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Children Talk About Their Mathematics Lives

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This work is dedicated firstly to the real subjects of this book, known here as Dominic, Fleur, Georgina, Jared, Jessica, Liam, Mitchell, Peter, Rochelle, and Toby, whose unfolding mathematical learning narratives this book captures, secondly to all the children learning mathematics around the world whom they represent and on whose collective behalf they speak, and thirdly to Otto Caspian Kulpe-Greer, who was born while this book was in the writing. He symbolises the next generation of mathematical subjects for whom the book has been created in the hope that their stories might speak of pleasure and fulfilment in their learning of themselves through mathematics.

Preface

Teaching and learning mathematics is a political act in which children, teachers, parents, and policy makers are made visible as subjects. As they learn about mathematics, children are also learning about themselves – who they are, who they might become. We can choose to listen or not to what children have to say about learning mathematics. Such choices constitute us in relations of power.

Mathematical know-how is widely regarded as essential not only to the life chances of individuals, but also to the health of communities and the economic well-being of nations. With the globalisation of education in an increasingly market-oriented world, mathematics has received intensified attention in the first decade of the twenty-first century with a shifting emphasis on utilitarian aspects of mathematics. This is reflected in the reconceptualisation of mathematical competence as *mathematical literacy*, loosely conceived as those ways of thinking, reasoning and working "mathematically" that allow us to engage effectively in everyday situations, in many occupations, and the cut and thrust of world economies as active, empowered and participatory citizens.

It is no surprise then that mathematics has become one of the most politically charged subjects in primary school curricula worldwide. We are experiencing an unprecedented proliferation of regional and national strategies to establish benchmarks, raise standards, enhance achievement, close gaps, and leave no child behind in mathematics education. Industries have sprung up around the design, administration and monitoring of standardised assessment to measure and compare children's mathematical achievement against identified benchmarks and each other. Whether regional, national or international, such tests wield substantial political power. They are used by educational policy makers to report to parents and to education ministers, or to gauge teacher and school effectiveness, and because they are widely believed to provide robust evidence of the mathematical strengths and weaknesses of individual children across demographic groups, schools, and geographical regions, standardised test results are used to justify particular pedagogical approaches over others and to support further research. Despite these efforts, significant disparities continue to be observed.

Somewhere in the nexus of mathematics, government, education, commerce and industry, our children are socially constituted. Children are generally oblivious to the wider forces that shape their everyday worlds and take it for granted that school is the place where every child must go to learn. School is also the place where, from a very young age, children first meet formal learning of the subject we call "mathematics." From the outset most children have little say in how their learning of mathematics will be presented, structured and sequenced or in the mathematical content they will encounter. Children's unique and individual qualities, including their mathematical ways of seeing and interpreting the world, are seemingly of little account as they are processed through the apparatuses of testing, grading, grouping and mathematical instruction that reify and position them as the objects of mathematical education.

Since the 1980s there has been an increasing global focus on human rights in the design and implementation of social policy, of which education forms a significant part. In documents such as the widely ratified United Nations Convention on the Rights of the Child,[1] the *child* is figured as an active agent with the right to participate in decisions that affect the child's life. Children are produced in the discourse of human rights as valued members of their communities with legitimate if diverse (childish?) ways of seeing, their thoughts and feelings about the world valued as necessary and worthwhile contributions to our societies, yet studies show that children themselves believe that adults show little concern or respect for their views and opinions (e.g. Tucci et al. 2007).

Recognition of children's right to inclusion in decisions about their schooling can be seen as part of a movement towards a critical education that seeks to enhance learners' participation and thus reconfigure learning spaces to reflect the child not merely as a cognising and increasingly autonomous unitary "self" but also as a socially connected, corporeal, emotional, ethical, and aesthetic self constantly in the process of becoming in dynamic engagement with her or his environments (Lloyd-Smith and Tarr 2000). As such, this book is radical for its assertion that it is in our recognition of the different and equal being of children as mathematically active *subjects* whose experiences, worldviews, proclivities, passions, and aversions are a continuously engaged and constitutive part, that the right of children to be heard, not simply to be seen as a demographic to be researched, operated upon, manipulated and inscribed within our educational policies and institutions, might be enacted in a critical mathematics education that serves, rather than being served upon, our children. In such a spirit this book acts as a mouthpiece through which children speak about their mathematics lives.

[1] *Children* in this convention are defined as those between the ages of 0 and 18 years. I have used the same definition throughout this book.

Acknowledgements

As with any constructive endeavour, books are never solely the work of their authors. They emerge as socially contextualised artefacts and as such, bear the marks of a multitude of contributors from forebears, family and friends to colleagues and mentors, all of whom I acknowledge fulsomely.

I wish to make specific mention of the following people whose support over many years, manifested through their love, inspirational ideas and intellectual guidance, and provision of beds and breakfasts, research grants and study leave, dwells particularly powerfully between the lines of this work:

My family Alastair Wilkinson, Manu Greer, Tara Greer, Ben Greer and Antje Kulpe; my mathematics education mentors Jim Neyland and Megan Clark of Victoria University of Wellington, New Zealand; my colleagues Nola Alloway, Malcolm Vick and Jo Balatti of James Cook University, Australia; my mathematics education soul mates Mônica Mesquita and Aléxandre Pais of Sao Paolo/Lisbon; my accommodating (literally) friends Barbara Smythe, Nikolien Van Wijk, Gerda Yske (late) and Joe and June Stewart, and my publishing team Kristina Wiggins-Coppola and Marie Sheldon of Springer, USA who believed in this project when it was but a germ of an idea.

In the interests of privacy, the children and their family members, teachers and principals who took part in this study cannot be named, but their contributions are particularly lovingly acknowledged. It is in their generous opening of their homes and classrooms and their frank telling of life as they experienced it that these remarkable everyday people have given life to this book.

Proceeds from the sale of this book will be donated to UNICEF in support of the global Child-Friendly Schools Initiative, “a cause that helps children in education” as suggested by the children in this study. It is hoped that this book will raise awareness of the power that mathematics education has to *make* children and of the largely unquestioned and often obscured practices that adults adopt in their teaching of mathematics that determine who our children might become.

Contents

Introduction: An Overview

This book is focussed around a central question: How are children made as *mathematical subjects* in their learning of mathematics, and what does this mean for their participation and achievement in the subject of mathematics and their lives beyond?

The book is organised into four parts.

Part 1: Understanding Children as Mathematical Subjects: Theories and Methods

This section of the book contains two chapters that outline the purpose of the research, theoretical frameworks and research design. The first examines the concept of "subject" in post-modern theory, particularly in the senses in which it has been employed by Michel Foucault, how this is linked to identity theory and how viewing children as subjects might be useful in our understanding of children's engagement and performance in mathematics. The key idea is that children are discursively produced, through social interactions including everyday mathematics classroom routines, as mathematical learners, and it is this process of subjectification/identification that is implicated in their engagement in the subject of mathematics. The second chapter outlines the methodological approaches Foucault termed "archaeology" and "genealogy" which have been adopted for this research for their aptness in investigation of subjects over time, inscribed within discursive educational practices.

Part 2: The Art of Becoming Mathematical: The Primary/Elementary Years

Divided into four chapters, this section of the book focuses on the children's learning of mathematics in the elementary (primary) school years from the ages of 7–10 years. It was during these years that the children came to recognise mathematics, and themselves in the learning of it, as occupying a unique temporal space in a school day distinguishable through routines and rituals that were distinctively separate from their learning in other subject areas. Four closely interconnected discursive practices emerged across the experiences of all 10 children in which home and classroom could be seen as sites productive of children as mathematical subjects: (1) doing mathematics as engagement in a particular kind of work, (2) mathematical cultures of competition, (3) the nature of mathematics itself as a corpus of facts and procedures and its discipline a process of memorisation and replication of these and (4) the classification, sorting and treatment of children according to manufactured perceptions of their mathematical abilities. These discursive features of the children's lives are explored for their production of children as subjects of mathematical subjectivities.

Part 3: Subjects of Choice: The Secondary Years

This section explores the children's post-primary years, in which discursive practices established in the primary years were seen to be consolidated and new discourses emerged: (1) the production of mathematics as a subject, and learners as mathematical subjects, through formulaic pedagogies of the secondary school, (2) national examinations as discursive apparatus implicated in mathematical subjectivity/subjectification including children's views of success and failure, (3) interventions in the production of the mathematical self through the interaction with peers and teachers and interventions such children's engagement with tutors and booster programmes and (4) the part mathematics played in occupational subjectivity enacted through the children's choice – of subjects, continuing schooling or entering the workforce, further study and careers.

Part 4: Mathematical Futures: Life Beyond School

The final section looks across the children's experiences and considers: (1) what it is that the study might say to us in terms of the wider implications of children's becoming as mathematical subjects within everyday discursive practices of mathematics education and (2) implications for people whose lives are touched by mathematics education – children, parents, teachers, researchers and policy makers. It is divided into three chapters examining the discourse surrounding wider social concerns as experienced by the children. Chapter 11 looks particularly at gender as a mediator of choices about school subjects, tertiary study and vocational outcomes. Chapter 12 examines the children's stories as grounded in social context and considers the contribution such context makes in mathematical subjecthood. Chapter 13 contemplates how this research expands our understandings of children's learning of mathematics in light of the disparity statistics on mathematical achievement including gender, social class, and ethnicity, and how we might use the children's stories to envision discursive practices in which new kinds of mathematical subjects might emerge.

Explaining the Education Systems Experienced by the Children

The New Zealand Education System

Much of this research is based in New Zealand: seven of the children in the study were schooled entirely in the New Zealand education system. Education is compulsory between the ages of 6 and 16 but most children begin school at the age of 5. The first year at school is known as Year 1 and the last as Year 13. Most children attend school until the end of Year 11 and an increasing proportion to the end of Year 13. During their primary years, national assessment is not compulsory, but schools may choose to test children using standardised Progress and Achievement Tests that include mathematics. The study of mathematics is compulsory until the end of Year 11. In Year 12 children have only one mathematics subject option – General Mathematics. By Year 13 they are able to choose between Mathematics with Calculus and Mathematics with Statistics. National assessment begins at around Year 11 with the NCEA (National Certificate of Education), which can be made up of "unit standards" and "achievement standards" in subjects across three levels, gained through a combination of school-based standardised assessment and external examinations. Each standard is worth a certain number of credits. For achievement standards children can gain "Achieved," "Achieved with Merit" or "Achieved with Excellence" but the grades make no difference to the child's overall accreditation since they do not translate into a numeric score. For unit standards, children either gain "Achieved" (pass) or "Not Achieved" (fail). Most children start at level 1 in Year 11, or earlier, if the school offers a suitable programme. Schools prepare a programme using a mix of standards to assess students as they progress. Not all students are assessed against the same standards. The school determines those standards students may attempt.

