools have *structures* and *powers* that make them capable of taking certain actions and susceptible to certain forms of modification. Thus a student’s capacity to learn mathematics may be real whether or not they actually learn mathematics. This introduces the second level of critical realist ontology, the *actual*, or events that happen. The *empirical* is what we observe and experience (Sayer, 2000). Distinguishing the real from the actual introduces the notion of contingency; a state where one thing does not necessarily lead to another, but depends upon a range of

*enabling conditions*. Thus critical realism enables discussion about capacities that are not actualised, what could be but is not. Furthermore, unlike empirical realism, it claims that there is more to the world than meets the eye (because the real and actual are not necessarily empirical) and that what we observe does not correspond unproblematically to what exists. Students are able to learn mathematics but not all of them do; students who see themselves as ‘good at maths’ are able to be popular, but aren’t always, and the enabling conditions for popularity could be different depending on whether a student is ‘good at maths’ (Francis, Skelton, & Read, 2010).

A critical realist ontology changes the structure of the debate around how much power schools have to combat educational inequality. Gorard (2010) argues that schools can only make ‘a bit’ of a difference, on the basis of analysing large datasets which show little variation between schools in terms of the power of social class to predict achievement. His argument uses the widespread approach of looking at what has happened in the past in a very large number of cases and using this to make inferences about future causal powers, in this case the power of effective schools to reduce educational inequalities. Critical realism frames the problem differently and asks whether the structure and powers of schools and teachers are such that they can create an environment which enables working-class students to achieve well in mathematics (Sayer, 2000). Thus a critical realist approach to a literature review highlights ‘pockets of hope’ which may not be large in scale, but nevertheless demonstrate important possibilities.

Critical realism’s ontological distinction between the empirical (including all research data), the actual, and the real, has consequences for its epistemology (Sayer, 2000). In each case it is necessary to critically analyse the relationship between the real object (for example, an identity or attitude) and what we observe; as we do so we are looking for ‘traces’ of the real. Such an exercise lends itself to a social constructionist epistemology, but of a ‘weak’ rather than ‘strong’ sort. ‘Weak’ social constructionism acknowledges “the socially constructed nature of knowledge and institutions, and the way in which knowledge often bears the marks of its social origins”, whereas ‘strong’ social constructionism claims knowledge is *merely* a social construction, nothing more (Sayer, 2000, p. 90). “Realists can happily accept weak social constructionism, while noting that the social character of knowledge does not mean that it cannot

successfully identify real objects (including social constructions) which exist independently of the researcher” (Sayer, 2000, p. 90). Students’ learner identities are socially constructed, *but not by me*, so my description of their identities may be accurate or false. So whilst I acknowledge that what I report carries strong traces of my own experiences and biases, this does not mean that I can just exercise wishful thinking and report what seems right to me (the empirical). Indeed, critical realism is a highly appropriate meta-theory for conducting rigorous interpretative research (Scott, 2005; Siljander, 2011).

## 2.2 *Ethical framework*

The methods used in this study were guided by ethical guidelines published by the British Educational Research Association (BERA, 2011) and the New Zealand Association for Research in Education (NZARE, 2010). Principles of voluntary informed consent, anonymity, and confidentiality are endorsed by both associations and are reported alongside the relevant research procedures. The focus in this section is on broader ethical issues; responsibilities to the research community, and to the general public.

Ethical responsibilities to the educational research community need to be understood in the context of my position as a postgraduate student researcher. In addition to the general responsibility to communicate my research effectively through appropriate channels (BERA, 2011), I have a responsibility to make the most of a highly supported research environment and to learn about educational research as well as about my specific object of study. Therefore, there is a particular responsibility during this time to engage with literature that underpins discourses in educational research. This engagement will be evident in the presence of philosophical, theoretical, and methodological discussions that might be considered superfluous in a peer-reviewed journal article.

The most nebulous level of ethical responsibility, but perhaps the most important, is that which relates to the general public; the responsibility to conduct “research that seeks to affect educational knowledge, goals, policies, practices, services, facilities or justice in beneficial ways” (NZARE, 2010, p. 3). How to achieve this is a question that necessarily entails morally evaluative statements concerning what constitutes a

beneficial effect. Moral philosophy appears only rarely in the typologies of philosophical assumptions presented in methodological texts, which tend to focus on ontology and epistemology (e.g. Scott & Usher, 1999; Taber, 2007). However, I hold moral concerns to be central to the whole enterprise of this research project, in line with Sayer's call for a "normative turn in social theory" (2000, p. 172).

Nussbaum's (2001) neo-Aristotelian moral theory is based on the premise that our basic moral duty to our fellow human beings is to enable flourishing and reduce suffering. Herman (2007) argues that flourishing includes the development of the capacity to reason and make decisions about one's own life. Control over our lives, or agency, is not available to us all to an equal extent; a fact long-acknowledged within sociology but less prominent in moral philosophy (Sayer, 2005). Furthermore, flourishing and suffering are not simply emotional states devoid of content; they have *reasons*. Nussbaum (2001) makes a powerful case for our emotions being *about* something, and deconstructs the popular dichotomy between emotion and reason. Sayer, building on the moral philosophy of Nussbaum and others, has developed a framework in which emotions are central to the sociological analysis of inequality, and he analyses the emotional responses, including anger, resentment, shame, and pride associated with various class positions (Sayer, 2005).

This framing of emotions as rational responses to objective circumstances which we care about (Sayer, 2011) has ethical and methodological implications. Ethically it means that if students feel anxious, frustrated, or embarrassed this is a problem whether or not it impacts on their achievement (although I think it does), because it causes suffering. Methodologically, it means that emotions can point us towards the reasons that produce them. If a student feels joy and pride in their mathematics work, there is probably a reason for this and it would be good to know what it is. This ethical framework also forces us to address the thorny issue of whether *learning mathematics* contributes meaningfully to students' capacities as authors of their own lives, and whether it is an enabling or constraining condition of later flourishing and suffering. I would contend, with *social realist* authors such as Young (2008) and Wheelahan (2010) that mathematical knowledge is 'powerful' and contributes to agency and flourishing.

### 2.3 *Conceptualising identity*

If mathematics education research is to address the inequalities discussed earlier, it requires a conceptual point of connection with social class, ethnicity, and gender. Given the significant disparities present along each of these dimensions, approaches that treat them as peripheral will lack explanatory strength. Sociology as a discipline has engaged at a highly sophisticated level with inequality, and the sub-discipline of sociology of education with inequality in schooling. A recurring critique of sociological explanations of inequality is that they prioritise structure over agency, that is, that they portray people as victims or benefactors of an inherited social position, powerless in shaping the trajectories of their own lives (Sayer, 2005).

My defence of taking a sociological stance despite this critique is twofold. Firstly, sociology has highlighted how powerful external structuring forces really are (e.g. Bourdieu, 1984; Ingram, 2011; Savage, 2000). In other words, sociology has made a significant contribution to the deconstruction of the idea of meritocracy, a discourse with significant currency in political rhetoric and lay understandings of education (Sayer, 2011). Secondly, insofar as some sociological theory does underestimate individual agency, the sociology on which I draw has engaged with this critique and emerged with more flexible models with space for individual agency. In particular, whilst I will refer to the seminal work of Bourdieu (1984, 1986, 1991), most of my sociological understanding is based on the work of scholars who have revised Bourdieu by incorporating agency, as well as morals, values, emotions, and identity, into his theoretical framework (e.g. Reay, 2005; Savage, 2000; Sayer, 2005; Skeggs, 2004).

#### 2.3.1 **Academic and social fields**

According to Bourdieu (1986) individuals are located in various positions in *fields*, which can be thought of as metaphorical ‘spaces’. Fields are multi-dimensional spaces, so locations are complex rather than positions on a linear continuum, and they are also hierarchical in the sense that some positions afford more access than others to material and symbolic resources. Bourdieu used economic metaphors to speak of social *capital*, *products*, *profit*, and *loss*. Fields can change over time, although they often have very durable structures, and people in more powerful positions have greater control over such changes (Bourdieu, 1991; Devine & Savage, 2005). Individuals positioned



within these fields have a *habitus*, a durable but not completely static set of dispositions that are generative of the types of action, thought, and speech ('products' in Bourdieu's economic metaphor) that people can produce. A person's actions are generated in the interaction between their *habitus* and the part of the *field* that they inhabit. 'Products' have a value determined by the powerful actors in the field, and may have different values in different fields. They may be accrued or exchanged to generate 'capital' (friends, qualifications, skills, and ways of speaking, acting, and understanding). The amount and types of capital that people have determines, to a large extent, their position in the field (Bourdieu, 1984, 1986; Devine & Savage, 2005).

Students and teachers exist simultaneously within two fields, which I will call the *academic field* and the *social field*. The academic field is dominated by the teacher, and the structure of the field is determined by factors like pedagogy, curriculum, and assessment. The valuable products within this field are mathematical ideas and practices, especially those that lead to success in high-stakes tests. The credentials gained in tests are a form of capital that can be put to use within the school's educational field in order to gain access to extension programmes, top-set classes, and high-tier GCSE examinations. These credentials also have value in the field of tertiary education, in which they facilitate access to restricted-entry courses and competitive universities.

The *social field* is structured by principles simultaneously vague and intimately familiar: popularity, friendship, loyalty, jealousy, and a very high level of emotional vulnerability to the esteem and admiration of others. The valuable products are ways of relating, acting, dressing, playing sport, and so on, that contribute to the positions of dominance such as 'popular' and 'pretty'. Position in the social field is incredibly important to students' well-being and flourishing (Sayer, 2011) because it involves human relationships. Adolescents will pay extraordinary costs in the pursuit of social 'profits'; extreme examples of this pursuit include eating disorders in the pursuit of being 'pretty', taking harmful drugs in order to be 'cool', or abandoning important friendships in order to stay 'popular'. It is significant to the current study that being 'good at maths' is an element in *both* fields, as we shall see.

### 2.3.2 Fixity, movement, conflict

In Bourdieu's terms *identity* could be construed as a particular configuration of the habitus that has meaning to people in terms of how they *categorise* themselves and others. People are not evenly distributed within a field, nor do different elements of the *habitus* vary independently. For example, the way we dress is usually related to how we speak, our level of education, the types of films we watch, and so on. There tend to be clusters of people in particular regions of social space, with boundaries between those inside the region 'us' and those outside 'them'. Of course social space is cross-cut by many lines; people may be united by gender but divided by education level, or united by class position but divided by age. People may cluster into quite different groups in different fields, for example, boys who bond over sport won't necessarily see eye-to-eye in the mathematics classroom.

The groundwork is now laid to introduce the theoretical framing of how students access the learner identity 'good at maths'. Skeggs (2004) describes how some markers of identity *fix* people in place, limiting their movement through social space and constraining the range of identities that they are able to adopt. She employs this metaphor extensively in her research with white, working-class women (Skeggs, 1997). For modern, middle-class cosmopolitans Skeggs uses the metaphor of *prosthesis*, the 'putting on and taking off' of identity markers (Skeggs, 2004). The ability of some to glide through social space and 'put on' what is valuable in a given field is a particular feature of 'cultural omnivores', those who show their 'multicultural capital' in their ability to appreciate both high and low culture. One approach to the research question would be to examine whether the metaphors of fixity and mobility help describe students' relationships to seeing themselves as 'good at maths'. For example, does being popular in the social field 'fix' students, pinning them to regions of the educational field that do not lead to success in mathematics (Francis et al., 2010)? Are there regions that it is hard to simultaneously occupy within the educational field, such as 'creative' and 'good at maths'?