The English Education System

When he was 10 years old, Dominic's family moved to England where Dominic attended school for 2 years. His experiences included the highly competitive screening processes children undergo at the end of their primary schooling to gain entry into secondary schools. In England, primary school education is usually divided into Infant (ages 4–7 years) and Junior (ages 7–11 years) School. At the end of the Infant School, pupils sit Key Stage 1 SATs (Standard Assessment Tests) with Key Stage 2 SATs taken at the end of Year 6. At the age of 14, children sit the Key Stage 3 examinations. The majority of local authorities set the primary to secondary transition age at 11 years. Dominic experienced this transition. At Year 5 he was learning mathematics under the 1999 National Numeracy Strategy.

The State of Victoria Education System, Australia

Dominic moved to the state of Victoria in Australia at the end of Year 9. In Australia, each state runs its own education system within broad national guidelines. Children in the state of Victoria enter secondary school in Year 8 (the equivalent of Year 9 in New Zealand). From Year 11, children undertake examinations for credits towards *TheVictorian Certificate of Education* (*VCE*), which recognises the successful completion of secondary education and provides pathways to further study at university or Technical and Further Education (TAFE). Based on a combination of SAC (School Assessed Coursework) and external examinations, students receive an ENTER score (Equivalent National Tertiary Entrance Rank), which allows them entry into restricted courses at Australian universities. In this study, Dominic's final 3 years at school were Years 10, 11 and 12 in the Victorian State system.

An International School Education System

When Toby's family moved to Switzerland for 5 years, Toby attended a private international school including 1 year as a Year 5 primary student in the English-speaking part of the school. The school followed a programme of primary and secondary education not unlike systems commonly found elsewhere in the world. Primary school ended at Year 6, after which Toby entered the bilingual secondary French/English secondary school where he remained until halfway through Year 9 at which point he returned to New Zealand with his family. Mathematics was taught much as in other Western systems around the world.

The Swedish Education System

Fleur spent her final year of schooling (Year 13) in Sweden on a student exchange programme. She attended a high school. High school programmes run for 3 years and although non-compulsory, around 98% of students who finish secondary school go on to high school, usually around the age of 16 years. Students can choose from many different programmes that provide general qualifications to study at colleges and universities. Fleur was expected to attend mathematics classes for the first 6 months of her stay – the second half of Year 2 of the Swedish High School system – since it was a compulsory subject, although she had stopped studying mathematics as a subject at the beginning of Year 12 in New Zealand. In the second 6 months of her stay – the first half of Year 3 in the Swedish high school system, she was able to drop mathematics when it had become optional. She enrolled in a social sciences programme of study.

Part 1

Understanding Children as Mathematical Subjects: Theories and Methods

Chapter 1
Of Subjects, Subjectivity, and Subjectification: Subjects Made Visible

I hate maths …'cause I hate it when we do tests. I only get three, or four or five or something,'cause it's really hard.

Georgina, 7 years

I wish I was a bit better [at maths] but I don't exactly mind that much'cause not everybody's good at everything.

Fleur, 8 years

I'd rather go out and kick a ball than spend three hours doing maths problems which I don't need to do – which may help me, but generally won't.

Dominic, 16 years

Learning to read, write, and do mathematics functions as a rite of passage in the lives of children, as a sign of their growing up and coming of age. This process is far from easy for many children, as the opening statements in this chapter attest. In describing their experiences of mathematics these children spoke of their learning as something deeply personal – something *lived* and *felt*. Their learning of mathematics was clearly bound up with power, knowledge, and self.

Children have much to tell us about their mathematics lives. This book aims to provide a child's-eye-view of a school subject whose learning produces well-recognised emotional responses. It presents the experiences of ten children who took part in a longitudinal study, documenting their learning of mathematics from the ages of 7–18 years. The children's stories allow us to slip into classrooms, chat with teachers, and tune in to family discussions, offering us important insights into the everyday complexities of the production of children in mathematics education.

Children's accounts of learning mathematics are rarely included in public debate. The pervasive social lens through which children's learning is figured is an adult one. Typical approaches to mathematics education, from the development of national curriculum policy to a classroom teacher's blitz on the times tables, position children as objects upon which adults must operate to effect improvements. This objectification of children can be found in official statements that speak of maximising children's potential as though this were a measurable capacity, in frameworks that present children's learning as a clearly defined pathway, or in the application of classroom techniques such as repetitive written exercises that treat

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children as (disembodied) minds to be programmed for optimal function. Reay and Wiliam (1999) made a strong case for research that takes account of children's subjectivities in education, particularly in the processes of national assessment.

> There is virtually no literature which engages with students' perspectives. Rather, it is in the silences in relation to children's perspectives that it is assumed that either National Curriculum assessments have minimal impact on children's subjectivities or that children's concerns and attitudes are merely a backdrop to the assessment process; simply part of the social context. On the one hand the interplay between the assessment process and children's identities and identifications is not considered an important area for research and theoretical consideration, while on the other hand children are subsumed as a means to an end within a process which is primarily an exercise in evaluating schools and teachers. (pp. 344–345)

Commonly-held views of learning are founded on the perception that within naturally occurring neurological constraints, children can be shaped, conditioned, or acculturated into specific communities of practice (Ernest 1998). Such views take the position that children's learning of mathematics is something predictable and therefore controllable, the *fact* of children's mathematical success and failure accommodated, rather than created, in schooling. Children's thoughts are of little account in this approach which reflects and perpetuates assumptions about the purpose of learning, the nature of mathematics, and the place of children in our society.

In the opening statements of this chapter, Georgina, Fleur, and Dominic spoke of the means by which mathematics operates as culturally constructed and constructive, producing and positioning children in pedagogic practice, and in their lives beyond school. The construction of *self* can be detected in their talk about mathematics, a calling of themselves into existence as mathematical beings or *subjects*. As they described their experiences, voiced their emotions and offered explanations for their relationships with mathematics, they became in those moments, particular kinds of children, students of mathematics, and future adults. *Doing mathematics* became a particular kind of activity through which they could recognise themselves.

At the same time, they were speaking of learning mathematics as a process of *subjectivity*. Georgina's hatred of mathematics was linked to difficult tests. Fleur's wish to be better at mathematics grew from her perception of others as naturally more capable. Dominic's resistance to what he saw as mathematics' unreasonable and coercive demands was created in tedious routines of study and examinations. As *mathematical subjects* these children were not simply subjected to regimes of learning mathematics at school, but engaged as bone fide agents embroiled in the interplay of power and knowledge within which human beings are inscribed and the possibility of refusal to "play" always exists. Dominic conceded, for example, that doing mathematics problems may have helped him. He recognised the power that can be gained through acquisition and mastery of the discursively produced knowledge and techniques we call mathematics.

We can read the children's reflections in many ways. We might recognise them as resembling our own, as the statements of victims of schooling in which mathematics is inaccessible and unappealing. We might despair at the children's negative dispositions or blindness to the elegance or utility of mathematics. We might explain this as a symptom of the twenty-first century where standards have slipped or on an over-reliance on calculators. Each of these readings not only produces the children as subjects, but also the reader as subject at the same time since an act of interpretation is necessarily one of *subjectification*, of making oneself accountable to those social, cultural, and historical discourses, which enable such visibility.

In the following sections of this chapter, I look more closely at the three terms I have used in the opening paragraphs: *subject*, *subjectivity*, and *subjectification*. These are the concepts that recur throughout the work of Michel Foucault whose studies of the constitution of self in practice provide powerful methods by which to examine – and critique – systems of management and regulation that make us who we are by circumscribing who we might become. It is through Foucault's frame of the subject, using the tools he developed for investigating subjectification as social process, that I have collected and presented the stories of the ten children who became the mathematical subjects of this book.

Subjects

In the English language the word "subject" has a multiplicity of uses: as a noun, a subject can be seen as a *topic* of discussion or investigation, or a *branch* of learning that forms a discipline or course of study. A subject can also be seen as a *person* ruled by a figure of authority, as someone who receives treatment, or as the one who becomes the focus of an activity or work of art. In grammar, the subject is the *part of a sentence* that the rest of the sentence asserts something about; the subject typically performs the action expressed by the verb. As an adjective, subject indicates *likelihood of being affected* by something, *under the control* of somebody or something such as a ruler or a law, and *obliged to obey*. Subject as a verb means *to cause somebody to undergo something unpleasant* or to *bring a person* or group *under the power or influence* of another person or group. These usages are linked in the Latin word *subjectus* derived from *subicere* meaning "to place beneath" and *jacere*[1] "to throw", and all speak in some way about objects produced in a relationship of power within specific loci or sites of production.

I use the word *subject* in this study for the very lexical and polysemic versatility that Foucault found so suggestive, so illuminating and so political and in his examination of individuals in society. In one of the many explications of what he meant by subject, Foucault distinguished between the differing yet connected connotations of this word:

> There are two meanings of the word "subject": subject to someone else by control and dependence, and tied to his own identity by a conscience or self-knowledge. Both meanings suggest a form of power that subjugates and makes subject to.
>
> Foucault 1994a, p. 331

[1]Shorter Oxford English Dictionary, 2002, Oxford University Press, 5th Edition, Volume 2, p. 3085

A human subject can therefore be viewed as produced in action, in relationship, both active and acted upon, existing in the positional, and constituted in time and space. Walkerdine (2002) in speaking of the work of Venn (2002) captured this when she stated that, “The subject position is not fixed… [It] is produced at the intersection of history, biography and the body” (p. 9).

Subject is a word that can be used to refer not only to mathematics itself, but also to those who learn it, as Hardy (2004) noted.

> Foregrounding the discursive nature of mathematics education practices marks a shift away from viewing culturally accepted norms as perpetuated through traditions and sees knowledge as produced through a process of describing and ordering things in particular ways. It is this process that produces “subjects”. “Subjects” here are understood in both senses, as persons and bodies of knowledge.” (p. 106)

This view of individuals as socially produced emerged in the post-Freudian philosophical discourses of theorists such as Althusser, Lacan, and Foucault, signalling a move from psychological views of the self as interiorised and separate, to an understanding of *self* and *others* as bound together in a mutual and recursive process of becoming, a continuous, reflexive co-constructive relation. Foucault in particular rejected the traditional approach to history that reinforced the “stable subject position”, that is, the way history presumed to reveal and affirm essential human characteristics (Walshaw 2007, p. 11). He argued instead that as subjects, we exist – for ourselves that is – only in the ways we enact ourselves.

Based on Foucaultian theory, Walkerdine’s research (1988, 1998) made compelling use of the idea of children as subjects within schooling:

> The truth of children is produced in classrooms. ‘The child’ is not coterminous with actual children… If children become subjects through their insertion into a complex network of practices, there are no children who stand outside their orbit… These practices therefore produce and read children as ‘the child’.
>
> Walkerdine 1988, p. 204

To apply this idea in mathematics education – as part of a discursive practice that is seen as more than simply what happens in the classroom – we might suppose then, that whenever children hear their teachers say, “It’s time for maths”, enlist their parents’ help with their maths homework, discuss their mathematics test results with their family or mates, observe a character doing mathematics in a television show, exchange views with friends about a particular mathematics teacher, or choose whether to continue their study of mathematics at secondary school, they are at the same time engaged in a discursive process of self-construction as they bring themselves and each other into being as both “children”, and as “mathematical subjects” in their hearing, seeing, uttering, and doing. These social enactments construct and reinforce what is possible and what is normal: they define what mathematics *is*, what it means to *learn* and *teach* mathematics, to *know* mathematics, and to *succeed* or *fail* at mathematics. In short, such acts authorise and inscribe the child as a “mathematical subject”.