### 3 Literature Review

In Chapter One I introduced the ethical and educational problem that motivated this study: inequalities in experiences and outcomes in school mathematics. I then developed the research question, *how do students' social environments and classroom experiences make it easier or harder for them to identify as 'good at maths'?* In Chapter Two I laid theoretical foundations for the rest of the study, outlining how a critical realist approach helps us to focus on unrealised possibilities and 'pockets of hope'. The current chapter reviews a body of research that addresses various aspects of the research question.

The literature reviewed in this chapter was located through recommendations from my supervisor and other academics and searching education and social science research databases. Further studies were unearthed by scouring the references of the initial works and finding more publications by the same authors. Literature was included if it related to the formation of identities in relation to being 'good at maths', in the sense of being able to take up this subject position or 'put on' this identity marker (Skeggs, 2004). The literature on which I have drawn is primarily sociological and has theoretical roots in post-structural gender theory and Bourdieu's understanding of social class. The authors of the selected publications are not the only people writing about mathematical identities, but they are the ones talking about it in the same way I want to, so it is their academic 'conversation' that I am trying to join.

The initial shortlist of publications which I deemed might be appropriate for inclusion in the literature review contained 31 publications. After re-reading less familiar texts, I collated the abstracts and my research notes on all publications and reviewed the list. In this phase I reluctantly eliminated studies that described social-class or gender differences in how students approach or understand learning tasks, in mathematics (Boaler, 1994; Cooper & Dunne, 2000; Player-Koro, 2011) and more generally (Mason, Cremin, Warwick, & Harrison, 2011; Neves & Morais 2005). These studies will prove central to my doctoral research (see Section 1.2) but are about 'good at chess' rather than 'good at rap' identity formation<sup>2</sup>. I noted where multiple publications were drawn from a single project (e.g. Mendick, 2005a, 2005b, 2006,

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<sup>2</sup> See page 6 for my explanation of this metaphor.

2008) and reported these as a single study. This process resulted in the inclusion of eight studies, all conducted in the United Kingdom.

My first attempt to bring these studies together into a coherent narrative convinced me that the studies don't form a linear sequence, and are too 'messy' to be compressed into a tidy table of locations, sample sizes, and findings. The most coherent 'sense making' process for writing this review seemed to be the approach that many of the researchers took to their own data; organising it around significant themes. Two themes that emerged strongly during the first attempt at the review were how access to the learner identity 'good at maths' is regulated by:

- *discourses* about mathematics and (gendered) people, and
- *experiences* of learning mathematics at school.

Studies of the former tended to take a post-structural approach to how students used historical, public, and popular-cultural discourses in their identity construction, and all of these studies had a strong emphasis on how these discourses were gendered. Studies of the latter drew on a more eclectic mix of traditions, including educational psychology and Bourdieusian sociology. They reported on the dynamic relationship between students' identification as 'good at maths' and their experiences in mathematics lessons. Sayer (2000), applying a critical realist lens to discourses, argues that they are powerful and performative, but not all-powerful; reality can take the wind out of their sails. Conversely, powerful discourses can blind us to what is really there. Students live in a world filled with discursive resources that they may deploy in their views of what type of people they are, what type of subject mathematics is, and what type of people can be good at mathematics. However, these *discourses* may be reinforced or troubled by their *experiences* of growing up, living with others, and learning mathematics at school. Therefore I see *both* themes as relevant to my question about how access to the identity 'good at maths' is regulated.

### 3.1 *Discursive identity construction*

The studies that follow examine how discourses like enlightenment rationality, neo-liberal individualism, and the 'autistic genius' can function as building-blocks or straightjackets for students as they develop a sense of who they are and what

mathematics is. Discourses can tie things together, like masculinity and rationality in the discourse of enlightenment rationality, or create *binaries*, like hard work/natural talent (Walkerdine, 1988). A powerful discourse can ‘create truths’ when people become caught up in the discourse. For example, the discursive binary hard work/natural talent, if accepted, forces people to identify which side they are on, so a ‘hard-working’, high-achieving student may protest that they are not *really* good at maths.

The late twentieth century saw the decline, and in some instances the reversal, of the ‘gender gap’ in school attainment in England (Moore, 2004). The late 1970s, during which this gap was highly topical, was also a time when post-structuralism was starting to have a major influence on the sociology of education (Moore, 2004). This era forms the backdrop of a series of studies carried out by Walkerdine and her colleagues, which are the earliest trace I have found of an identity-based approach to understanding success in school mathematics (Walden & Walkerdine, 1985; Walkerdine, 1988, 1998). The participants were mainly girls, ranging from 4-year-olds at home with their mothers to 15-year-olds approaching the end of their formal schooling. Walkerdine used a post-structural approach to the interpretation of the data, challenging the ‘commonsense’ wisdom of the time that girls, by nature, lacked something in relation to mathematics. She traced the historical construction of women as *emotional* and *incapable of reason* through the discourse of enlightenment rationality. Nineteenth century science produced as fact “weak and fainting middle-class Victorian women whose minds, like butterflies, were unable to concentrate, moving from a little embroidery to a little this, a little that; gentle, accomplished, but shallow” (Walkerdine, 1998, p. 35). In deconstructing discourses of women and ‘reason’, Walkerdine highlighted a number of binaries, including active/passive, real understanding/rote learning, and boy/girl.

Walkerdine’s studies used a wide range of methods including interviews, observations, and test results (Walkerdine, 1998). She drew on the wide-ranging data in ways that posed a significant challenge to the idea that mathematics attainment was a simple index of innate ‘ability’ and that the ‘gender gap’ was evidence that girls had less of this ‘ability’ than boys. Walkerdine showed how parents and teachers drew on the discourse of the gendering of reason, and how children then positioned themselves in

relation to these discourses from a very young age. In relation to the gendered binary active/passive, she showed how aggression, disruption and displays of overt sexuality were seen as natural for boys but pathologised in girls (Walkerdine, 1998). Thus boys were able to adopt more powerful identities in relation to learning; active practitioners of reason rather than passive, receptive learners.

A related gendered binary was real understanding/rote learning. Drawing on teachers' descriptions of students' mathematical ability and behaviour, Walkerdine (1998) argued that teachers interpreted high attainment as evidence of 'hard work' in girls, and 'natural talent' or 'flair' in boys. Low attaining girls were 'stupid' and low attaining boys were 'lazy' but *had potential*. Drawing on students' self-identifications and test results, Walkerdine showed that girls tended to perceive themselves as less able mathematicians than boys attaining at the same level. Girls were more likely to admire boys than *vice versa*, and students of both genders valued girls for being 'nice' and 'helpful' and boys for being 'clever' and 'good at sports'. Thus it was much easier for boys than girls to have confidence in their mathematical 'ability' (Walkerdine, 1998).

Walkerdine's studies have provided exemplars for those wishing to go beyond a commonsense notion of fixed 'ability', or even the more flexible notion of *cognitive habitus* (Nash, 2005), in studying inequality in school mathematics. Describing how their approach differed from previous research, Walkerdine explained:

I am not setting out to demonstrate the *real* of the proof that girls *really can* do maths or that boys actually do not have real understanding. Rather, it is how these categories are produced as signs that I am interested in and how they 'catch up' the subjects, position them, and in positioning create a truth. (Walkerdine, 1988, p. 208)

This approach is taken up and developed to varying extents by Mendick, Epstein, Moreau, and Smith, whose studies I now review.

A study by Mendick (2005a, 2005b, 2006, 2008) is the closest I have found to a direct precedent for my M.Phil. project. Mendick observed lessons in AS-level mathematics classes in three secondary education sites in England. She conducted semi-structured interviews with 42 students, mostly aged 16-19, asking them about their experiences of learning mathematics, the reasons for their subject choices, their perceptions of

different subjects, and their feelings about gender. In her post-structural analysis of how different students chose to continue with mathematics, she explicitly discusses how the students were (not) able to take up the subject position 'good at maths'. In a strategy similar to Walkerdine's, she attempts to uncover binaries in the discourses that the students drew on, and to chart how students positioned themselves in relation to these binaries. The binaries she describes include "maths people/non-maths people", "fast/slow", "independent/collaborative", "active/passive", "naturally able/hard-working", and "masculine/feminine" (Mendick, 2006, pp. 105-106).

Only five of the 42 interviewees identified as 'good at maths', four of them boys. The students who were 'good at maths' strongly distinguished mathematics and sciences from languages and arts, the former ordered and rule-based, the latter creative and emotional. They identified as competitive, independent, active and naturally able, whereas other students were collaborative, dependent, and hard-working. Mendick argues that the students who were 'good at maths', including the female, were drawing on strongly gendered discourses and "doing masculinity" (2006, p. 86) in order to be 'good at maths'. Referring to Walkerdine, she discusses the discourse of "unreasonable women" (Mendick, 2006, p. 61) which positions femininity as incompatible with reason and rationality. However, her analysis diverges from Walkerdine's where she draws on popular culture, especially films, to propose two archetypal portrayals of mathematicians, the 'geek/nerd' and the 'madman/genius'. Mendick writes of the 'geek/nerd' that "within popular culture, the dominant image of the mathematician depicts them as boring, obsessed with the irrelevant, socially incompetent, male, and unsuccessfully heterosexual" (p. 62). Not surprisingly, this is a spectre that most students wanted to keep at arm's length. Students *not* identifying as 'good at maths' were quick to distance themselves from those they perceived as 'good at maths', with one student commenting "I'd rather be like medium stage in maths, and have social skills" (p. 63). These students defined themselves in opposition to the 'geek/nerd' because of the importance of being social; this also made it harder to adopt the identity 'good at maths'.

Mendick (2006) also describes a less ubiquitous but still well-known archetypal mathematician: the madman/genius. This figure, found in a number of contemporary films, is endowed with the gift of mathematical genius, which often comes at the cost

of his mental health. This figure was mobilised by students not identifying as ‘good at maths’ in their views of mathematical ability as something that was very rare, and that either you had or you didn’t. This mathematician is also sometimes a heterosexual hero, using his skills to crack enemy codes and often ‘getting the girl’. Students who are ‘good at maths’ might find this image preferable to that of the ‘geek’ but it is still highly problematic (and always male). Both of these images “help to maintain rationality as masculine and being ‘good at maths’ as a position that few men and fewer women can occupy comfortably” (Mendick, 2006, p. 66).

Mendick subsequently collaborated with Epstein and Moreau in a study that further examined how students deploy popular images of mathematicians in their identity construction (Epstein, Mendick, & Moreau, 2010; Mendick, 2007; Moreau, Mendick, & Epstein, 2010). In the first stage, 556 14-15-year-olds and 100 university students completed a questionnaire about their perceptions of their own mathematical ability and of the popular cultural representations of mathematicians with which they were familiar. The second stage comprised 27 focus group interviews which used video clips from sources mentioned in the questionnaires to stimulate further discussion of the discourses about mathematicians that the young people used. The final stage involved 26 interviews, which were “in-depth explorations aimed at understanding how the young people identified as mathematical or not, whether and how they deployed popular cultural resources in shaping themselves as gendered, raced, and classed (non)mathematicians” (Epstein et al., 2010, p. 48).

Consistent with and extending Mendick’s (2006) earlier analysis, the popular cultural texts depicted mathematicians as “white, heterosexual, middle-class men” (Moreau et al., 2010, p. 25) who are “isolated, obsessed, possibly autistic but certainly socially inept” (Epstein et al., 2010, p. 52). The authors are cautious not to over-emphasise the impact of these images on identification with/against mathematics, explaining how many students approached the stereotypes critically. In fact, some university mathematics students deployed the images positively, enjoying being perceived as ‘brainy’ and ‘eccentric’. However, despite this critical awareness, students who did identify as ‘good at maths’ still had to do a lot of work to resist the ‘nerd’ image, going to great lengths to assure the interviewers and their friends that mathematicians are ‘just normal people after all’. What I found most significant about the findings of



this study was that, although students were critical of the discourses about mathematicians in popular culture, they were generally unable to find any alternative discourses on which to draw. Popular culture provides no resources for the construction of a positive mathematical identity by students who are not white, middle-class, males, and even for these triply-advantaged students the resources are undesirable.