Subjectivity

Walkerdine (1988) extended her argument that classroom practices produce children as subjects by linking this to subjects' self positioning and behaviours, dispositions, and orientations that constitute their *subjectivity*.

> Within [classroom practices such as 'activities'] children become embodiments of 'the child' precisely because that is how the practice is set up. They are normal or pathological, and so forth. Their behaviour therefore, is an aspect of a position, a multifaceted subjectivity, such that the children describe only their insertion into this, as one of many practices. (p. 204)

Subjectivity is best explained then, not as something the subject *has,* but as something the subject *does, feels,* or *experiences,* that makes the subject known to itself and to others, and which is multi-faceted and mutable rather than singular and fixed. To explain subjectivity further, it is useful to look at the related and much more widely used concept of "identity" to highlight important differences between the two.

Identity theories are reasoned according to beliefs about where identity is located and how it is shaped. Côte and Levine (2002) described this as a "structure-agency debate", which argues the degree to which individuals exercise control independent from social structure and how much social structure determines individual behaviour.

Lacan (1977, 2002) broke from psychoanalytic theories, which saw identity as located entirely within the individual, by explaining identity as an active process, created in the interplay of self and other, including the work of the subconscious, and engaging what he suggested to be the three registers of self – real, symbolic, and imaginary. He believed that in the desire of the self to be present as a secure identity, individuals continuously seek certainty in their self-understanding. Using a Lacanian approach, we could observe children as they confront competing versions of what it means to be good at mathematics, engaging within social settings in individual processes of reconciliation of current beliefs about what it means to be a good mathematics student and how the self is implicated in these beliefs, in other words, to what degree learners' as selves are allowed to be present, how their engagement supports or threatens the security of learner self conceptualisation, and how this allows for learners to imagine themselves as successful. This view sees identity as developed in social interaction.

Holland et al. (1998) took a similar approach in describing identity as self-in-practice, with a particular focus on the nexus of sociocultural worlds and the world of the individual. They distinguished between *figurative* and *positional* identity, that is, the generic, desired, and imagined identity, and the specific, located, and relational identity. In this view, identity is a state of being to which an individual aspires and against which one compares oneself. Identity, then, can be conceived as something one can have or a state one can attain.

Socio-cultural perspectives have also been used to explain identity in children's learning of mathematics as a form of social self-recognition e.g. Winbourne (1999). An example of this can be found in the work of Grootenboer and Zevenbergen (2008):

> We want to focus on the development of student's identity in mathematics, and the relationship between students' mathematical identities and the discipline of mathematics. For this purpose we view identity as "how individuals know and name themselves…, and how an individual is recognised and looked upon by others" (Grootenboer et al. 2006, p. 612). Identity is a unifying and connective concept that brings together elements such as life histories, affective qualities and cognitive dimensions. (p. 243)

Identity is construed here as a particular set of qualities or orientations a student *gains* and *has*, in a process of moulding or crafting over time in interaction with others. Identity is conceived as a psychic composition which children and others can "know and name", determined by exterior forces and expressed in the ways that children feel and behave in the classroom. This suggests that the variables implicated in the formation of identity-as-entity can be seen in a cause-effect bond.

A similar view of identity appears in many contemporary policy statements such as the New Zealand national curriculum (Ministry of Education 2007) which states:

> As they explore how others see themselves, students clarify their own identities in relation to their particular heritages and contexts. (p. 30)
> The transition from early childhood education to school is supported when the school: fosters a child's relationships with teachers and other children and affirms their identity. (p. 41)

The Queensland *P-12 curriculum framework* (Department of Education, Training and the Arts 2008) correspondingly recommends that, "A curriculum for all promotes… use of a range of resources that are appropriate to students' learning needs and reflect students' *identities*" (p. 10). In the joint declaration on educational goals for young Australians (Ministerial Council on Education, Employment, Training and Youth Affairs 2008) it is asserted that, "Confident and creative individuals have a sense of self-worth, self-awareness, and personal *identity* that enables them to manage their emotional, mental, and physical wellbeing" (p. 9) [italics added for emphasis]. Identity is portrayed in each of these curriculum statements as something a child *has*, as though identity were the substance of the child, something able to be recognised and known, something requiring reflection, clarification, and affirmation. Such statements suggest that identity can be realised, made visible, and fixed in the act of schooling. But more importantly, child-as-identity can be invoked to recognise, name, explain, judge, and manage the child.

Looking beyond commonly-held views of identity as a state of being or having, Miller Marsh (2002) saw identity instead as a dynamic process of becoming, constrained and guided by social forces.

> … the various discourses that define what it means to be a particular type of student or teacher in this particular moment… are rooted in the social, cultural, historical, and political contexts in which schools are situated… These discourses of schooling shape what and who schools, teachers, children, and families can become. (p. 460)

Brown et al. (2004) also reasoned that identity should not be conceived as a stable entity, as something people *have*, suggesting instead that identity be seen as something they *use* in a shifting dialogical process to reconcile complex demands (p. 167) and account for themselves in particular contexts. Mendick (2006) similarly argued that, "the word identity sounds too certain and singular, as if it already exists rather than being in a process of formation" (p. 23). She adopted the term *identity work* to better explain identity as active and always a work-in-progress. These accounts of identity draw us closer to Foucault's view of subjects not as fixed, clarified, or affirmed but in a continuous state of being made, and manifested as subjectivity.

Foucault's notion of subjectivity did not imply worlds as pre-existing, exterior to, or shaping of the individual, but saw instead the *social* and *subject* as co-constituted in action. Subjectivity in this view is understood not as something one *is* or possesses or has become at any given moment; rather it is something one does which makes oneself and one's world visible at the same time. Thus, if a child says, "I am a slow learner" Foucaultian theory regards this kind of statement as an *act of subjectivity*, of the child calling her/himself into being through the articulation of the statement about self, made in relation to others and pertaining to events in which this statement has been produced. However fleeting, such knowing or naming is not, Foucault would urge, to be read as evidence of the child's possession of an identity. Subjectivity in the Foucaultian sense is not seen as located and moulded in the individual, but as lived and enacted. It is a concept that asks us to pay particular attention to the context in which such statements about self are made, their position among other statements, and their contiguousness with the discursive circumscriptions, delineations, and delimitations that make these particular utterances possible. Is a statement made in reference to a particular activity in the classroom, for example? How are others constituted in this statement? In what other circumstances might the child say, "I am a fast learner?" More importantly, what is it about the discursive formation in which the child is immersed that brings the words *slow* or *fast* into subjective and (op)positional play when talking as/of a mathematical subject?

The Foucaultian explanation of self as *subject in discursive production* regards subjectivity as the act of self upon self – subject constituted in the act of subjectivity – of *becoming* a subject – rather than existing as, in or through a fixed identity, even momentarily. Subjectivity then is at once a process and a position in motion. It is necessarily social, since nothing we do or say as an individual comes about as a socially disconnected act of the will of the *self*. It is this view of self as subject in a perpetual enactment, ever folding upon itself in new and renewing acts of recognition that I have found most useful in making sense of children's experiences and accounts of learning of mathematics. In this view, a child who is learning the times tables (basic multiplication facts), themselves a social construct in mathematics education, is produced as a particular mathematical "subject" about which we can talk, and whose subjectivity – something felt and lived by the child and reflected in her/his actions and descriptions of the self – is continuously made and remade through performance as the times tables are encountered in the classroom and home.

Subjectification

Subjectification (from the French *assujettissment*) is a concept Foucault used to refer to the act of production of subjects and subjectivities. Subjectification is a term that recognises the power of discourses to not only produce subjects, but also to order, control, and discipline them. Walshaw (2007) described subjectification as the ways in which individuals (subjects) are produced as, "accountable to specific discourses that claim their hold – the way they condition themselves without any compulsion to do so" (p. 114), cautioning that this was not to be confused with subjection which implies coercion. Bergström and Knights (2006) understood subjectification to be the interaction between human agency and organisational discourses, a discursively constitutive process whereby the self is produced and self-produced as a self-in-making, open to inscription and re-inscription according to culturally situated practices.

Foucault (1977) described the test or examination as a primary mechanism of subjectification used in the management of populations through modern institutions.

> The examination combines the techniques of an observing hierarchy and those of a normalizing judgment … it establishes over individuals a visibility through which one differentiates them and judges them. That is why, in all the mechanisms of discipline, the examination is highly ritualized. In it are combined the ceremony of power and the form of experiment, the deployment of force and the establishment of truth. At the heart of procedures of discipline, it manifests the subjection of those who are perceived as objects and the objectification of those who are subjected. (pp. 184–185)

To continue the example of the child learning the times tables, it is those daily routines in which memorisation of tables is tested and a truth established about the child who is in turn treated accordingly, that engages the child in a process of subjectification. Through such activities the child is made visible as a subject as she/he is subjected to, and subjectified by, this regulatory and disciplinary regime of practice rooted in the historical, political, and social, which defines mathematics, directs the actions of children and teachers, and acts as a site of subjectivity. For the child who is thus produced as a mathematically capable subject, subjectification may be pleasurable for the rewards of accomplishment it generates, but for the child whose incompetence is revealed, *subjectification by times tables* may be experienced as humiliating or debilitating.

Subjects, subjectivity, and subjectification can therefore be seen as inter-linked, co-productive, and co-dependent concepts that position self and others in relationships of truth-telling and the power such truths engage.

The Role of Discourse

Foucault's explanations of subject, subjectification, and subjectivity locate the production of self-as-subject in discourse. By *discourse* Foucault referred not only to the words we say or write that produce the objects of which we speak (Foucault 1972) but also to the systematic practices and rules that govern them and that generate and permit our ways of speaking and doing within specific bodies of related statements and actions he termed *discursive formations*. Kendall and Wickham (1999) described this relationship:

> Subjects' actions take place in discourse and subjects themselves are produced through discourse. Subjects are the punctuation of discourse, and provide the bodies on and through which discourse may act… in the realm of the body, the realm of force and the realm of knowledge. Human action within discourse is always positional. (p. 53)

Foucault talked of discourse as an *episteme* or, "group of statements that belong to a single system of formation" (Foucault 1972, p. 121). Central to Foucault's approach is the idea that discourses are *productive,* thus he argued that penological discourses *produce* the "criminal", and medical discourses *produce* the "insane" or "healthy". In this view, *sinners, the insane,* or indeed *slow, average,* or *gifted* learners of mathematics are made visible and signified through discourse. His historical studies of discipline and punishment (Foucault 1977), reason/unreason (1967) and sexuality demonstrated how discourses constitute the sayable, transmute over time and space, and are engaged in a continuous process of *production.*

Discourses of power/knowledge/truth can be seen as creating and supporting social structures that exercise control through the subject positions of "normality" and "abnormality" produced in these discourses. These binary oppositions enable modern institutions such as prisons, hospitals, armies, and schools (Foucault 1977) to make visible and to manage through processes of discipline – including self-discipline – the subjects they bring into existence. He looked to historical sources (Foucault 1970) to understand how human systems of classification over time and in differing cultural settings have been concerned with *noticing*, *describing*, *defining*, and *ordering*, proposing that it is our systems of classification that structure our view of the world and permit us to "see" and proposed that classification of the self had become a pervasive managerial technique within institutions such as schools, whose purpose it is to correct or train.

Foucault described social systems operating within discursive domains as *ensembles of practice* (Foucault 1980), and the relations between discourse and institutional apparatus a *dispositif* (Foucault 1980), reasoning that it is only within particular ensembles of practice, supported by a specific dispositif, that *criminals* require *punishment*, the *insane* require *treatment*, and the *uneducated* require *schooling.* He demonstrated that as the histories of such institutions are obscured with time, their purpose and methods become accepted as common sense or best practice, thus fictions come to operate as truths. He suggested that where such systems create and maintain social injustices, it is possible to look to founding discourses to challenge current practice and contemplate alternatives.

Foucault's view of self as subject constituted within discourse can be seen to operate within the discursive formation of education and schooling that produce us as teachers and learners. Subjectivity is not something one *gains,* or *has* as a result of schooling; rather it is something one *does* or *experiences* within regulating pedagogic discourses.

Within the epistemic domain of *education*, schools and schooling comprise the ensembles of practice in whose daily performances of a reality – discursive "games of truth" – are played out, determining what may be said and what is unsayable, how one may or may not behave, and who one is permitted to *be*. Those sites in which subjects are designated and acted upon according to authorising discourses such as those of school and family, Foucault termed *surfaces of emergence* where subjects and objects embedded in everyday discursive enactments become visible. Thus children can be seen as entangled in the production of themselves as mathematical learners within the authorising institution of school, whose discourse limits what/who “exists” and how one may act.

Foucault argued that it is in its processes of surveillance, measurement, and judgement, its supervision, management and control of living bodies he termed bio-power (Foucault 1978), that schooling makes children as subjects, a process which neither crystallises nor reveals subjectivity, but produces it. Thus a child may experience shifting or contradictory views of the *self as a mathematical learner* through engagement in pedagogical regimes, interactions with friends and classmates, or discussions with parents and siblings.

Throughout his career Foucault urged us to *refuse to be who we are*, meaning that although we may be subjects, our subjectivities produced through processes of subjectification by and with those around us, and by the institutions and signifying social practices in which we find ourselves embedded, we can actively work to accept, to remake, or to reject those constructions of our selves where they do not serve us well. His declaration, “Do not ask me who I am, and do not ask me to remain the same”, (Foucault 1972, p. 19) illustrates that for Foucault our view of what it means to be a “self” is not natural or inevitable, rather it is a social and historical construct. He argued that because we produce ourselves and each other through the continuous and contingent discursive processes at play within intersecting social networks such as family, workplace, institutions, community, and the political domain, we can operate upon the discourses that produce subjects and subjectivities.

To return to the children’s statements with which this chapter opened, we can begin to appreciate the apparatuses of subjectification – the repeated performance of particular kinds of activity such as “maths tests” or “doing maths problems” for example – within which Georgina, Fleur, and Dominic actively took up the discourse of mathematics, “as if it were their own”, (Davies 1993, p. 13). As subjects they were made visible and positioned in performances based in and productive of, specific forms of knowledge which they variously accepted as inevitable (true), assessed for possible gains, and/or resisted by distinguishing between what they could chose and what was imposed, their self-narration operating as an act of subjectivity and subjectification at the same time.

Chapter 2
Of Archaeology and Genealogy: Choosing Sites and Tools

Archaeology

Research that aims to understand humans as subjects calls for methods that do not seek to discover the truth, but to apprehend a process. Within theories that see people not as socialised into a self-evidently real world but as engaged in continuous discursive processes of subjectivity, investigative techniques are required that will allow us to catch subjects in discursive acts of subjectification. Foucault established an approach he termed *archaeology*, which he developed to better understand the slippery stuff of subjects in process, located and made visible in discourses. His method is a way of examining and understanding complex social phenomena through careful attention to their production. In his work *The Archaeology of Knowledge*, Foucault (1972) outlined four principles of archaeological method which I have abbreviated here. To steer researchers away from traditional methods that seek causes and effects, "hard facts" and universal truths, Foucault based his principles on what was to be avoided, offering an alternative framework for conceiving the focus and purpose of social research.

> 1: Archaeology tries to define not the thoughts, representations, images, themes, preoccupations that are concealed or revealed in discourses; but those discourses themselves, those discourses as practices obeying certain rules …
>
> 2: Archaeology does not seek to rediscover the continuous, insensible transition that relates discourse, on a gentle slope, to what precedes them, surrounds them or follows them … on the contrary its problem is to define discourses in their specificity; to show what set of rules that they put into operation is irreducible to any other …
>
> 3: Archaeology … does not wish to rediscover the enigmatic point the individual and the social are inverted into one another. It is neither a psychology, nor a sociology, nor more generally an anthropology of creation … it defines types of rules for discursive practices …
>
> 4: … archaeology does not try to restore what has been thought, wished, aimed at, experienced, desired by men in the very moment at which they expressed it in discourse … it is the systematic description of a discourse-object. (pp. 155–156)

His archaeological approach stresses that the site of investigation is discourse itself, particularly its productive and regulatory powers which Walshaw (2007) described:

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> Archaeology takes discourses as its object of study, investigating the way discourses are ordered … offers a means of analyzing 'truth games' by looking at history and uncovering the rules of construction of social facts and discourses …' (p. 9)

In an archaeological approach to understanding mathematical subjects it is the discourse that produces those subjects-which must be of prime interest; subjects are not seen as psychological, sociological or anthropological, but as discursive. Wherever discourse emerges and subjects with it, a site of archaeological investigation can be found. Cotton (2004), for example, uses this kind of archaeological approach in his examination of assessment in mathematics education.

In recognising discourse not only as the words that we say or write that bring the objects of which we speak into being for us, but also the systematic practices and rules that govern them and that generate and permit our ways of speaking and doing (Foucault 1972), an archaeological investigation of mathematical subjects must include schools, classrooms, popular culture and homes as *discursive sites of emergence*, exercise books, textbooks, school reports and other artefacts of schooling as *discursive objects*, and the acts and utterances of *discursive subjects* such as children, principals, teachers and parents as *acts of discursive production*. Foucault's notion of *archive* in such an archaeological investigation is nicely explained by Bate (2007):

> The archive in Foucault's work … involves the whole system of apparatus that enables artifacts to exist … In this model the "archive" is already a construct, a *corpus* that is the product of a discourse. One must dig to make sense of the systems behind what one sees. (p. 3)

The archaeologist must look beyond the surface of things – a mathematics worksheet for example – to the discursive systems and their rules that have brought such an artefact into being and the subjects, subjectivities and subjectification that are produced in its use.

In my archaeological approach I have taken education, schooling and the discipline of mathematics itself to be the primary intersecting discursive formations in which children as mathematical subjects are constituted. Rather than attempt within the limited scope of this book, a comprehensive investigation of the archive, I have taken samples of archival material from a range of sources as evidence of the systems of management and techniques of power that typify discursive modes of production of mathematical subjects, their subjectivity and subjectification. These include statements of vision and intent from education policy documents, mathematics curricula, school brochures, textbooks and guides for teachers of mathematics.

Genealogy

Archaeology and genealogy are closely linked as supporting methodologies in Foucault's approach to understanding our lives. Through genealogy Foucault was able to connect discourse with its everyday enactments, which was particularly useful in examining how subjects are made as both discursive and "real" at the same time; genealogy explains how subjectivities become realised as subjects play out the discourses that delimit and circumscribe what is possible – who they might "become." Foucault (1994c) described genealogy:

> Genealogy is gray, meticulous and patiently documentary … it must record the singularity of events outside any monotonous finality; it must seek them in the most unpromising places, in what we tend to feel is without history – in sentiments, love, conscience, instincts; it must be sensitive to their recurrence, not in order to trace the gradual curve of their evolution but to isolate the different scenes … genealogy requires patience and a knowledge of details, and it depends on a vast accumulation of source material. (pp. 369–370)

Genealogy focuses on the "doings of everyday doings" [Foucault (1983) cited in Winecki (2007)] providing links between the archaeology of a discursive formation and its practice. Kendall and Wickham (1999) listed the following characteristics of Foucault's genealogical approach:

> Genealogy … describes statements but with an emphasis on power; introduces power through a 'history of the present', concerned with 'disreputable origins and unpalatable functions' … describes statements as an ongoing process, rather than as a snapshot of the web of discourse; concentrates on the strategic use of archaeology to answer problems about the present. (p. 34)

Walshaw (2007) viewed genealogical method in educational research as important for its power to reveal obscured discursive meanings and ulterior purposes of taken-for-granted practices of the classroom as they are experienced by the subjects they create:

> Genealogical analyses that explore the interaction of power and knowledge within the practices and social structures of education are able to highlight the profound influence of discourse on shaping everyday life in education. (p. 14)

An investigation of mathematical subjects engaging both archaeology and genealogy methodology must therefore include an examination of the rules of production of the discourse of mathematics education itself and its manifestation in everyday situations as technologies of power. The use of mathematics exercise books as a practice designed to consolidate learning for example sits within a wider discourse that enables and validates its existence and in which power is inevitably at play.

Foucault (1994b) was careful to observe that power is not necessarily negative. He recognised the many uses of power in schooling, but distinguished certain kinds of authority in education he called *domination*, as something to be rigorously challenged:

> Let us take … something that has often been rightly criticised – the pedagogical institution. I see nothing wrong in the practice of the person who, knowing more than others in a specific game of truth, tells those others what to do, teaches them, and transmits knowledge and techniques to them. The problem in such practices where power – which is not in itself a bad thing – must inevitably come into play is knowing how to avoid the kind of domination effects where a kid is subjected to the arbitrary and unnecessary authority of a teacher … philosophy is that which calls into question domination at every level and in every form in which it exists … (pp. 298–299)

Foucault regarded the purpose of philosophy to be its political acts of questioning, particularly of power in the form of domination emanating from what he termed “arbitrary and unnecessary authority.” Archaeology and genealogy are techniques of enquiry that invite the researcher to take a forensic approach to examining power in all its forms and manifestations at both micro and macro levels. This approach is particularly suited to investigations over time that span a multiplicity of classroom, family, community, institutional, governmental and international educational settings.

Children Talk About Their Mathematics Lives: Framing the Research

Mathematics is universally regarded as a core subject of the school curriculum and accepted without question as something that children must learn and teachers must teach. So great is the belief in the benefits of teaching children mathematics from a very young age that governments devote a significant proportion of public funding to building teachers’ capacities to deliver improved outcomes in mathematics. Over recent decades, approaches to mathematics education in New Zealand have echoed those of other English-speaking countries. The outcomes-based Years 1–13 mathematics syllabus introduced in 1992 for example represented a shift in teaching and learning mathematics reflecting international trends in its emphasis on processes of working mathematically, such as problem solving, logic and reasoning and communicating mathematical ideas. Appealing to the discourses of inquiry learning and learner-centred pedagogy, the syllabus aimed to improve the quality of children’s engagement in mathematical learning and increase their understanding of the underlying principles of mathematics.