Smith (2010) reports early findings from an ongoing study of English students taking Further Mathematics<sup>3</sup> AS- and A-levels, based on semi-structured interviews, email surveys, and classroom observations of 24 students. She focuses on how students use *work* and *happiness* as discursive tools in their identity formation, choosing these two foci “because of their prevalence in educational discourse and sociological theory” (Smith, 2010, p. 101). Students struggled between two conflicting discursive imperatives about work: the need to work hard in Further Mathematics because it is so difficult, and the need to *not* work hard, because talented mathematicians should achieve effortlessly. Students felt that they ought to be happy, and stated that enjoyment of mathematics was a determining factor in choosing to continue with the subject. Furthermore, they had to *work on* being happy, deploying the neo-liberal discourse of conscious self-improvement in a life-optimising biographical project. Feeling happy about doing Further Mathematics was most closely associated with working together on something challenging, and with the perception that Further Mathematics was a dependable pathway to future success. Smith’s (2010) research provides an instructive counterpoint to the previously reviewed studies, which mostly emphasised the challenges of forming a positive identification with mathematics. Her participants were able to form a very positive identity towards mathematics when they were able to enjoy the subject, see it as a path to future success, and see themselves as working hard enough but not too hard.

Francis, Skelton, and Read (2010) carried out classroom observations and interviews with 71 high-achieving Year 8 students in a range of co-educational state schools in England, including 22 students who were high achieving and popular (HAP). Popularity was judged by students’ peers in a process that is not fully explained, and achievement was judged by test performance relative to the students’ peers. Although

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<sup>3</sup> Further Mathematics can be taken in addition to Mathematics by students in their final two years of secondary school. It is perceived to be a very challenging course.

working-class and ethnic minority students were present in the HAP sample, most of the HAP students were white and middle-class, so there was insufficient variation to draw conclusions about how class or ethnicity intervene in the quest to be HAP. However, the authors conduct a rigorous analysis of their data in terms of how students were able to simultaneously achieve popularity and academic success, and how this identity work was strongly gendered.

HAP students were confident, good-looking, and highly sociable inside and outside of the classroom. The authors suggest that the students were confident and sociable as a result of their good looks, although this interpretation seems to underplay the role of grooming, dress, diet, and exercise in the production of gendered performances of good looks. HAP students interacted confidently with members of the opposite sex, and performed normative gender roles. HAP girls were mature and somewhat aloof in class, successfully 'othering' both the boys and the less popular girls, who were more noisy and boisterous. HAP boys were mostly good at sport and used highly overt sexual innuendo, and some played a 'cheeky' class clown role. Francis *et al.* (2010) suggest that these gendered performances may have served to 'provide cover' for less gender-normative academic behaviour.

Regardless of gender, class, and ethnicity, HAP students simultaneously produced typically 'popular' and engaged learning behaviours, with some subtle differences. Unlike the 'geeks' who were high achievers but not popular, they engaged in learning 'with attitude'; they contributed to pedagogical discussions in engaging and confident ways. Unlike popular students who were not high achievers, HAP students avoided confrontations with the teacher, and were more likely to exhibit low-level 'cheeky' but good-natured behaviour that did not result in disciplinary action. Of the very popular high-achievers, many had a 'fall guy', a more deviant close friend who was involved in serious confrontational behaviour. This put the popular high-achievers at the centre of classroom events whilst avoiding the negative fallout of misbehaviour (Francis *et al.*, 2010). This non-subject-specific study presents an intriguing contrast to mathematics-focused studies (Epstein *et al.*, 2010; Mendick, 2006; Moreau *et al.*, 2010) which emphasise the negative stigma of high achievement. From a critical realist perspective, it is another 'pocket of hope'. The students on which the authors focus were achieving good results and in powerful social positions. The current study

attempts to address the question of why this combination seems so elusive in mathematics.

### 3.2 *Experiencing mathematics*

Apart from Walkerdine's research, the other 'famous' study, to which most of the others make at least passing reference is Boaler's groundbreaking study carried out in an English city in the early-mid 1990s (Boaler, 2002). The three-year study followed cohorts of students through Years 9, 10, and 11 (age 13–16) in two predominantly white working-class comprehensive secondary schools. Boaler used a grounded theory approach to make sense of her extensive data which included mathematics assessments, student and teacher interviews, and lesson observations. The study is a detailed, observant account of two contrasting approaches to teaching mathematics, 'traditional' and 'reform', each typical of one of the schools. I will not attempt to summarise the study as a whole, but rather to highlight what seems most relevant to student identity formation and emotions in mathematics.

Students at the 'reform' school were taught in mixed-ability groups, using open-ended projects. The 'traditional' school set<sup>4</sup> students according to test results and taught procedures for solving repetitive text-book problems. Students were much more likely to enjoy mathematics in the 'reform' school, regardless of gender. In the 'traditional' school, students' experiences were characterised by boredom and disengagement, with school mathematics being perceived as important for exams but irrelevant to life outside of the classroom. Furthermore, girls struggled with the 'traditional' approach more than boys did. Girls seemed to have a stronger desire than boys to *understand* what they were doing rather than simply to memorise and repeat procedures for getting correct answers. After three years, there was a large 'gender gap' in favour of boys at the 'traditional' school and no 'gender gap' at the reform school (Boaler, 2002). Boaler's discussion relates the emotions of enjoyment and boredom directly to how mathematics is taught, and is particularly convincing given the strong similarity between the two cohorts when they entered the schools and the stark differences after three years. Boaler's study exemplifies the approach of analysing identity formation

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<sup>4</sup> 'Setting' is a British term for allocating students into 'sets', which are classes with relatively homogenous levels of attainment. Non-British readers may be more familiar with the terms 'tracking' or 'streaming'.

in relation to *how mathematics is taught*, an approach also taken in the following studies.

Bibby (2002) investigated the mathematical experiences and histories of seven London primary school teachers (six women and one man), conducting five to seven ethnographic interviews with each teacher and drawing out themes using a grounded theory approach. She identifies *shame* as a significant formative factor in the teachers' mostly negative recollections of learning mathematics. Bibby (2002, p. 706) argues that "there is a connection between experiencing mathematics algorithmically, procedurally or as a product and experiencing shame in mathematical contexts". Drawing on Walkerdine's work, Bibby explains how "abstract logico-mathematical thinking is frequently taken to be the pinnacle of intellectual achievement – the most advanced form of thinking" (p. 709). Because of the perception that mathematics is 'either right or wrong' and the high value placed in being right, doing mathematics often entails "a fear of (imagined or real) criticism, ridicule or rejection by others" (p. 710). Doing mathematics with a real or imagined audience (being asked a question in class, or knowing that your written work will be examined) is a kind of 'soul-baring'. It is felt to expose something of the student's intelligence in a very one-sided, uncomfortable manner, without the scope for self-protection through the "impression management" (p. 713) that is a normal part of sharing in a safe social setting.

Bibby (2002) goes on to explain how the teachers she interviewed recalled coping with, suppressing, or avoiding shame. Their coping strategies included physically or mentally distancing themselves from mathematics, misbehaving to change the focus from learning to behaviour, and using pre-emptive self-denigration. The study is very detailed in its analysis of how, contrary to popular wisdom, "for many people [mathematics] is experienced in highly emotional ways – people come to know mathematics through emotions" (p. 706). Bibby goes beyond simply describing emotions (in particular shame) and looks at the *reasons* for shame, an approach to emotions echoed in the work of Nussbaum (2001) and Sayer (2005, 2011), thus providing a precedent within mathematics education for an analysis of emotions of the type I proposed in Section 2.2.

More recently, Bibby collaborated in secondary data analysis based on a large-scale study examining reasons for students discontinuing mathematics after the age of 16.

Around 1,500 students near the point of decision whether or not to continue with mathematics, from 17 diverse English and Welsh secondary schools, completed a four-page survey. The analysis (Brown, Brown, & Bibby, 2008) focuses on a question about how students felt about mathematics (circle any words from a list including *enjoy, like, hate, bored, anxious, difficult, easy*), whether students were planning to continue with mathematics, and their predicted GCSE mathematics grade.

Three themes summarised students' reasons for not continuing with mathematics: it was *difficult, boring, and not useful*. Although students with lower predicted grades were more likely to cite *difficulty* as a reason for not continuing, it is striking that 22 per cent of students with a predicted grade of A\* and 47 per cent of students with a predicted grade of A also gave difficulty as a reason. Analysing the open responses, the authors note that "some students appeared to believe that there were fixed 'boundaries' for each individual person in mathematics, beyond which learning becomes extremely difficult and frustrating" (Brown et al., 2008, p. 8). They suggest that these perceived boundaries are reinforced by institutional boundaries such as boundaries between different sets, different exam tiers, and between GCSE and AS-level. They also note that many of the written responses were "charged with emotion", for example, "my GCSE maths experience has put me off it for life" and "I hate it when I get it wrong and get frustrated" (both of these students had a predicted grade A). These results are consistent with those of previous studies mentioned in terms of the key role of emotions in learning mathematics, although the 'thin' nature of the data makes it more difficult to speculate about the *reasons* for these emotions.

This study (Brown et al., 2008) included an analysis by gender, motivated by the fact that far fewer girls than boys take mathematics beyond GSCE despite achieving similar GCSE results. There were no gender differences in the selection of 'bored' or 'like', but girls were more likely than boys to select 'difficult' (42% versus 30%) and 'anxious' (35% versus 21%). Female open responses included "I feel it would be too difficult at higher level" (predicted grade A\*) and "I don't feel confident enough to [continue with maths] even if I'm at an A grade" (predicted grade A) (Brown et al., 2008, p. 12). Over twenty years since Walkerdine *et al.*'s studies, and with the 'gender gap' in attainment now officially closed, girls are still more anxious in mathematics and many still don't feel that they can *really* be good at maths.

### 3.3 Conclusion

In reviewing research about what makes it harder or easier for students to identify as 'good at maths', I found that most of the findings related either to how students used available discursive resources in their identity construction, or to how school experiences taught students whether or not they were 'good at maths'. Mathematics is discursively connected to the idea of male rationality, and to the middle-class, male, white figures of the 'geek' and the 'madman/genius'. However, some students are able to either valorise being a 'geek' or make their academic achievement socially acceptable by accompanying it with 'cool', confident, or hyper-sexualised behaviour. In terms of school experiences, doing mathematics was much more enjoyable and equitable using a project-based 'reform' approach than a repetitive and procedural 'traditional' approach. Students often felt exposed doing mathematics, because of the belief that answers are either right or wrong, and getting the 'wrong' answer indicated a lack of intelligence.

This literature has provided strong support for my contention that mathematical identity formation is an important factor in enjoying and succeeding in mathematics. It has addressed my research question extensively in relation to gender, but only superficially in relation to social class, a significant and enduring axis of educational inequality in England and New Zealand (Rata, 2012; Reay, 2006b). Cooper and Dunne (2000) have researched social class differences in how students approach contextualised test items, but their work was focused on social class differences in problem solving techniques rather than identity formation. This points to a need to explore whether, and if so, how, social class inequalities in mathematics are a result of working-class students struggling to identify as 'good at maths'.

## 4 Methodology and methods

So far we have examined several aspects of the question of how students' social environments and classroom experiences make it easier or harder for them to identify as 'good at maths'. In Chapter One we looked at why this question interests me so much and why it is not just interesting but *important*. Identity is a word with many diverse usages, so I devoted Chapter Two to why I would want to frame the research question in these terms, drawing on Skeggs' (2004) theoretical work on fixity and mobility, and on Sayer's (2000, 2011) developments of critical realism for the social sciences. In Chapter Three I summarised the story so far in terms of one academic 'conversation' about mathematical identity formation. The current chapter explains how I designed and carried out a small-scale empirical project which I hoped would add to this story. The chapter begins by documenting how I developed a methodological strategy based on methodological literature (Section 4.1) and inspirational prior studies (Section 4.2). It then details the development of the interview schedule, the participants, and the actual implementation of the interviews (Section 4.3) and how I analysed the data (Section 4.4)

### 4.1 *Phenomenological multiple case-study*

The most fundamental division of methodologies in the methodological texts consulted (e.g. Cohen, Manion, & Morrison, 2007; Creswell, 2007; Johnson & Christensen, 2008; Sarantakos, 2005; Somekh & Lewin, 2005) is between *qualitative* and *quantitative* research, although this division is not universally regarded as productive (Sayer, 2010; Symonds & Gorard, 2010). Creswell (2007) suggests that we conduct qualitative research in order to *explore* aspects of the social world which are *complex*, and an exploration of the formation of students' learner identities certainly meets these criteria. Johnson and Christensen (2008, p. 19) explain that exploratory (as opposed to confirmatory) research uses "a *bottom-up* approach because it emphasises starting with particular data and observations and discovering what is happening more generally". Given these considerations, a *qualitative* methodology is most appropriate for addressing my research question.

Although social research texts offer somewhat varying typologies of qualitative methodologies, almost all texts include phenomenology, ethnography, case-study, and grounded theory (e.g. Cohen et al., 2007; Denzin & Lincoln, 2008; Somekh & Lewin, 2005). The knowledge I sought to generate concerned the role of students' social environments and classroom experiences in their mathematical identity construction. Therefore students' *lived experiences* of school life and studying mathematics are at the centre of the analysis, suggesting that the study contains elements of *phenomenology*, in which the researcher "attempts to understand how one or more individuals experience a phenomenon" (Johnson & Christensen, 2008, p. 48). However, whilst phenomenology focuses on *shared* experiences of a phenomenon (Johnson & Christensen, 2008), I am also interested in how individuals' experiences of school mathematics differ. In this sense my project has a *case study* nature, a case study being a "detailed description of one or more cases" (Johnson & Christensen, 2008, p. 49) in which each case provides "a unique example of real people in real situations" (Cohen et al., 2007, p. 253). Each individual can provide an instance of the conditions of mathematical identity formation, so my question does not inherently require comparison or generalisation, both of which need multiple participants to make methodological sense.

According to the definitions of the texts reviewed, the study is not an *ethnography* because I am not focusing on the culture of a particular group of students. Nor is it *grounded theory*; whilst there is a sense in which I hope to generate propositions grounded in the data, the theoretical framework of my study is predetermined in my focus on social environments and classroom experiences (Denscombe, 2007). Furthermore, the short time frame of the study precluded the time-consuming cyclical nature of grounded theory research, in which the researcher must be willing to gather additional data if it is required in order to achieve "theoretical saturation" (Denscombe, 2007, p. 96). Hence it was established that the study would be qualitative, with characteristics of case study and phenomenology approaches. Case study research can involve a single case or multiple cases; both have provided high-quality studies related to students' learner identities (e.g. Reay, 2002; Walkerdine, 1998). As a novice researcher, aware that studies which "require skills that you might not have ... should not be initiated" (Johnson & Christensen, 2008, p. 74), I deemed it unwise and risky to attempt an individual case study, as so much would have been



invested in the reflections of one participant. Furthermore, multiple cases could provide a greater range of responses, and I was interested, in an exploratory way, in any themes that might emerge.

#### 4.2 *Methodological exemplars*

I established the basic *methodological* characteristics of the study: a qualitative, somewhat phenomenological multiple case study, with in-depth interviews or focus groups. However, this methodology was a rather unsatisfying and non-specific basis from which to proceed to more detailed *methods*. It provided parameters to work within, but little detail and no inspiration. Therefore, in the current section, I review a small selection of potential methodological exemplars, selected on the basis of specific methods or interpretative devices they use which gave my methodology more substance.

Walkerdine's studies (Walden & Walkerdine, 1985; Walkerdine, 1998), reviewed in Chapter Three, have a number of theoretical and methodological implications for my proposed research. Firstly, they show that research seeking to explain inequality can explore very interesting territory by taking the focus off 'cognitive ability' and focusing on how students are positioned in ways mediated by gender and class. Much of their data takes the form of how students and teachers *categorised* and *positioned* themselves and others, and the qualities these participants expected and *valued* in others. Here I focus on the way the researchers conducted student interviews, since interviews are usually the primary data collection method in phenomenological research (Johnson & Christensen, 2008; Titchen & Hobson, 2005).

In semi-structured individual interviews, students were asked to name one person that they wished they were like and one person that they were glad not to be like. They were then asked what it was about these 'others' that they liked or disliked. In this way the researchers were able to analyse the associations different groups of students made between various desirable or undesirable identity markers and being 'good at maths'. For example "'nice', 'kind' and 'helpful' were seen as feminine characteristics. Cleverness is associated with these, but helpfulness seems most important and can be substituted if a girl is not understood as clever" (Walden &

Walkerdine, 1985, p. 67). The knowledge generated in these studies has strong resonance with that which I hoped to generate.

Kidman, Abrams, and McRae's (2011) case study of 32 Maori children aged 10-12 in a New Zealand Maori language immersion school used focus group interviews to investigate how these students positioned themselves in relation to school science and academic scientists. The study draws on Bernstein's (2000) claim that pedagogical discourses create models of an 'ideal student', then asks how Maori students position themselves in relation to school science and 'ideal' science learners. Students were asked about what scientists were like, including aspects of scientists' everyday lives. Nearly universally, scientists were viewed as a negative 'other', specifically as "lonely white men in white coats" (Kidman et al., 2011, p. 212). Kidman *et al.*'s study shares with the work of Walkerdine an approach in which students described and evaluated real or imagined others, who were defined in terms of their academic prowess *and* other desirable or undesirable characteristics. Kidman *et al.* (2011) use their interview data to argue that being a scientist was defined in opposition to being Maori, especially a Maori girl, and also in opposition to being social and valuing relationships. This study offers another creative example of interview techniques that can get at how students view their own identities in relation to a specific school subject.

Reay's (2002) single case study of Shaun, a poor, white, working-class boy in an inner-city 'sink' school describes the vast amount of academic and psychic 'identity work' required to "carve out a space for academic success in a peer group context where, at least nominally, it is despised and where he still retains very strong desires to belong" (Reay, 2002, p. 227). What this study offers methodologically is a model of qualitative interviews that encourage students to reflect on academic *and* non-academic considerations, as well as taking seriously the categorisations that students want to maintain ('tough') and avoid ('geek'). Reay also discusses fixity versus mobility; unlike middle-class boys, being simultaneously academically successful and cool "is not a subject position available to Shaun. In contrast, Shaun has to continually negotiate peer group pressure to prove he is still really 'a lad'" (Reay, 2002, p. 227).

### 4.3 *From strategy to data*

This section outlines three key processes in the implementation of my research strategy: planning the interviews, selecting the participants, and carrying out the interviews.

#### 4.3.1 **Planning the interviews**

Based on my review of methodological literature and examples from research literature, I began to plan my interviews with a number of principles, guidelines and ideas in mind. The interviews needed to:

- elicit participants' *experiences* of the academic and social aspects of school, with a particular focus on learning mathematics;
- be *open-ended* enough to allow participants to describe social groups and identities in their own terms, rather than using pre-determined categories; and
- use creative prompts to stimulate discussion of participants views of mathematics and people who are 'good at maths'.

Furthermore, the process of data analysis needed to:

- enable the participants' responses to generate meanings and categories that were not pre-determined; and
- be sensitive to how students positioned themselves/were positioned (Mendick, 2006) in relation to discourses about mathematics and mathematicians, and to how these positions can be comfortable or conflicted.

With these guiding principles and my research question in mind, I embarked on the process of planning my interviews. The interviews were to have three broad phases:

1. mathematical biography;
2. social groups and mathematics; and
3. experiencing mathematics teaching.

Questions in the first phase covered general information about schools attended, academic success, attitudes towards mathematics at school, and how and why these attitudes changed. Questions in the second phase investigated participants' social groups at school, characteristics of different groups, and people that the participants wished they were like or were glad not to be like. Questions in the third phase of the interview asked participants about their favourite and least favourite mathematics teachers and their reflections on effective pedagogy. This phase involved a simple activity to stimulate discussion of the emotions students experienced about learning mathematics. Participants would be shown cards with the words *pride*, *boredom*, *embarrassment*, *satisfaction*, *confidence*, *frustration*, *guilt*, *joy*, *anxiety*, *shame*, and *confusion* written on them and asked which of these, if any, they associated with learning mathematics at school. Once they had made their selection, they would be asked which situations tended to elicit these emotions. The full interview schedule is attached as Appendix A.

#### **4.3.2 Participants**

The research question specifies *students* as the group whose experiences of mathematics should form the empirical basis of this study, and I have suggested that I have a particular interest in senior secondary students aged 15–18. Thus I initially planned for the study to take place in a secondary school setting with students in this age range. My methodological plan (see Essay Two) was completed shortly before schools went on their Easter Break, during which time I prepared interview materials, information and consent forms, and gained ethical approval for the proposed research. This resulted in me attempting to gain access to students during the final school term leading up to their final exams, a time during which teachers and students alike are under considerable time pressure. Perhaps as a result of this pressure, I was unable to locate a school which was willing to host the research.

As a consequence, I required participants to which I could secure fairly rapid access, i.e. a convenience sample. Social and institutional connections are very effective in gaining access to participants, and the logistics of gaining consent is much more streamlined with adults than with school students. Therefore, I decided to ask acquaintances and colleagues to participate in interviews. Within this large pool of potential participants, I considered which characteristics would provide interview data

most pertinent to my research question. Most potential participants were students or partners of students at an elite university which I will call Victoria, thus it was not possible to contrast conventionally successful and unsuccessful students, as was planned initially with the inclusion of one low-set and one high-set class. However, the pool was highly international, and included very advanced mathematicians as well as those specialising in social sciences and law. This provided an opportunity to interview people from a range of cultures, including those at the high-achieving extreme of the mathematical achievement spectrum and those closer to the middle. I attempted to select a purposive sub-sample with maximum variation in terms of nationality and subject specialisation.

Kvale (1996) warns against waiting until after interviews are complete before considering the logistics of data analysis, so I considered several factors in determining my desired number of participants. I wanted a sufficient number of experiences to be able to see some hints of consistency and variation amongst participants, allowing for some interviews not yielding much data relevant to my research question. As an inexperienced transcriber, I expected an hour of interviewing to lead to a day of typing. Furthermore, this typing would generate transcript to be analysed in detail at a rate of around 10,000 words per hour of interview (Kvale, 1996). Two hours of interviews, transcribed verbatim, would generate a transcript the length of this thesis! The transcript length could be reduced by removing any irrelevant sections of the interview identified by listening to the audio recordings, however, I could still end up ‘drowning in data’ if I conducted too many interviews. This would lead to a superficial or selective analysis of data, and waste the participants’ time, which is an ethical concern (BERA, 2011). With these considerations in mind I set the goal of interviewing five to ten participants in two to three hours. I also wanted to conduct group and individual interviews. Given the nature of my research questions, groups of more than two would have been unwieldy. Thus I requested seven colleagues and acquaintances to participate in interviews. Basic profiles of the participants are summarised in Table 1. All participants immediately confirmed their willingness to participate.