When the results of the New Zealand TIMSS[1] research were released in 1997, one of the reported findings was particularly striking:

> While a majority of students have positive attitudes to learning mathematics … beginning from a fairly young age, there is an increasing proportion of students having lost interest in the subject, with a concomitant decline in their achievement. This effect is considerably greater for girls than for boys. (p. 252)

The gendered correlation between enjoyment, confidence and achievement in mathematics suggested fertile lines of investigation since changes in curriculum had failed to reduce traditionally recognised disparities. The first part of this book – Phase 1 of the study – is based on a project that began in 1998 and finished in 2000. It was focused particularly on issues of disaffection, alienation and marginalisation in primary school children’s learning of mathematics highlighted by the TIMSS results. This formed Phase 1.

[1]Third International Mathematics and Science Study.

After this phase of the study had been completed, links between confidence, enjoyment and achievement, and disparities by sex continued to be reported. The results of New Zealand children's performances in TIMSS[2] 2002/2003 for example stated:

> Proportionally more boys than girls in New Zealand expressed a high level of self-confidence in both mathematics and science. The relationship between confidence and achievement observed for all students was also evident within each gender group. (Caygill et al. 2007, p. 77)

Australia's report on the 2002/2003 TIMSS results (Thompson and Fleming 2004), contained similar findings.

> Students' self-confidence in mathematics had a clear positive relationship with mathematics achievement. Males had higher self-confidence in learning mathematics than females … At both year Levels [4 and 8] males enjoy learning mathematics more than females. (p. 9)

The same report also showed a significant overall decline from Year 4 to Year 8 in children's enjoyment and confidence with mathematics, a trend echoed elsewhere. The PISA[3] results that tested the mathematical literacy of 15-year olds revealed a similar gendered trend in disaffection. While there were no significant differences on the mean scores for *mathematical literacy* in the PISA 2003 results (Thompson et al. 2004) gender differences were revealed.

> Although Australia's results in PISA on average were very encouraging, when results for specific sections of the population are examined, areas of concern are revealed … While there are no significant gender differences overall in mathematical literacy, boys tended to be over-represented in the upper levels of achievement while girls appeared to be less engaged, more anxious and less confident in mathematics than boys. (p. xvi)

The gaps had reportedly widened in the 2006 study.

> Males significantly outscored females in mathematical literacy in Australia in 2006. Almost twice as many Australian males as females achieved the highest PISA proficiency level … Australian males significantly outscored females in mathematical literacy in PISA 2006, by 14 score points. More males achieved the highest proficiency levels in mathematical literacy, with 20% achieving at least Level 5 compared to 13% of females. (Thompson and De Bartoli 2008, p. 11)

Gendered differences in achievement were also reported in the New Zealand PISA 2006 results.

> On average, boys had higher mathematical literacy than girls, with a difference between their means of 11 scale score points. This pattern of a gender difference in favour of boys was also found in 2003 and was observable for many OECD countries. Across OECD countries the average gender difference in favour of boys was 11 score points. (Caygill et al. 2008, p. 16)

These studies also found that indigenous children, children from lower income families and children of parents with limited education and qualifications were consistently less likely to perform well in assessments of mathematical achievement.

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[2]Trends in Mathematics and Science Study.

[3]OECD's Programme for International Student Assessment.

Persistent global disparities by sex, ethnicity and socio-economic background in mathematical achievement, in the choice of mathematics as an upper secondary school subject, in the choice of mathematics in tertiary study or of occupations requiring advanced mathematics, were inadequately understood, it seemed, since interventions had done little to reduce the equity gaps (see Mendick 2006). Explanations for children's achievement in mathematics were unable to unravel the social, cultural, historical and political embeddedness of attitude/achievement connections revealed in the quantitative data of studies such as TIMSS and PISA.

Cotton and Hardy (2004) argued for research that could provide more than the flat accounts of the classroom free of power and affection that had failed to account for the enduring failure of groups of learners (p. 85) and suggested problematising the discourses in which such failure is produced. Longitudinal studies capturing the discursive processes of inclusion/exclusion for particular children in learning mathematics from an early age were scarce. Inspired by these issues and challenges I decided to extend my earlier research to include the children's learning of mathematics as they moved through secondary school.

Archaeology, Genealogy and Biography: Researching the Storied Subject

> *Every self is a storied self. And every story is mingled with the stories of other selves, so that each one of us is entangled in the stories we tell about ourselves and that are told about us. The understanding of subjectivity cannot be separated from the way selves are narrated, so that we can conceptualise the* 'who' *as narrated identity.*
>
> Venn (2002, p. 52)

> *Biography is the proper source of unity in human existence.*
>
> Weigert (1981, p. 62)

This research sought to document children's unfolding mathematics lives as narrated by the children themselves and by others around them. Venn and Weigert (aforementioned) recognised self-storying as a critical dimension in the production of the *self* and *other* suggesting that it is through sharing stories about ourselves we produce ourselves as beings we call "human." As humans we are engaged in a continuous quest to explain ourselves, and story-telling as a method of both defining and explaining human experiences and existence can be found in all human cultures. Personal stories are captivating for the ways in which they situate us within social and historical contexts, connect us, speak *about* us, and speak *to* us in ways that other forms of research such as large-scale quantitative studies cannot. As we learn about the lives of others we reflect on their experiences with reference to our own, expanding our awareness of self in community. Through such contemplation we recognise common challenges and contingencies at play in our lives. In (auto)biography – telling stories of our lives – as we bring ourselves into being for our selves *and* for others we exist more compellingly for each other as intersubjective subjects-in-making.

In combination, biography, archaeology and genealogy present the researcher with a formidable collection of tools with which the "power and affection" mentioned by Cotton and Hardy (2004) can be explored. Biography provides human plot lines by which the archaeology/genealogy of the discursive formation we recognise as mathematics education can be investigated for its personal, local and historical manifestations, its distinguishing artefacts, actions and utterances, and its power to delimit or allow particular subjects to exist. Centred on biographical case stories, this became the methodological approach I adopted for its power to provide insights into learner subjectivity, recognising children as active beings in learning mathematics, and the discursive domains in which they emerge as subjects, including the discourses of policy and pedagogy that surround the doing of everyday doings in classrooms.

Case-based ethnographical method in gathering such stories is supported by researchers such as Verma and Mallick (1999) who claimed that, "the greatest advantage of this method is that it endeavours to understand the individual in relation to his or her environment" (p. 82). They added that:

> … one of the strengths of the case study is that it allows the researcher to focus on a specific instance or situation and to explore the various interactive processes at work within that situation … its prime value lies in the richness of the data that are accumulated and that can only be acquired as a result of long and painstaking observation and recording followed by subsequent analysis. (p. 114)

An example of such research is Loughran and Northfield's (1996) ethnographic case study of life for students in one Year 7 classroom. They instanced two students who spontaneously introduced themselves as mathematical subjects.

> Kathy: I'm Kathy and I'm no good at maths.
>
> Rhonda: My name is Rhonda and I can't do maths … I'm not much better at other subjects. (p. 64)

This illustrates how mathematics as a subject is implicated in subjectivity, apparent even in studies where learning of mathematics was not the subject of investigation.

Case-based studies focused specifically on learner perspectives in mathematics (e.g. Walshaw 2001; Boaler 2002; Mendick 2006) have made valuable contributions to our understanding of pupil experience in mathematics education particularly in describing gendered learners and the effects on learners of contrasting pedagogical approaches. These studies were located in a time-specific period in students' lives and investigated a particular aspect of learning of mathematics such as issues of gender or pedagogical effects. Walkerdine's (1998) research focussed on children's mathematical learning in early childhood settings, with a small group tracked into their fourth year of secondary schooling. Her ethnographic study included interviews with parents and investigated the processes by which girls and boys became gendered subjects in mathematical discourse.

This research was designed to generate greater richness of biographical and archaeological/genealogical data than previous studies had been able to provide.

Through a method of biographical ethnography, I aimed to produce multi-dimensional accounts of the complex processes of mathematical subjectification for specific children over the greater part of their schooling and into their post-secondary years. In closely documenting a small sample of children as mathematical subjects in unfolding narrative, located in their sites of production such as classroom and home and positioned and contextualised in everyday discursive settings, I expected to better understand how failing/succeeding children are made in the learning of mathematics. Rather than a truth I was trying to reach, it was a lived *process* I was seeking to discern through an investigation of both the material and discursive worlds that produce the mathematical subject. This view of realities as situated and as constructed in the doing suggested the kind of research focus Walshaw advocated (2007).

> Once you accept that reality is constantly mobile, then our interest in research moves from establishing truth onto an understanding of how meaning is produced and created and in how these productions factor into larger decisions concerning power and privilege. (p. 151)

Biographical ethnography requires that the researcher enter the worlds of the participants in a relationship that allows for the data (the storied self) to emerge in situated acts of narration since it is in the telling that the storied subject can be "seen." To this end I set about generating a sample of primary school children who were prepared to talk about their experiences of learning mathematics over several years and whose families and teachers were also willing to contribute to these emerging stories. Through random selection of schools from a list of all schools within a large urban area in New Zealand, I established a group of 10 schools whose principals and one Year 3 teacher were willing to participate. From there I randomly selected one Year 3 child from each of these 10 schools. The selection was made from lists supplied by the Year 3 teachers who were to become participants in the study, of all the Year 3 children in their classes who had recently reached 7 years of age. The parents of the selected children were then approached through the schools and without exception, the parents and their children agreed to take part. The sample group formed by this method included 4 girls and 6 boys (see Table 2.1).

Substitute names were adopted for the children and have been used throughout the study. Pseudonyms for schools and teachers were also used, based around a theme of geographical landforms which bore no relation to the schools' actual locations.

The children's schools were located in a range of geographical areas and social communities within the region. As Table 2.1 shows, they varied markedly by type, size and decile (socioeconomic status) rating.

The children were all speakers of English as their first language. Their families included New Zealand Māori (indigenous) parentage (1 child), first generation Asian immigrant parentage (1 child), and first generation Northern European immigrant parentage (two children). Family relationships and circumstances altered over the period of the study, with parental separations (2 families), changes of primary school (5 children), changes of secondary school (5 children), shifts from living with one parent to another (1 child), and relocations from one house to another (all of the children).

Table 2.1 The children's schools by name, type, composition (mixed- or single-sex), size and decile rating

	Year 3	Year 4	Year 5	Secondary Years 9–13
Fleur	*Hill* – State primary, mixed, medium, 6	*Hill*	*Pukeiti* State primary, mixed, medium, 8	*Upland* (Yrs 9–12) – Private secondary, single-sex, large, 8 *Kull* (Yr 13) - State secondary, mixed
Georgina	*Island* – Catholic primary, mixed, medium, 6	*Motu* – State primary, mixed, small, 10	*Motu*	*St Skerry* (Yrs 9–12) – Catholic secondary, single-sex, medium, 10
Jessica	*Lake* – State primary, mixed, small, 8	*Roto* – Private primary and secondary, single-sex, large, 10	*Roto*	*Roto* (Yrs 9–13)
Rochelle	*Bridge* – State primary, mixed, large, 8	*Bridge*	*Bridge*	*Crossover*(Yr 9) – Catholic secondary, single-sex, medium to large, 7 *Arches* (Yrs 10–11) Private secondary, single-sex, small, 9 *Arawhata* (Yr 12) State secondary, mixed, large, 4
Dominic	*River* – State primary mixed, medium, 7	*River*	*River*	*Braeburn* (Yr 9) International, mixed, medium (Yrs 10–13); *Beckham*, mixed, large
Jared	*Spring* – State primary, mixed, medium, 5	*Spring*	*Spring*	*Holy Fount* (Yrs 9–12) Catholic secondary, single-sex, large, 9
Liam	*Mountain* – Catholic primary, medium, 5	*Mountain*	*Mountain*	*Summit* (Yrs 9–10) Catholic secondary, single-sex, medium, 5 *Taranui* (Yrs 11–13) State secondary, mixed, large, 4
Mitchell	*Cliff* – State primary, mixed, small, 1	*Pari* – State primary, mixed, medium, 4	*Pari*	*Edgecombe* (Yrs 9–13) State secondary, mixed, large, 8

(continued)

Table 2.1 (continued)

	Year 3	Year 4	Year 5	Secondary Years 9–13
Peter	*Beach* – State primary, mixed, large, 10	*Beach*	*Beach*	*Dockside* (Yrs 9–13) State secondary, single-sex, large, 10
Toby	*Bay* – State primary, mixed, medium, 8	*Bay*	*Harbour* International primary, mixed, large	*Harbour* (Yr 9) International secondary, mixed, large *Portsea* (Yrs 10–13) State secondary, single-sex, large, 10

Size: School size as determined by number of students: large (> 500), medium (250–500), small (<250)
Decile rating: In New Zealand, schools are rated according to socioeconomic status of a sample of students. A school's decile rating indicates the extent to which the school draws its students from low socio-economic communities. Decile 1 schools are the 10% of schools with the highest proportion of students from low socio-economic communities, whereas decile 10 schools are the 10% of schools with the lowest proportion of these students (http://www.minedu.govt.nz/index.cfm?layout = document&documentid = 7697&data = l)

Learning mathematics is most commonly associated with schools and classrooms, but it is also experienced at home and in other settings including after-school tutoring programmes. All of these locations were viewed as sites Foucault termed *surfaces of emergence* (Foucault 2002), that is, places where subjects are made in discourse. These sites were included in the study where possible. A schedule was devised to firstly meet and get to know the children and their families, and then to maintain regular but low-intrusive contact over the initial three years of the study.

Structured interviews with teachers took place at the beginning of each year of the study, yielding important information about the specific research children, as well as insights into the mathematical pedagogies of their classrooms. On subsequent visits, the teachers reported on the children's engagement with mathematics and their participation in school life in general. These conversations played a critical role in the construction of composite pictures of classrooms as discursive sites of productivity in the children's mathematics lives. Teachers were also able to provide updates on the children's progress, their placement for instruction, and records of the children's assessment in mathematics.

The support of school principals was critical to the study. Principals facilitated access and provided essential information about school-wide mathematics programmes, professional development for teachers, and data about the school composition, climate and overall mathematics achievement of the children. Where the children moved class or school, it was necessary to negotiate participation with principals and teachers who were new to the study. In every case this was accomplished without difficulty.

Detailed interviews with children and parents were held at the beginning of the first year of the study, and informal conversations conducted three times a year for the following three years to track the children's ongoing experiences with mathematics. Most discussions with parents took place in the children's homes. In meeting their families, I was better able to appreciate what it was that the children brought to their mathematical learning at school and how the parents – and occasionally other siblings or grandparents – viewed and supported the child's mathematical learning. These visits often included chatting over a cup of coffee, sharing meals or even staying overnight in one case where I had to travel a great distance to visit the child when the family moved city. As a genealogical approach, this closeness of contact helped me to appreciate the children's lives beyond school, and allowed me to keep abreast of change over time.

Interviews with the children took place within school settings, but in suitable spaces removed from the classrooms. These often turned out to be school staff rooms, libraries, medical rooms, unoccupied storage or small group teaching areas adjacent to the classroom, or even outside in the playground. It was important that the children felt sufficiently comfortable that they were able to talk freely about their lives and the place of mathematics within them, so our conversations were based around a flexible set of questions that acted as a rough guide rather than a fixed structure and often took unexpected turns in the flow of our talk. I tried various supplementary approaches to assist the children in expressing themselves as mathematical subjects. At the beginning of Years 3 and 4 the children were asked to draw themselves doing mathematics and to talk about their drawings. These drawings appear in Chap. 3. A simple survey sheet entitled "*How I Feel about Maths*"[4] (see Appendix) also proved to be a useful discussion tool, particularly the scale for children's self-ratings in response to questions about how they felt about mathematics and how good they thought they were at the subject. These methods provided a broad overview of the children's subjectivities as mathematical learners based on their self-reported confidence, their feelings about doing mathematics, and the connections between the two.

Information about the children's mathematical learning was also gathered through classroom observations. During mathematics teaching and learning sessions I sat among the children taking field notes of my observations of the lessons. I also made short video recordings of some classroom sessions, aiming for one per year from each classroom. These were useful starting points for my conversations with the teachers and children, because I could ask about the classroom practices I had observed. Additional evidence of the way children engaged in mathematical learning was gained from children's mathematics exercise books, worksheets, test papers and work displayed in the classroom, supporting and enhancing the children's accounts of their mathematics lives.

The children's classmates were keen to fill me in on how things worked in their classrooms. Their talk often centred around how much they personally liked or disliked mathematics and why, who else did or did not like it, who was good at mathematics in their class, and how they *knew* all this. Their unsolicited views were compelling indicators of mathematics classrooms as socialised, culturally defined and culturally defining political spaces productive of children as mathematical subjects.

At the time of renewed contact in Phase 2 (See Table 2.2), the children were nearing their 16th birthdays and those who had remained in New Zealand were approaching the end of Year 11, an important juncture in their schooling because they were soon to face their first external standardised national mathematics examinations for the NCEA.[5]

Table 2.2 The scope of the research by children's Year levels at school

Phase 1				Phase 2		
Year 3	Year 4	Year 5	Years 6–10	Year 11	Year 12	Year 13
Conversations with children parents, teachers and principals Classroom observations			No contact. Children and parents provided retrospective descriptions of these years	Conversations with children and parents Viewing of school reports, mathematics exercise and text books and test results, where offered		

[4]From Beesey and Davie (1991). *Level 2b, Children's Recording Book*, p. 3.

[5]NCEA – National Certificate of Educational Achievement. Children are able to accumulate points towards their certificate in a range of subjects. Some points are gained through internal school-based assessment and others through external examinations.

I visited the children and their families early in Year 12 after the examination results had been received, contacted them again late in Year 12, visited all except Fleur who was on a student exchange programme in Europe in mid Year 13, and made final contact late in Year 13 or after those who remained at school had received the results of their final national examinations. By this time all of the children had confirmed their occupational plans for life after school.

As their stories will reveal in the following chapters, it was within the situated discourse of social sites of production such as school, home and peer group interaction that the children were made as mathematical subjects. Within their experiences as both learners of mathematics and members of social networks, and in their recounting of them, the children as mathematical subjects were made visible. Their stories are representative of children's learning of mathematics in classrooms all over the world and remind us as parents, teachers and policy makers that learning mathematics is not a singular pathway of individual cognitive development, but a socially significant, complex, fraught process in which children are subjected and subjectified with profound implications for their life chances and choices. Subjectification of the kind that involves the "arbitrary and unnecessary authority" of which Foucault spoke, supported within regimes of truth and knowledge that justify its "domination effects," emerged as recurring and enduring themes in the children's speaking about their mathematics lives.

The stories are presented as interwoven biographical accounts, organised around unifying themes that emerged in their telling, supported by the self-storying of teachers and parents, and supplemented by my observations from the classroom. The "gray and meticulous detail" of years of data gathering is reflected in copious excerpts from interviews and observations. Interspersed with archival material that helps to peel back the everyday and familiar to reveal the discursive underlay of mathematical "doing of doings" the data speak compellingly of mathematical children in the making, illuminating commonplace practice in children's learning of mathematics, and revealing the processes by which confidence and competence, success and failure are structured in discourse.

Part 2

The Art of Being Mathematical: The Primary years

Chapter 3
Children at Work

Researcher: So what things do you usually do at maths time?
Jared: The teacher says, 'Go and get your maths books out.' And she writes stuff on the board for maths … Maths is heaps of work.

—Mid Year 4

Jared and the other children in this study came to read mathematics as it was generated in the regulation of its everyday practice. For these children, the "doing" of mathematics – its patterned daily enactment in temporal and physical space – was a potent site of social production. Eight-year-old Jared's response to my question (aforementioned) was typical of the children in this study. Jared recognised *maths* as a subject, knew what to do at *maths time*, and engaged in this process as a self-recognising/recognisable participant. He spoke of *doing maths* as a particular organisation of actions that distinguished maths from other school subjects and as ways of behaving that were predictable, their purpose and form naturalised in habit. Above all, he understood doing maths as a form of work, at the same time recognising himself as a mathematical worker.

From numerous classroom observations, conversations with children, teachers and parents, informal discussion with classmates, questionnaires, and examination of children's mathematics exercise books, a picture emerged of how learning mathematics was typically experienced by these children. The mathematics lesson was found to be a distinctively structured regular discursive act consisting of mutually recognisable markers that enabled teachers and children to distinguish doing maths from doing other things. The notable similarities across the schools and over many years suggested the existence of a tacitly binding set of discursive rules regulating the actions of teachers and children in the doing of mathematics.

Meeting the Mathematical Subjects

Evidence of these rules was found early in the study when I met the children for the first time. During our initial conversations at the beginning of Year 3 I provided the children with a blank page headed, "This is a picture of me during maths time."

F. Walls, *Mathematical Subjects: Children Talk About Their Mathematical Lives*,
DOI 10.1007/978-1-4419-0597-0_3, © Springer Science+Business Media, LLC 2009

I encouraged them to draw themselves in any way that best showed what they usually did during this part of the school day. As images of mathematical subjects, the drawings of these 7-year-olds were remarkable for the sense they conveyed about how the children recognised themselves as learners of mathematics (Figs. 3.1–3.10).

Eight of the children drew themselves seated at a desk or table, pencil in hand and their maths book or a worksheet in front of them. Jared's drawing is notable for its action and movement (see Fig. 3.1) and Peter's is faceless (see Fig. 3.2). Liam was the only child to draw himself actively engaged with others. Naming each person as he drew, he depicted himself with friends constructing a tower of wooden blocks (see Fig. 3.4). Dominic drew himself at a table with other children, but all working individually in their maths books (see Fig. 3.8). Toby drew other (childless) desks with worksheets to indicate the presence of classmates, but portrayed himself working alone (see Fig. 3.5).