*Table 1.* Interview participants (items in italics are intentionally vague to preserve anonymity).

<b>Interview</b>	<b>Pseudonym</b>	<b>Gender</b>	<b>Nationality</b>	<b>Occupation</b>
A	Amanda	female	Chinese	<i>Social sciences</i> research student
	Katie	female	<i>East Asian</i>	<i>Social sciences</i> research student
B	Paula	female	<i>Latin American</i>	<i>Social sciences</i> research student, mathematics teacher/educator
	Connie	female	<i>Latin American</i>	<i>Social sciences</i> research student
C	Peter	male	Australian	Law postgraduate student, lawyer
D	Lizzie	female	Irish	<i>Biological sciences</i> research student
E	Chris	male	English	Mathematics research student

### 4.3.3 Interviews

During the interviews, I had the interview schedule (Appendices A and B) in front of me and referred to it regularly. I covered all themes in every interview, but did not necessarily use all the prompts I had written down. I responded to comments that participants made in relation to my themes of interest with prompts asking them to elaborate. I also responded to biographical details given; Paula moved from a small, village school to a large city school at age 15 and I used this transition as a nucleus for questions around the pedagogies and social groups of the two schools. In every interview it was clear early on whether participants had been successful at mathematics in school and whether, overall, it had been a positive or negative experience. Once I was convinced that I had a clear idea of this identity I asked questions later which assumed it, such as “at what point did you become consciously aware that you were good at maths?”

Interviews A (52 minutes) and B (68 minutes), each conducted with a pair of participants, took place in teaching rooms on the university campus. In these interviews I encouraged participants to comment on each others’ responses, which they often did. In some cases they were able to clarify to me the significance of what their co-participant had said. In both cases the pairs had spent a lot of time together socially and knew each other reasonably well, so in this sense they facilitated each others’ openness to share, and raised the level of humour and ‘flow’ compared to individual interviews. At no point did I get the sense that any of the dual-participant

interviewees was 'holding back' because of the concern that they were being monitored by the other participant. In fact it is likely that they would have been far more comfortable sharing with each other than with me; male, from a different culture, and not so well acquainted. This experience lends support to conducting group interviews of this sort in the future, particularly with small groups of friends. Following these two interviews, I wrote reflections on the content and process in my research journal. Based on these reflections, I made some minor changes to the interview schedule, and this second version (Appendix B) was used in the final three individual interviews.

The final three interviews (50, 36, and 35 minutes respectively) were conducted individually with acquaintances from university social groups. In the group interviews participants would develop a dialogue in a direction that I was not encouraging, whereas in the individual interviews it was easier for me to 'steer' the conversation. This is a skill I will need to develop so as to facilitate more focused 'focus groups' in the future. I was able to spend a short period of time socially with each participant before each interview, having dinner or sharing a coffee. As a result of this I judged it sensible to embark on the substantive focus of the interview very quickly, without general 'warm-up' questions that I might have used had I not already built rapport before the interview.

Ethics in a broad sense are a central motivator of this project, and ethical considerations were discussed as part of the theoretical framing of the study (Section 2.2). In terms of the fieldwork, I consulted the guidelines of the national educational research associations of Britain (BERA, 2011) and New Zealand (NZARE, 2010) whilst planning the interviews. I ensured that all participants were informed about what the interview would involve, via personal communication and an information sheet, and all participants gave informed consent to take part (see Information and Consent Form, Appendix C). I maintained anonymity as far as possible by using pseudonyms for the participants and the research setting, and by omitting or making vague information that could be used to identify them. I valued participants' time by ensuring that I arrived at interviews punctually and with fully functioning recording equipment, and gave them small gifts as tokens of appreciation.

#### 4.4 Data analysis

Interviews were transcribed within the qualitative data analysis software NVivo 8, enabling me to move quickly between the written transcript and the audio recording. I listened to all of the interviews at least three times, making notes on major themes and particularly interesting or relevant sections, and reflecting on the quality of the interviews in terms of ‘leading’ or unclear questions. It quickly became clear that six of the seven participants were mathematical ‘success stories’, in that they had achieved very highly in mathematics and identified as ‘good at maths’. I knew before the interviews that Chris was a postgraduate mathematics student, and that Connie and Paula were interested in mathematics education, so it was not surprising that all of these participants were highly successful mathematicians. What I didn’t know was that, of the other four, Peter was “pretty easily the best kid in [his] year at maths”, Lizzie had enjoyed and excelled in mathematics from a young age and continued to use it extensively in her tertiary study of biological sciences, and Amanda was an outstanding mathematics student at school, being selected for mathematics competitions. From a critical realist perspective, this begs the question of what *enabling conditions* facilitated this rare, contingent occurrence. Only Katie did not identify as ‘good at maths’.

As an unintended but not completely surprising result of my choice of participants, there was little evidence in the participants’ biographies of how access to being ‘good at maths’ was regulated in the negative sense. However, there was plenty of evidence about how access was *facilitated*. I am under no illusion that this was any kind of ‘representative sample’. It is closer to an ‘extreme case’ sample in terms of the participants’ experiences and achievement. Because of the nature of the data, it was necessary to modify the research question from “how do students’ social environments and classroom experiences make it easier or harder for them to identify as ‘good at maths’?” to:

***“how do social environments and classroom experiences enable high-achieving students to identify as ‘good at maths’?”***



Initially I planned to use a highly structured three-phase analysis for each case, then conduct a more open cross-case analysis (see Essay Two). The planned stages for each case were:

1. identify all identity markers, and who (if anyone) they were applied to;
2. analyse the configuration of identity markers in terms of whether there are pairs that seem to 'attract' or 'repel'; and then
3. note all reference to mathematics teaching and the evaluative/emotional responses to these teaching events.

I did apply this procedure to the analysis of Peter's interview, and found that it was too prescriptive to allow a deep exploration of his experiences and views. Also there seemed little merit in conducting the analysis in three discrete phases, so in my analysis of the second transcript I carried them out simultaneously during a single close reading of the transcript. At this point I started to code some segments inductively with more emergent, data-driven themes, such as 'gender' and 'emotions'. The rationale for using a more inductive strategy was that there appeared to be evidence in the data that these themes might relate to participants' mathematical identity formation.

Inevitably, my "noticing" of these themes in the data (Mendick, 2006) is related to the literature I have read and to my own experiences. My noticing of Peter's strong discursive division between science subjects (including mathematics) and humanities subjects, and the corresponding division in ways of thinking, was probably framed by the frequent analysis of discursive binaries in the writings of Mendick and Walkerdine. As I listened to the interviews I noticed that all of the success stories included membership of an academically supportive peer group, so I generated the code 'peer protection'. Reflecting on my own biography, I attended one school for twelve years and had a very stable, safe peer group who perceived me as 'good at maths' but did not require significant 'identity work' on my part to maintain social credibility. I mention these influences on the interpretative process not as a confession of bias that I hope to eliminate, but rather to be as clear as possible about how I interpreted my data. My own experiences of school, as a student and then later a teacher, provided the motivation to embark on this project (see Chapter One) so it is appropriate that they

continue to inform the data analysis. My recent sociological reading, some of which is reported in Chapters Two and Three, has helped me generate and then contextualise my research question, so these too are and should be part of the interpretative process.

## 5 Results and Discussion

This chapter is the culmination of this research project. In it, I introduce three participants in detail in order to provide a sense of their unusually successful educational stories, and to show how I approached individual cases before embarking on cross-case analysis. I then discuss what I consider to be the two most significant and well-substantiated themes from across the interviews. Each of these thematic analyses draws on interview data from this study and prior literature, and includes a discussion of implications. This mode of presentation is intended to keep ideas which are closely connected together in the text; it also means that this chapter is rather long, and the Conclusion rather short.

### 5.1 *Three mathematical biographies*

The purpose of each interview was to try to understand the participant's perception of themselves as mathematician and how this identification developed. Since only one participant did not identify as 'good at maths', the most constructive manner in which to make sense of the cases is in terms of how the students came to identify as 'good at maths'.

#### 5.1.1 **Paula's story**

Paula was bubbly and relaxed during the interview; she and Connie had become close friends since meeting each other at Victoria. They were from the same Latin American country, spoke the same first language, and frequently finished each other's sentences, interrupted each other, and expanded on each other's comments during the interview. Paula's mother had an undergraduate degree and worked in a bank, and her father had no post-secondary education and owned an accounting firm. She grew up in a small town where she went to a public school from age two to nine, then to a private school until the age of fifteen, when she moved to a private secondary school in a nearby town. Her classmates were her friends, and she had a stable, supportive, socio-economically advantaged peer group, although this changed when she changed schools at age fifteen. She studied mathematics at a university that Connie clarified was "one of the best universities in [the country]", trained as a teacher, taught

secondary mathematics, trained mathematics teachers, and did a masters degree in education before coming to Victoria to conduct educational research.

Paula had wanted to be a teacher from a very early age, and decided when she was 15 to become a mathematics teacher, as mathematics was her favourite subject: “I like math, I don't know I think it's something that is inside me, I think it's never boring”. At the school in her home town, her teachers frequently called her up in front of the class to explain mathematics. She felt good about this, enjoying the feeling of helping her classmates and the teacher, and felt that her contributions were genuinely valued. Sometimes her classmates would joke about her being a ‘geek’ when she achieved high grades; but her tone as she recalled this suggested that she perceived this as affectionate and ironic, conveying genuine admiration. When we discussed this further she explained that her high attainment was not used to marginalise her, because her classmates were good friends and were happy about her success: “my class were students that were with me since we were two years old so we were friends, really friends, so, you know, we didn't have this problem”. Paula recalled how when she moved to a larger school, a mathematics teacher who had moved from her old school was about to ask her to come to the front of the classroom and explain some mathematics; she was petrified at the thought, and quickly indicated to him not to do so. The difference, she explains, is that she would have felt terrified being ‘shown up’ in front of a group of peers that weren’t her friends.

Paula’s story conveyed a remarkable confidence in being positioned, highly visibly, as an expert mathematician, although this confidence was context-dependent. She was aware of the stereotypes associated with being ‘good at maths’, in particular the ‘nerd’ figure and the perception of mathematics as masculine, both prominent themes in some of the reviewed literature (Epstein et al., 2010; Mendick, 2008; Walkerdine, 1998) . She and Connie both recalled reactions of overt surprise from people when they revealed their connection to mathematics; part of this was a generic admiration and awe of anyone ‘smart’ or ‘crazy’ enough to study mathematics at tertiary level, but it was especially surprising because they were women. Despite these reactions, Paula saw the discourse of mathematics as masculine as a myth or stereotype; she was certainly *aware* of it, but this did not seem to prevent her from developing a very comfortable and positive sense of herself as a woman and a mathematician. Paula

knew from teaching in less privileged schools that not all students were so insulated from the potential negative social consequences of academic success, and remembered how some students that she taught were excluded for doing well in school: “sometimes what I see in my classroom, when you have that geek girl or geek guy that they like math and they are always asking questions, the other students are looking at him or her and like ‘oh no, she is strange, don't talk to her’ or something”.

Paula viewed her own success in mathematics as a result of who she was, not what she had done. She stressed how she always enjoyed and was good at mathematics, that it was something “inside” her. She contrasted mathematics positively with languages and social sciences, which involved more writing. She didn't enjoy university mathematics as much as school mathematics and I asked her why this was. Paula responded “the way I was used to being taught, I think I didn't learn to think too much, you know, and then when I started a math degree it was really hard for me to think all of those things and solve all of the problems” This response puzzled me, and I asked, “how do you do maths without thinking?” This is all the prompting Paula and Connie need to describe the repetitive, procedural, teach-to-the-test pedagogy that they thought was typical of their national education system, and reminded me of Boaler's (2002) ‘traditional’ school. Connie was especially adamant about this, and used her experience at a British primary school, in which students “spent a lot of time doing games”, as a contrasting case: “I think that's why it's so boring for most of the students”. Paula, however, did not find mathematics boring even though, as a mathematics teacher, she was quick to distance herself from this pedagogy.

### **5.1.2 Amanda's story**

Amanda was calm and thoughtful during the interview, which also included Katie, the one participant who was not a mathematical ‘success’. Amanda grew up in a large city in China, however, she was impressively articulate in English. Her parents were both public sector professionals who went to a polytechnic when they were younger and were studying at university part-time at the same time as Amanda. She attended a public primary school and then boarded at a selective secondary boarding and day school that was “quite famous” and charged a “relatively high fee” although it was not technically private. Amanda's secondary school was unusual in that students stayed for seven years, combining middle and high school, and it had a strong focus on

English (her favourite subject). It had small classes, and Amanda thought it had a better reputation than a lot of the private schools. Amanda took the university entrance examination for humanities, studied history in China as an undergraduate, and has continued her studies in humanities at postgraduate level at two prestigious British universities.

Amanda achieved highly in primary school across all subjects; she was an only child and her parents were very supportive of her education. At secondary level Amanda specialised in humanities but continued with mathematics, which was compulsory throughout school. Amanda “always attached very, very great importance to math, because it's one of the subjects of the national college entrance examination” and worked “very, very hard” at mathematics. She “did math pretty well” and was at different times the mathematics subject representative at her school and in the ‘maths Olympics’, reserved for the top few students in each class. She voluntarily took after-school mathematics classes, and, on her father’s advice, kept a notebook of mathematics problems she found especially challenging. As these events emerged I began to assume that Amanda must have enjoyed mathematics, but when I asked her she claimed that she didn’t. Whereas Paula’s attachment to mathematics came across as an almost childlike fascination, Amanda was being very strategic, doing what was necessary to get ahead in an environment of intense academic competition. Like Smith’s (2010) Further Mathematics students, she saw doing well in mathematics as part of a biographical project, however, she did not seem to have the same need to enjoy the subject. Her school overtly fostered academic competition, sometimes handing out tests publicly from lowest to highest grade.

In secondary school Amanda’s friends were a close-knit group of girls who boarded at the school. They were high academic achievers who were also active in leadership roles and extra-curricular cultural activities. When I asked her what they did in their spare time, she was bemused; aside from going home on the weekends, school was life. Other social groups included day-girls who liked fashion and shopping, socialised outside of school, and didn’t achieve so well academically as Amanda’s friends. However, Amanda didn’t perceive that there was a necessary tension between high academic achievement and having an active social life, and her peer group seemed to achieve both to some extent. However, she described how one extremely high-

achieving female classmate told her that, whilst “it's important to go out and to be social and for girls to put on beautiful clothes”, secondary school is not the time for this. Perhaps more than any other participant, Amanda went to a school in which academic achievement carried very high value in the academic *and social* fields. Furthermore, mathematical achievement seemed to be particularly highly valued socially. Mathematics and English were the subjects that “get the most respect” from her friends, especially mathematics, because it was so strategic in terms of university entrance and because it was viewed as a very difficult subject, a real test of intelligence. Bibby's (2002) participants also viewed mathematics as a difficult test of intelligence, but for them it yielded shame rather than respect because they identified as mathematical failures. Amanda and Katie disagreed about what mathematics was; Katie saw it as meaningless symbols, quoting algebra as an example of something completely disconnected from the real world. Amanda saw it as more logical and conceptual, “we think maths is more about logic and people with smart brains can solve problems”, and this sets mathematics apart from English and Chinese. Amanda enjoyed mathematics when it gave her a sense of satisfaction, such as when she approached a problem from different angles. However, it also created confusion and anxiety, especially when she was not confident about attaining a high grade in an assessment.

### **5.1.3 Peter's story**

Peter, whose parents were both academics, grew up in a large state capital city in Australia. He started primary school in a Catholic parish school then went to a series of private Catholic boys' schools, although his secondary school did admit some girls during his final two years. He is in his mid-thirties and, since leaving school, he has completed history and law degrees, practiced as a lawyer, and is now study postgraduate law at Victoria. He engaged with the interview in a highly reflexive and articulate manner. Since meeting Peter I have warmed to him for his honesty, thoughtfulness, and very quick sense of humour. I asked him to participate because I was aware of his strong interest in philosophy and social sciences and his professional experience in law, hoping that this might provide a different perspective to that offered by participants I knew to be strong mathematicians. However, as mentioned earlier he was also a very high achiever in mathematics.

Peter returned often to the binary distinction between subjects in the “science/mathematics kind of family” and “the arts”. For him, this disciplinary division reflected an important division in ways of thinking, which he applied at different points in the interview to lawyers and philosophers. Sciences and mathematics were “black-letter, rational subjects”. I was unfamiliar with this terminology and Peter explained that

a black-letter lawyer is one who is basically a legal literalist, he kind of thinks that you can just apply the text of the law literally and get one absolute right meaning as opposed to somebody who takes a more interpretative approach to the law. (Peter)

Peter resisted all the usual stereotypes of mathematicians, but in some ways he described their characteristics more clearly than any other participant. Legal philosophy was more ‘mathematical’ when it had a logical structure; less ‘mathematical’ writers “waffle on for ages, and it takes you forever to work out whether there's any substance to their argument or not”. He distinguished mathematical intelligence from intelligence more generally when I asked him to describe people that strike him as very good at maths:

Mathematical skills are quite closely allied to logical reasoning and there's a certain way of thinking, a way of arguing, which I think people who are good at maths are more likely to have. But it's not just that, I mean I can have an argument with somebody who's very intelligent but doesn't think in the same kind of crisp, clinical way that I think someone who's very good at maths probably does. (Peter)

For Peter, mathematics was easy, logical, and produced “black-and white answers”. He enjoyed it as a kind of “intellectual game”, but towards the end of secondary school became increasingly bored with it, his interests shifting towards subjects with “more of a substantive element”.

Peter was unable to articulate exactly why he lost interest in mathematics and sciences, but connected it with becoming more emotionally mature and developing an interest in human life. In the years that followed secondary school he “blossomed”, developing a keen interest in history and philosophy. During this time he came to identify more strongly with the arts than the sciences, because he connected with them emotionally rather than just intellectually. After the interview, we discussed a similar



development in my own life, discussing how I chose to train to be a teacher rather than continuing to postgraduate chemistry. We were discussing how scientific ‘intelligence’ does not necessarily lead people to deal with philosophical, spiritual, or social questions in a sophisticated way, and I asked Peter if I could start recording again. He continued:

sometimes I think the scientists I meet just have much clearer answers in their minds to those problems, or sometimes they're less interested in them. One of the reasons they're less interested is maybe they think that they're easy, so that's something I notice, well I think that's kind of a flaw in their thinking, that's one of the weaknesses of the scientific mind, that they kind of don't understand problems that aren't solvable by the scientific method. (Peter)

This shift in allegiances did not change what Peter described as a fairly fixed “skill set”. He felt “slightly cursed” that, unlike his parents, his “natural talents lie in the sciences and not in the arts”. The perception of mathematical ability as natural and fixed has been noted by Walkerdine (1998), Bibby (2002), and Mendick (2006), and I will expand on its implications later in this chapter (see Section 5.3).

## 5.2 *Academically supportive friends*

In this section I argue that peer group culture is powerfully involved in the regulation of the process of coming to identify as ‘good at maths’. Because of the characteristics of the participants, the data mainly illuminate how peer groups act as a *positive* influence. In the analysis that follows, I paint a picture of the characteristics of my participants’ primary social groups during school. Despite the cultural differences between the groups, they all placed high value on academic achievement and were relatively close friendship groups. Thus, despite the participants’ awareness of discourses that pathologise high achievement, these discourses were ‘disarmed’ because of the value systems of the social fields that the participants inhabited.

*Valuing academic achievement* was a common characteristic of the participants’ school friendship groups, cutting across gender and culture. Peter talked of his closest friends as his “academic rivals”, implying that academic achievement accrued social credit with the “bunch of mates” that formed the ‘geek’ group at his secondary school. Paula and Connie described the affectionate and half-jealous teasing they were subject

to for getting high grades in mathematics. Both girls helped their friends with mathematics, and felt socially valued for doing so. Amanda described mathematics and English as the two subjects that accrued “the most respect” from her peers. Chris’ and Lizzie’s friends were also supportive of high achievement, although for Lizzie this changed with age because “the older you get the less inclined you are to be like ‘hey I got an A+ on my maths test’, like that’s not cool when you’re a teenager”. Lizzie, like the high-achieving and popular (HAP) students in Francis *et al.*’s (2010) study, recalled downplaying and concealing her high achievement so as to maintain social capital with her peers and ‘stay cool’. However, there was a notable absence of this tendency in the other participants, who would only occasionally downplay their achievement. When the other participants downplayed their achievement, they did so in order to avoid embarrassing their lower-attaining friends, rather than as a result of the need to maintain social credibility.

There was not a norm of high achievement in all of these peer groups; most of Connie’s friends had to re-sit mathematics exams during their holidays because they failed first time, Chris had friends from a range of mathematics sets, and Lizzie, Paula, Peter, and Amanda were all attaining better mathematics results than most of their peers. The common factor across these peer groups was not that high achievement was *normal*, but that it was *valued*. In Bourdieu’s terms, the impression that these descriptions give is that high achievement is a ‘product’ with high value in the academic *and* social fields. For these students, high achievement was not a balancing act, but something that was actively rewarded without being simultaneously punished. My participants attributed the ease and comfort with which they were able to identify as ‘good at maths’ to their academically supportive (though often lower-attaining) friends. Unlike Mendick’s (2006, p. 63) students who would “rather be like medium stage in maths, and have social skills”, my participants’ supportive friends did not pathologise higher achievers. Whilst not the primary focus of this analysis, there is also some evidence within the interviews that academic achievement was highly valued by the students’ parents. For example, Lizzie’s response to getting a good test result in primary school would have been to “run home and tell [her] parents”, Peter remembers his father’s disappointment when he withdrew from an extra-curricular ‘maths camp’, and six of the seven participants attended private schools for at least

part of their schooling, indicating a significant financial investment in education on the part of parents.

Six of the participants said that academic achievement was not so highly valued in other social groups in their school. For example, Peter's 'jocks' and 'wogs'<sup>5</sup> included some high achievers, but they would have "kept this pretty close to their chest" or "laughed it off". Paula's "gang" students, the "bad boys" in the lower sets at Chris' school, and Lizzie's students from "a more deprived area" wouldn't have valued academic achievement very highly, they thought. The South-East Asian "studious girls" at Peter's school achieved well, but the "social, confident girls" would have concealed their achievement in a similar way to the 'jocks' and 'wogs'. These descriptions of 'others' who didn't value academic achievement were often related to social class.