Mitchell was the only child who did not distinguish maths in his drawing from the many other things he did at school. He drew himself skipping, the activity in which he had been engaged a short time before the conversation, and drawing, the school activity he said he most liked (Fig. 3.3). His depiction of himself drawing his own portrait shows a remarkable awareness of the self as a self-observing subject.

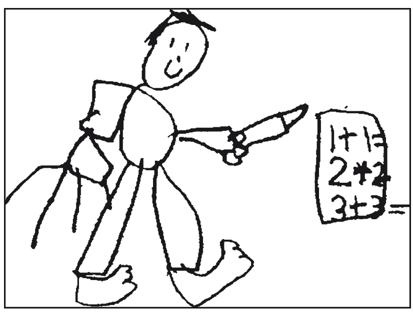


Fig. 3.1 Jared (Early Year 3)

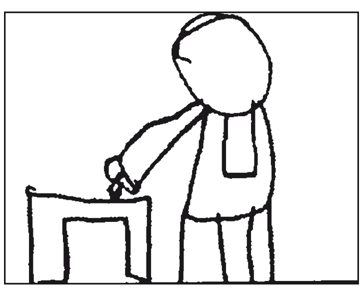


Fig. 3.2 Peter (Early Year 3)

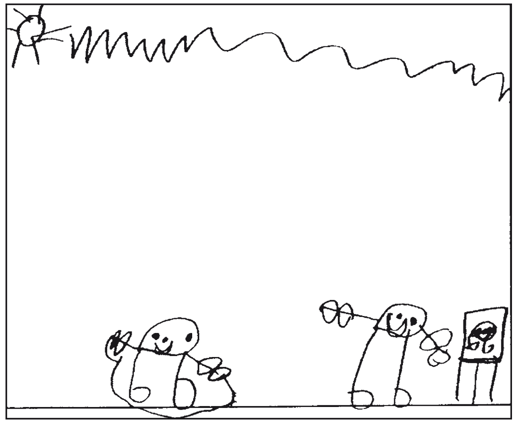


Fig. 3.3 Mitchell (Early Year 3)

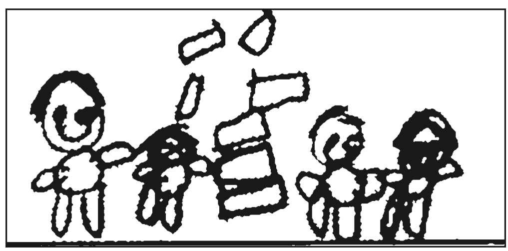


Fig. 3.4 Liam (Early Year 3)

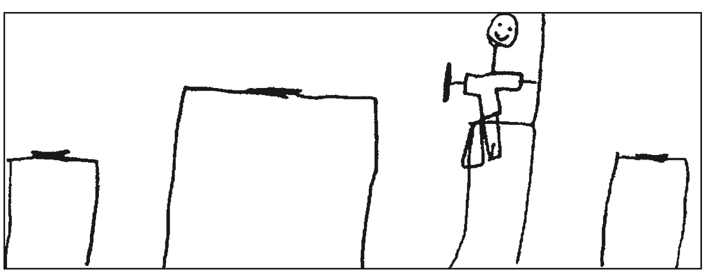


Fig. 3.5 Toby (Early Year 3)

Fig. 3.6 Rochelle (Early Year 3)

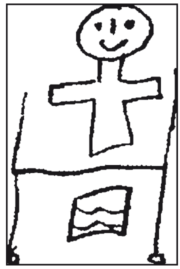
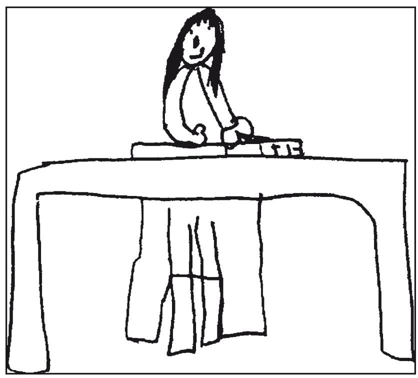


Fig. 3.7 Georgina (Early Year 3)



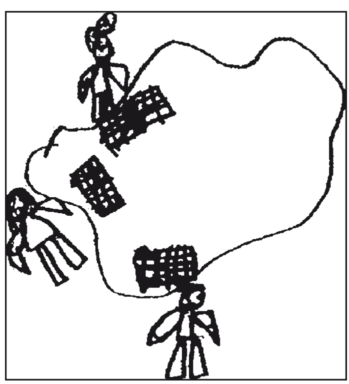


Fig. 3.8 Dominic (Early Year 3)

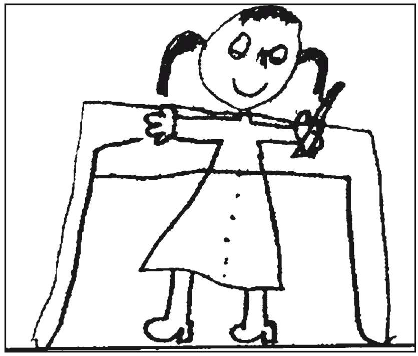


Fig. 3.9 Fleur (Early Year 3)

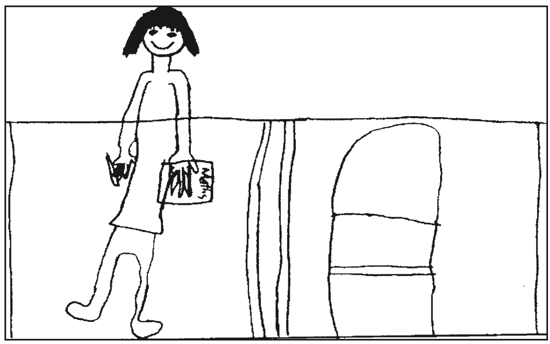


Fig. 3.10 Jessica (Early Year 3)

The children were encouraged to talk about their drawings.

Toby: This is the table and that on there is the worksheet (see Fig. 3.8). (Early Year 3)
Researcher: And what's that you have just drawn (see Fig. 3.9)?
Rochelle: It's my desk.
Researcher: So what's this here?
Rochelle: Book.
Researcher: Is that your maths book? (*Rochelle nods*) (Early Year 3)

At the beginning of Year 4, the children were again asked to draw themselves during maths time (Figs. 3.11–3.20). This time Mitchell talked about what happened at maths time and identified maths as a distinctly recognisable subject:

Researcher: How could you show me that you're doing maths on your picture?
Mitchell: I've got a desk.
Researcher: (*Pointing to an object on his drawing*) And what's that?
Mitchell: My maths book.
Researcher: And it's got a tick on it, has it?
Mitchell: No, it's a 'seven' (see Fig. 3.11). (Early Year 4)

Fig. 3.11 Mitchell (Early Year 4)

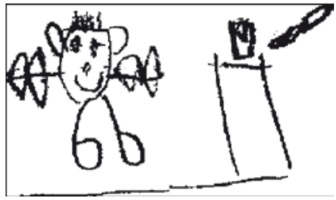


Fig. 3.12 Peter (Early Year 4)

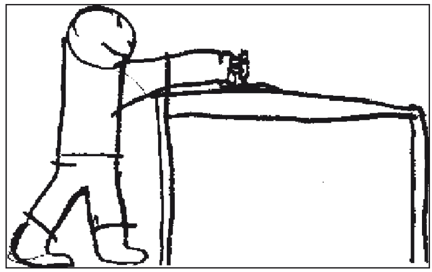


Fig. 3.13 Dominic (Early Year 4)

Fig. 3.14 Liam (Early Year 4)

Fig. 3.15 Fleur (Early Year 4)

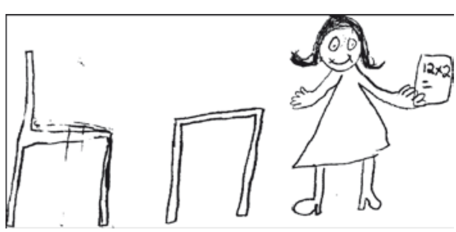


Fig. 3.16 Rochelle (Early Year 4)

Fig. 3.17 Jared (Early Year 4)

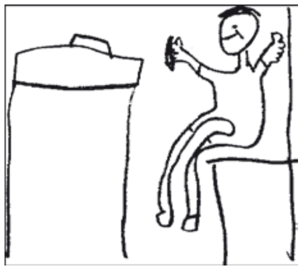


Fig. 3.18 Toby (Early Year 4)

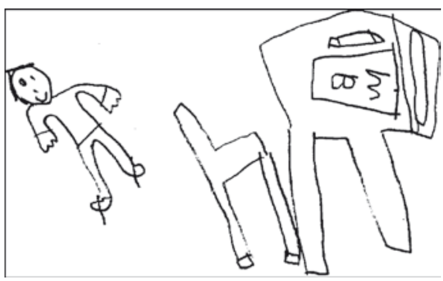


Fig. 3.19 Georgina (Early Year 4)

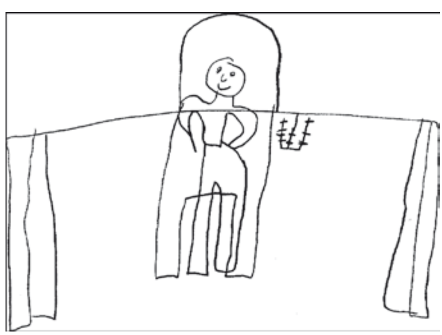
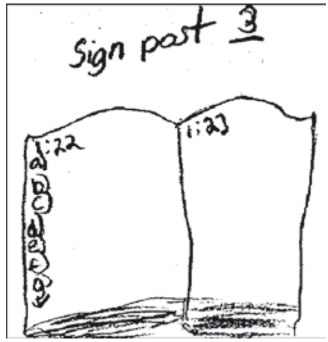


Fig. 3.20 Jessica (Early Year 4)



As 8-year-olds, 9 of the 10 children drew themselves engaged in a writing task. Georgina drew herself with a 3-bar abacus on her desk – something that did not usually happen at maths time (see Fig. 3.19). Earlier in the interview she had described using the abacus as one of the few mathematics activities she had really enjoyed, so the abacus was added to her drawing to explain the smile she had drawn on her face, as the following conversation shows:

> Researcher: Here's a place for drawing a picture of yourself during maths time. So what would you usually do?
> Georgina: Shall I draw a table [desk]?
> Researcher: Yes. (*After Georgina has drawn herself with a big smile*) You're looking pretty happy. (*She has earlier rated herself at only 1.5 out of 10 on the self-rating scale for how happy she feels at maths time*)
> Georgina: I'll put the abacus.
> Researcher: So what things do you usually do in maths time?
> Georgina: Get out our maths books and do our maths. (Early Year 4)

Jessica was not keen to draw herself, so drew her mathematics exercise book instead (see Fig. 3.20).

> Jessica: Do I have to do it of me? Can I just do it of my maths book?
> Researcher: It's hard drawing you is it? (*Jessica nods*) How would you want to draw yourself if you could? How would you imagine yourself? What would you be doing with the maths book?
> Jessica: Um, well, what I could do is I could do us standing looking at the maths book and then you could see a little bit of the writing.
> Researcher: Sounds great. Away you go.
> Jessica: Then it would be the one we work out of … (*Draws her mathematics exercise book opened at a page of exercises*)
> Researcher: What's the book called?
> Jessica: We usually put the label "Signpost 1", "Signpost 2."

Researcher: Which one would you usually use?
Jessica: “Signpost 3.” (*Writes this above the drawing of her exercise book*) (Early Year 4)

Liam’s Year 3 and Year 4 pictures differ markedly. When Liam moved on to Years 4 and 5, mathematics exercise books were introduced and used almost daily, while peer collaboration and the use of equipment became increasingly less frequent. Overall, there was an overwhelming prevalence in the children’s representations of themselves as mathematical subjects “doing maths” as solitary deskwork, with an emphasis on written number tasks, such as completing equations. This distinctive feature of their drawings indicated that individual written work was repeatedly experienced by the children at maths time, and what they most identified as “doing maths.”

The Shape of “Doing Maths”

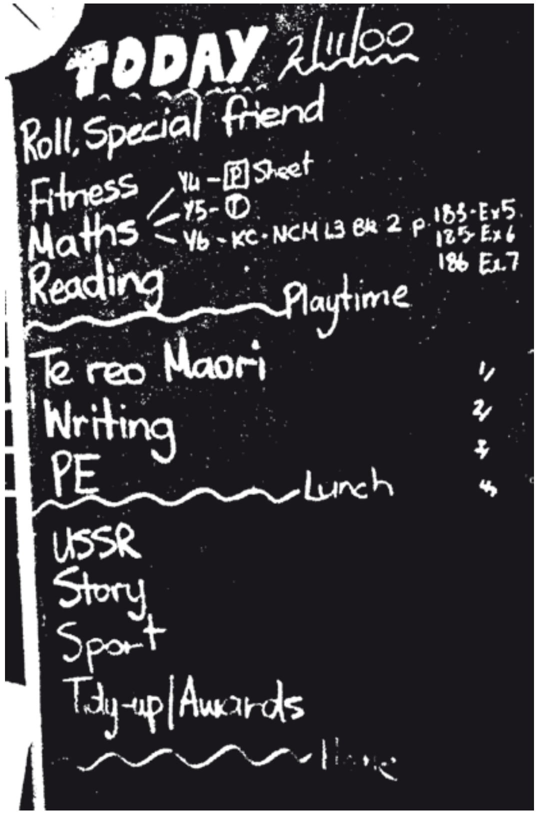
Mathematics lessons were found to be a daily occurrence in the majority of the research classrooms. In only one of the 32 classrooms visited was mathematics taught on 4 days of the week rather than 5. “Maths time” usually occupied between 40 and 60 min of the daily programme and was without exception, a morning activity. In the majority of the classrooms, mathematics was taught before morning interval, usually between 9:30 and 10:30 AM. In four classrooms, mathematics was taught just after morning interval, and in two it was scheduled just before lunchtime. The regularity of mathematics teaching, the proportion of teaching time it received, and its morning placement, believed by teachers to be the time of day when most learning is likely to occur while the children’s minds are “fresh,” indicated that mathematics was highly valued as a school subject.

“Maths” often appeared in the daily programme written on the board at the front of the classroom, as shown in the photograph in Fig. 3.21. This particular timetable specified each year group task, P meaning “practice,” T meaning a session with the teacher, and KC meaning “keeping clever.” Apart from Y5 (Year 5) who were to work with the teacher for part of the time, the other children in the class were to be engaged for most of this mathematics lesson in individual writing tasks using worksheets or the textbook. In no other subjects on this timetable did such task specificity appear.

The shape of the daily lesson engaged child and teacher in a performance. As Lemke (1990) noted, “A lesson is a social activity. It has a pattern of organization, a structure. Events follow one another in a more or less definite order. It has a start and a finish. But like all other kinds of social activities, it is made. It is a human social construction” (p. 2). It was within this discursive construction that children and teacher became visible as subjects.

The following extract in which Ms Fell described a typical mathematics lesson in her classroom illustrates the place of written work in her daily programme.

Fig. 3.21 Timetable on the blackboard, Motu School (Late Year 5)



> Ms Fell: I'll bring everyone down on the mat and we'll talk about what we're doing that day. If it's something new, quite often we won't be doing anything in our books, we'll be talking about a lot of things, get in a circle, and you know, talk, and then send people off for ten or fifteen minutes to do some work in their books so I can get around and work with people individually … We've just purchased halfway through last year, that AWS[1] series of books where there's one for every strand and they've been excellent…we've been able to photocopy off class sets. (*Pukeiti School, Mid Year 4*)

Working in books featured strongly in her description – "we won't be doing anything in our books," and sending people off "to do some work in their books" – suggesting that book work was the activity that most anchored her daily practice in the real business of doing mathematics.

Although each classroom operated within its own particular *regime of truth* enacted in the established routines of doing maths, which legitimised and sanctioned

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[1] AWS: Stark (1997–2000) author of mathematics worksheets and teacher guides.

the discursive space for certain practices and social arrangements (Walshaw 2007, p. 121), there was a commonality in children’s descriptions of what usually happened at maths time. Mathematics appeared as a subject whose temporal space in schooling was positioned and controlled in a regime of practice that normalised its “doing.” Working in their books featured prominently suggesting that wider discursive regimes were at work in shaping the actions of teachers and children in mathematics classrooms.

> Rochelle: A group goes on the mat. Then the group that was on the mat does the group sheet. (Late Year 3)
> Liam: We do sheets and we work with Miss Peake. (Early Year 3)
> Jared: Write stuff. (Mid Year 3)
> Georgina: We get into our groups and do the worksheet. (Mid Year 4)
> Jared: Work. Yep, working in our maths books. (Early Year 4)
> Peter: Just do worksheets … finishing all the worksheets and sticking it into your book. (Late Year 4)

> Mitchell: We go back to our desks.
> Researcher: Do you do work in your books or does she give you a sheet or…?
> Mitchell: In the maths book.
> Researcher: Does she write stuff up on the board?
> Mitchell: Hm.
> Researcher: So at maths time it’s usually writing? (*Mitchell nods*) (Late Year 4)

> Toby: We mostly turn to the front of our book and do proper maths. Mrs Kyle gets the questions out of a book, and we have to get the answers.
> Researcher: How does maths time finish?
> Toby: It just finishes after we’ve done our proper maths, like you put your maths books away and sit on the mat. (Mid Year 4)

> Jessica: It would usually be out of a textbook and once we’ve finished that we would do a sheet. (Late Year 5)

> Dominic: Then we do NCM. Do you know what that is?
> Researcher: Yes, one of those textbooks.
> Dominic: Yeah, or “Figure it Outs”. (Late Year 5)

> Fleur: We go into our book. Our green or red books. [NCM textbooks[2]] (Mid Year 5)

> Mitchell: You have to sit down and do some times tables or pluses or take away. (Late Year 5)

It was found that a significant proportion of the typical mathematics lesson was spent on written tasks. As evidenced by their drawings and descriptions, doing “proper” maths as Toby called it became established in the children’s minds as the written recording of answers to questions and that from Year 3 onwards “doing maths” became increasingly established as some kind of individual written task referred to as *work*.

[2] NCM: *National Curriculum Mathematics* series (Tipler and Catley from 1998 onwards).

Doing maths or *doing work* were expressions used to signal a particular practice. They were not used by the children when referring to other kinds of mathematical learning such as using concrete materials or participating in discussions on the mat with the teacher. Table 3.1 plots the frequency of the kinds of activities the children reported experiencing at maths time. It shows the use of concrete materials diminishing from Year 3 onwards. By Year 5 written work from textbooks and worksheets had become an entrenched mode of operation in the mathematics classroom. Doing maths, it seemed, was as much about grooming children as particular kinds of workers as it was about learning mathematics itself.

Table 3.1 Frequency and type of mathematics “work” experienced by the children

	Year 3	Year 4	Year 5
Fleur	F 🕮●■🗎 S■	D ■ F 🗎 *AWS*	D 🕮 *NCM*
Georgina	F 🗎●■ S ●	F 🗎 S ●	F 🕮 NCM 🗎
Jessica	F 🕮 *SM2*[a] S 🗎	F 🗎 🕮 *Signpost* S	D 🕮 *NCM* or 🗎 *AWS*
Rochelle	F 🗎	D work cards ■ 🕮 *SM3*	D computation cards F 🕮 *FIO*
Dominic	F 🗎	F ■ 🗎 S ●	F 🕮 *FIO* and *NCM*
Jared	D 🗎 S ●	D *Wellsford Maths*[b] S *SM*	D 🗎 *Wellsford Maths* S ● ■ 🕮 *SM3*
Liam	D *BSM* Group Box[c] and from “maths shelves”	F	F ■ S 🕮 *FIO*
Mitchell	D 🗎*BSM* Group Box S	F ■ 🗎 S 🗎 teacher-designed tasks	D F 🕮 *NCM*. S Mitchell allowed to use counters
Peter	F teacher- designed written tasks ●	F 🗎 S 🕮 *SM*	F ■ 🗎
Toby	F 🗎●	F 🗎 ■	D 🗎 *Longman Maths*

D daily, *F* Frequently, *S* sometimes
🕮 = Textbook; 🗎 = worksheet; ■= exercises from the board; = ●using concrete materials
[a] School Mathematics a series of Department of Education (1983) teacher resources
[b] Wellsford Maths Programme (Pinada Publications, 1996 onwards)
[c] The BSM (Beginning School Mathematics) Group Box is a collection of activities, stored in a box labeled with a group name, and designed for the children belonging to that group to use independently

Working to Rule: Setting Out and Doing Exercises

In the majority of the research classrooms, as the children's drawings suggested, doing maths was made most visible in the children's engagement with the mathematics exercise book or *maths book* as it was familiarly termed – an artefact that made the doing of mathematics discursive and material at the same time. When their teachers announced maths time the children read this as the cue for taking out their mathematics exercise books. These exercise books differed from those of every other subject. Dominic's Year 3 picture of doing maths (see Fig. 3.10) provides a view of mathematics exercise books in use, in his careful depiction of their grid paper pages. In Year 3, 1H5 exercise books with 9-mm squares were being used in all the research classrooms. In Years 4 and 5, these were replaced by 1E5 exercise books with smaller 7-mm squares, requiring finer writing.

The word *exercise*, as associated with the children's mathematics workbooks and the examples they were expected to complete, hints at the pedagogic history of teaching in general and teaching mathematics in particular, where children are shown specific procedures that they replicate in a series of similar examples known as exercises, until the skill is thoroughly mastered, much as an athlete or musician undertakes exercises to prepare for real performances. This model of learning assumes that it is through the assiduous repetition of discrete, decontextualised actions that knowledge/skills become fixed and children are properly prepared for doing "real" mathematics at some time in the future.

Teachers devoted much effort in training children in the correct use of mathematics exercise books, their setting out and neatness in particular.

> Mr Loch: (S*peaking of Jessica*) She's one of the children who seems to have been able to make that transition from juniors to Standard 1.[3] It's a big step, and they have to start writing in books and setting out to a certain, [standard] you know, date and page number, number with answers, those sorts of things and she seems to be able to do that. But she can be a little untidy at times. (Early Year