The extent to which social class featured in the interviews seemed to depend to a large extent on how socially elite the students' schools were; some simply were not exposed to their social class 'others'. All descriptions that I coded as relating to social class divisions referred to state schools. This structural division meant that there was very little possibility of my private school participants having working-class peers. However, mixed social class schooling did little to support social integration. Lizzie described how the state secondary school she attended for five years was "quite near a deprived area. There were a lot of students there who were from very deprived backgrounds, who had obviously not come from households where they were encouraged to do well at school and were rewarded for it, like I was". She was very clear that there was a social divide between these working-class girls and those from her 'nicer' neighbourhood. Her description of these girls with their "tongue piercing, belly piercing, Spice girl kind of platform shoes, [and] peroxide blonde hair" was full of the 'excess' that Skeggs (2004) argues is attributed to white, working-class women. There was also a social division in the state school at which Paula taught. The "gang" boys, who Photograph B (see Figure 2) reminded her of, talked amongst themselves, but not to other students or the teacher. Paula admitted that she had difficulty establishing rapport with them, and I empathised with her experience. This lack of

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<sup>5</sup> 'Jocks' were "very stereotypical cool kids who were in all the sort of big sport teams". Peter explained about the self-titled 'wogs' that "in Australian slang it's basically someone from a Mediterranean background".

social integration is consistent with Reay, Crozier, and James' (2011) study of middle-class English parents who send their children to socially mixed comprehensive schools. The parents reported that their children tended to make friends with other middle-class children, thwarting the parents' efforts to broaden their children's horizons.



**Figure 2.** A photograph<sup>6</sup> used in Phase 2 of the interview (see Appendix A).

Structural and social divisions excluded working-class students from all of the academically supportive peer groups that the participants belonged to, and the participants tended to view working-class students as less interested in education. However, at least in the English context, the middle-classes tend to underestimate the value that is placed on educational achievement amongst the working-classes, who are often just as invested in education as their middle-class counterparts (Reay, 1998). This would suggest that my claim, that the participants were in social fields where academic success is highly valued, is a red herring; the working-classes value education too, yet for them academic success seems harder to come by. This tension can be resolved to some extent by acknowledging the complexity of academic success in working-class social fields. As Reay (2002, 2006a; Reay, Crozier, & Clayton, 2009) and Walkerdine (1998) have argued, there are often significant tensions in the identity formation of working-class students, with academic success being simultaneously valued and pathologised. So to say that my participants' peers valued their academic success, and that working-class peer groups do not, is to render simple a situation that

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<sup>6</sup> All photographs used were uploaded to public domain websites by the photographers and can be legally used in publications without permission or acknowledgement.

is complex. Comparing their stories to those of Reay's working-class students, the most striking contrast is that valuing of achievement is *simple and unproblematic*; there is a notable absence of identity work and the angst of a "habitus divided against itself" (Bourdieu, 1999, cited in Reay, et al., 2009). When I asked Lizzie about emotions she related to mathematics she said with a dismissive and incredulous laugh: "I've definitely never felt guilt, shame, frustration or anxiety about maths" as if I was daft to suggest that this could be possible.

The mediating role of social class in students' identity formation could add analytical strength to mathematics education research that takes discourse as its focus (Section 3.1). For example, Mendick and Francis (2012, p. 15) debate whether the 'geek' identity is "abject or privileged", citing empirical instances of both from their respective research. They argue that when the 'geek' label is taken up positively, typically by White, middle-class males, the pathologised, 'jealous other' is usually working-class. This is consistent with Lizzie's 'othering' of the 'teenage mums', and her identification as "cool in my own mind" as well as a 'geek'. However, Connie, Paula, and Amanda did not have any obvious 'other' and were all unable to think of anyone at school they were glad not to be like. Peter disliked the 'jocks', but he envied their popularity and sporting ability and certainly did not position them as abject.

The stories of Connie, Paula, Amanda, and Peter suggest a different interpretation from that offered by Mendick and Francis (2012). These participants did not position themselves positively within the discourse of the mathematically able 'geek', they were *insulated* from the discourse by an academically orientated peer group. Peter said of his 'nerd' group, "we probably weren't happy about the label but it wasn't anything we cared about too much and we certainly weren't bullied or anything like that". If their friends found out that they did well in a mathematics test Paula would feel "proud", Connie would feel "comfortable" and Amanda would gain "respect". These reactions to being positioned as 'good at maths' differed from those described in the post-structural literature reviewed in that the participants did *not* resist or subvert discourses which pathologise achievement, they simply didn't seem to care about them.

Here it is worth mentioning Katie, who hated mathematics and did not succeed in it. She attended private schools and had an academically supportive peer group. She did well in every subject *except* for mathematics, and her friends knew this. Her case demonstrates that, whilst peer culture may be an enabling condition for identifying as ‘good at maths’, it is not a sufficient condition. She did not have the ‘sweet taste of success’, which is the second of my two major themes.

### 5.3 *The sweet taste of success*

I set out to identify enabling conditions in students’ *experiences of school mathematics*, and in this respect I was initially disappointed with the interviews. I wrote in my research journal “I’m getting very little in terms of pedagogy specifics, especially anything to do with the real world”. This could be partially due to the fact that participants were recalling events from up to thirty years ago. Nevertheless, all students had memories of school mathematics that gave hints of what enabled them to see themselves as ‘good at maths’, and I would argue that one of the most powerful enabling factors was *the sweet taste of success*. I use this terminology rather than simply *success*, because what came through most strongly in the interviews was the pride and satisfaction that accompanied recognition of the participants’ success in mathematics.

The six participants who identified as ‘good at maths’ all had very high mathematical attainment at school and sometimes beyond, whereas Katie was “just passing”. This exact correspondence between ‘objective’ achievement and identity suggests a commonsense explanation for how the participants came to see themselves as ‘good at maths’, namely, that they *were* good at maths and simply recognised this fact. This is rather like the assertion that *experience of success* is the most influential factor in the formation of students’ self-efficacy for mathematics (Usher & Pajares, 2008). My argument in this section is not that this explanation of mathematical identity formation is necessarily *wrong*, but that it downplays the complexity and variability of experiences of success. The experience of success in mathematics is qualitatively different from success in other subjects. Exploring the experience of success (and its flipside, failure) through the interviews can shed light on how the participants came to see themselves as ‘good at maths’ and to enjoy this positioning.

I have chosen to explore the theme of success not only because it recurred frequently in the interviews, but because it was what the participants themselves used most frequently to explain how they came to identify as ‘good at maths’. Chris first became aware that he was ‘good at maths’ when he realised that most of his classmates did not know their multiplication tables and he did; Peter recalled finishing his single-column addition early and starting to teach himself how to do multi-column addition; Lizzie remembered starting to get 20 out of 20 for her weekly multiplication table tests; the others were more vague but reported ‘doing well’ from an early age. From this point onwards they reported quite a durable sense of being good mathematicians. They viewed mathematics as having strong ‘boundaries’, with some mathematics beyond the reach of many students (Brown et al., 2008), but not beyond their reach. Paula, Connie, Lizzie, Chris, and Peter all described their mathematical ‘ability’ as something intrinsic, for example, Peter was “naturally good at” mathematics, and for Lizzie algebra “doesn’t come naturally to everyone”. More so than other subjects, mathematics is a subject where you are either in or you are out; six of my participants were ‘in’ and therefore able to see themselves as ‘good at maths’.

The participants’ descriptions of success complement and extend upon the stories of Bibby’s primary school teachers, with their shame at being exposed as ‘failures’ (Bibby, 2002, see Section 3.2). My participants also gave the impression that mathematics was a subject with nowhere to hide if you ‘didn’t understand’, but since they *did* understand they mostly avoided the shame that Bibby’s participants experienced. For Peter, mathematics was “a discipline which produces black and white answers”. For Amanda, mathematics assessments were much more sensitive to what you were capable of than other assessments:

for English and especially Chinese you don't see really a big range of difference because you know if you just did that badly, they still give you marks so like 80 or 85 doesn't really count a lot if you're doing the whole ranking of three subjects, but for math it can really make a difference if you do 90, or if you cannot solve a problem you can suddenly become like 70 so everyone tries hard on maths. (Amanda)

When participants were asked directly about which emotions they associated with mathematics (see Section 4.3.1), positive feelings of *satisfaction* (5 participants), *confidence* (4 participants), and *pride* (4 participants) were the most frequent

responses. Following the assumption that emotions are responses to concrete events that we care about (Sayer, 2011, and see Section 2.2), it is worth examining these emotions a little further, to see what they can tell us about the formation of positive mathematical identities. All of the participants who were ‘good at maths’ associated mathematics with *pride*, *satisfaction*, or both; Katie was the exception, immediately selecting *frustration* and *anxiety*. For Lizzie “the first one would have been pride, you know that feeling of getting my 20 out of 20 on my sums or division test at school. And with that came satisfaction, you know the satisfaction of having achieved that”. Chris felt “satisfaction when you’ve done something right” and pride “if there’s a question that I’ve been working on and I get it”. These quotes and others not included here illustrate how satisfaction and pride in mathematics are often linked with experiences of ‘objective’ success, such as getting all questions correct (as opposed to wrong), or ‘getting it’ (as opposed to ‘not getting it’). The participants who had positive emotional experiences reinforced their identities as ‘good at maths’ through what they perceived as ‘objective’ indicators that they had done something right, especially if it was something difficult. Such positive experiences contrast with those of Boaler’s students at the ‘traditional’ school, especially the girls who became frustrated when they did not understand what they were doing (Boaler, 2002). This contrast should not be interpreted as an inconsistency; my participants felt pride and satisfaction when they *did* understand what they were doing.

My participants’ usually brief encounters with failure highlight how unforgiving mathematics can be of any deviation from being ‘correct’. Amanda and Paula both experienced some test anxiety because of high expectations; high achievement can’t be taken for granted and “sometimes we are not always good” (Paula). Amanda and Connie experienced confusion when they ‘didn’t understand something’, again emphasising the view that you either understand or you don’t, and that it is unpleasant if you don’t. As a teenager Chris would often correct his mathematics teachers, and he recalls how embarrassing it was when he “asked a stupid question” because when this happened he was publicly being shown up as having had an incorrect idea.

The data that led me to explore the theme of ‘the sweet taste of success’ is consistent with reviewed studies (e.g. Bibby, 2002; Boaler, 2002), in the sense that participants viewed doing mathematics as walking an emotional tightrope. The tightrope metaphor



helps to convey the key message that I have tried to convey in this section. If you are walking a tightrope you either stay on or fall off, and it is very obvious which you have done. This makes you much more open to ridicule from unsupportive spectators than, say, competing in the long jump. What was unusual about my participants is that most of them ‘stayed on the tightrope’, so they and their ‘spectators’ could infer unproblematically that they were good at it. As noted in the exploration of peer groups, these spectators valued tightrope-walking skills, so the attention they received was positive.

## 6 Conclusion

This concluding chapter comprises an evaluation of the study (Section 6.1), and a summary of the implications of the study for mathematics education research and practice (Section 6.2).

### 6.1 *Evaluation of the study*

The critical realist approach taken in this study was well suited to exploring a question concerned with how some students are able to identify as ‘good at maths’. In particular, the distinction between the *real* potential to identify as ‘good at maths’ and the *actual* realisation of this contingent event prompted me to look for *enabling conditions* in my participants’ circumstances (Sayer, 2000). However, I did not probe the distinction between the *actual* experiences of my participants and the *empirical* trace of these experiences that I had access to in their interviews with any rigour or sophistication; instead I generally took participants’ responses at face value. This was an under-developed aspect of my analysis, which could be strengthened with further training in discourse analysis. My framing of emotions as reasonable responses to circumstances that people care about (Nussbaum, 2001; Sayer, 2011) strengthened my analysis of emotions in prior studies (e.g. Bibby, 2002) and in my own participants’ experiences of the ‘sweet taste of success’.

A Bourdieusian approach to social and academic fields helped me to make sense of the way my participants’ peer groups differed from those of students in other research who had a much more problematic relationship with academic success. My intention to frame identity in terms of students being *fixed* or *mobile* (Skeggs, 2004) in social and academic fields (Bourdieu, 1991) was not well realised, and Skeggs’ framing of identity is not explicit in my data analysis. This is partly due to my engagement with the post-structural or ‘discourse’ framework that I had not initially intended to use but which dominated the literature that I reviewed. This engagement helped me to develop the idea that my participants’ peer groups had the effect of *insulating* them from some discourses about mathematics and mathematicians.

The interviews proved relatively effective in providing data that enabled me to draw conclusions about how my participants came to see themselves as ‘good at maths’.

The most revealing questions were those that explored participants' social groups and the emotions they experienced when doing mathematics. My participants were all forthcoming and articulate, hardly surprising given their high level of education and their personal connection with me outside the interview context. My pragmatic choice of a small group of high-achieving university students as participants meant that my results have very poor generalisability or "external validity" (Johnson & Christensen, 2008, p. 267). However, this choice also means that my data can complement prior studies of less mathematically successful students by broadening knowledge of how students use (or don't use) certain discourses in their identity construction. It also illustrates how a subject perceived as having strong boundaries is experienced by students firmly *inside* those boundaries.

The greatest weakness of the interviews in terms of my original interests was that I was unable to elicit any detailed reflections on mathematics pedagogy. This can be attributed partly to the long time that had elapsed since most of the participants were in school, but it is still worth considering how I could have prompted these recollections more effectively. In a school-based study, I would have the advantage of being able to refer to recent classroom events, or to use photographs or videos from the students' lessons to stimulate reflection. Another limitation of my choice of adult participants is that this project is a less realistic pilot for the planned doctoral research that will take place in schools.

The process of analysing the interviews was more open than I had originally intended, for reasons outlined in Section 4.4 and this resulted in a proliferation of potential themes that could have been explored. Through the process of transcription and repeated listening, I became very familiar with the interviews. The themes that I noticed, coded, and analysed were inevitably influenced by my own experiences and reading. Other researchers may have emphasised different facets of the interviews, so in this sense my findings are 'subjective'. However, a critical realist approach and a more general focus on reflexivity means that I actively searched for evidence that contradicted my findings. I scoured the interviews for evidence that participants *weren't* in academically supportive peer groups, that they *did* have to work hard to balance achievement and social status, or that they experienced mathematical success as *multi-dimensional*. In some cases this process led me to question my emerging

findings, but for the two themes that I included I judged the evidence to be overwhelmingly supportive.

## 6.2 *Looking to the future*

This study identified two conditions that seemed to be highly influential in the process of six high-achieving students coming to identify as ‘good at maths’. Firstly, they were in peer groups that valued academic achievement, making the subject position ‘good at maths’ much more comfortable to occupy than it was for many students whose experiences are recorded in literature reviewed in this study. Secondly, they viewed mathematics as a subject with clear and objective boundaries between right and wrong answers; they were on the ‘right’ side of these boundaries frequently enough to see mathematical ‘ability’ as inherently present in them and absent in others. Prior studies have explored the experiences of students who were not in academically supportive peer groups (e.g. Reay, 2002) or who were on the ‘wrong’ side of mathematics’ boundaries (e.g. Bibby, 2002). These studies show that when the enabling conditions identified in the current study are absent, there are significant barriers to forming a positive learner identity. Thus the current study reinforces the importance of reducing these barriers, by showing how successful students can be when the barriers are reduced.

It is difficult to imagine what steps could be taken to give a wider spectrum of students access to academically supportive peer groups, or even quite what this would mean. In post-structural terms I have suggested that this would involve insulating students from certain discourses about mathematics, and in Bourdieusian terms this would amount to re-shaping the social field such that academic success was valued *and not simultaneously pathologised*. Similarly, the perception that mathematics is a subject with strong boundaries that are hard to cross is present in prior literature (e.g. Brown et al., 2008) and in the current study. The participants saw this as inherent in the ‘nature’ of mathematics, but I would suggest that this need not necessarily be the case. Mendick (2006, p. 157) noted this perception of mathematics and its harmful effects, arguing that “certainty as the basis for mathematical truth needs to go, along with the elevation of mathematical proof to the top of the epistemological tree”. She speculates about what a less ‘certain’ version of mathematics might look like, and cites Skovsmose’s (1994) project-based pedagogy as an example. I would add

Boaler's (2008) *Railside* study, conducted in the USA, to this list. The pedagogy she reports on makes a specific point of rewarding a range of competencies, not just getting the 'right' answer. I quote Boaler at length here because what happened at *Railside* is highly significant to the current study, as it addresses both of the major themes I have drawn from my data: supportive peer groups, and the unidimensionality of mathematical success:

The multidimensionality of classes did not only mean that more students could feel successful and valued, it also meant that students learned to appreciate the different contributions that students made. As teachers valued students seeing problems in different ways, offering different methods, partial solutions, or different interpretations, the students also came to value these different contributions—and the people offering such ideas. This was particularly important at *Railside* as the classrooms were multicultural and multilingual. The equitable relationships that *Railside* students developed were only made possible by a conception of mathematics that valued the contribution of different insights, methods and perspectives in the collective solving of particular problems with particular solutions. (Boaler, 2008, p. 186)

My participants were exceptional; their stories contrast with most of those recorded in the literature I have reviewed because their success in mathematics was so comfortable and unproblematic. They walked the tightrope of mathematical success and seldom or never fell off. Their academically supportive peers admired and respected them for their success. A strength of this study is that it tells unusual stories that give insights into the enabling conditions of mathematical success; a related weakness is that the participants were members of a small, international, educational elite, which makes it hard to see how these enabling conditions could be extended to the disadvantaged students I mentioned in Chapter One, or to the working-class students who were excluded from the participants' peer groups. The analysis in this thesis has highlighted the need to examine in more detail the recent work of Boaler, and to locate other such 'pockets of hope'. Such an exercise could provide guidance for teachers and teacher trainers who want to exercise their agency in the academic and social fields of the school to make access to the identity 'good at maths' less problematic and more equitable.

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## Appendices

### *Appendix A: Interview schedule Version I*

The student interviews are designed to elucidate:

1. what categories students use to identify themselves and other students,
2. how these categories position students in relation having a positive mathematical identity, and
3. how this positioning is or could be mediated by mathematics pedagogy.

#### **Part 1: Maths biography**

Where did you go to school?

Compulsory until when?

Keep taking it? Why [not]?

[How] did that change?

*If you had to write your own maths report, what would it say?*

What about achievement?

What about behaviour, hard work, talent, homework?

Did you consider yourself good at maths? Since when? Did that change? Why?

#### **Part 2: Groups in school**

*What were the main groups in your school?*

Could talk about mine.

Who hung out together? For each group:

What were they like?

What was most important to them?

Who did they idolise?

What do you think they did in their spare time?

What do you think they watched on TV? What sort of music did they listen to?

Were they good at maths?

*Who did you wish you were more like, and who were you glad you were not like?*

Was there much conflict in the classroom? Between whom and why?

*Who is good at maths in your family/friends?*

How do you know which students are good at maths in our class here?

Here are some photos of people that I know a bit about, and some descriptions of them. I want you to rank them in terms of who you think is best at different activities and explain your reasons. (Socially confident, popular, visual art, football, poetry, like you, not like you, good at maths).

### **Part 3: reflections on teaching**

*Who has been your favourite maths teacher over the years?*

What was it that you liked about them?

What do you think makes a good maths teacher?

What do you think it would take to get you into maths / put you off maths [for students who don't / do enjoy maths]

Here are some pieces of paper with different things people have said they feel in maths lessons [pride, boredom, embarrassment, satisfaction, confidence, frustration, guilt, joy, anxiety, shame, confusion]. Do any of them remind you of how you feel in maths? Why? What was a time you felt like that?

*Tell me a bit about yourself*

Parents and siblings, their jobs, their education.

### **Appendix B: Interview schedule Version II**

[This version was used in interviews with Peter, Lizzie, and Chris]

The student interviews are designed to elucidate:

1. what categories students use to identify themselves and other students,
2. how these categories position students in relation having a positive mathematical identity, and
3. how this positioning is or could be mediated by mathematics pedagogy.

### **Part 1: Maths biography**

Where did you go to school?

Compulsory until when?

*If you had to write your own maths report, what would it say?*

What about achievement?

Do you consider yourself good at maths? Since when? Did that change? Why?

Who would you tell your marks?

Boring/interesting? Easy/hard? Useful/useless?

## **Part 2: Groups in school**

*What were the main groups in your school?*

Who hung out together? For each group:

What were they like?

What was most important to them?

Who did they idolise?

What do you think they did in their spare time?

What do you think they watched on TV? What sort of music did they listen to?

Were they good at maths?

*Who did you wish you were more like, and who were you glad you were not like?*

*Who was good at maths in your family/friends?*

How do you know which students are good at maths at [name] College?

Here are some photos of people. I want you to rank them in terms of who you think is most socially confident, then who is good at maths).

## **Part 3: reflections on teaching**

*Who was your favourite maths teacher over the years?*

What was it that you liked about them?

What do you think makes a good maths teacher?

What do you think it would take to get you into maths / put you off maths [for students who don't / do enjoy maths]

Here are some pieces of paper with different things people have said they feel in maths lessons [pride, boredom, embarrassment, satisfaction, confidence, frustration, guilt, joy, anxiety, shame, confusion]. Do any of them remind you of how you feel in maths? Why? What was a time you felt like that?

*Tell me a bit about yourself*

Parents and siblings, their jobs, their education.

## Appendix C: Participant information and consent form

### Information for *Mathematical Identities* study

Dear Participant,

Thank you for offering to take part in the *Mathematical Identities* study I am carrying out as part of my postgraduate student research at the University of Cambridge. Please read the information below and sign the consent form if you are happy to take part.

#### *The Study*

The study is entitled *Mathematical identities: who can be 'good at maths'?* It is a short study and forms the first phase of an MPhil/PhD project which examines the reasons why achievement in maths is so tightly correlated with students' social class and ethnic backgrounds, and why so few girls are taking maths beyond GCSE. Large-scale studies and national datasets clearly show who is doing well in maths and who isn't, and a lot of the reasons behind these inequalities are related to wider social issues that teachers don't influence directly in the classroom. However, my focus is on what teachers *can* do in the face of these alarming inequalities, particularly in the ways they use real-life or imaginary contexts as pedagogical tools. This initial phase of the study examines the reasons why people think of maths as a subject that 'people like them' can be good at, for example whether they see doing well at maths as being compatible with being sporty, good at art, or popular. This will form the basis for becoming more aware of how the way maths is taught can engage or alienate different students.

This study has received ethical approval from the University of Cambridge. I have recent, comprehensive CRB checks (UK and New Zealand) and current, full teacher registration. This study is the result of questions that arose in my mind as a practising secondary mathematics teacher, and I hope that the findings will prove interesting and useful to mathematics teachers. Should you wish to contact me you can do so via email on [dcp33@cam.ac.uk](mailto:dcp33@cam.ac.uk). You are also welcome to contact my supervisor Prof. Diane Reay ([dr311@cam.ac.uk](mailto:dr311@cam.ac.uk)).

#### *The interview*

The interview will be recoded using a digital voice recorder. Some or all of the recording will be transcribed by me or a close associate. Extracts from the recordings may be summarised, paraphrased, or quoted in my thesis, subsequent publications, or at conference presentations. No real names of participants or institutions will be used, and I will not publish information that could be used to identify individual participants. All information shared in the interview will be kept confidential from other friends or classmates that might be known to participants.

### Consent Form

I have read the above information and understand what participating in this study involves. I agree take part in an interview that will be being recorded and used as research data.

Signed:

Name:

Date: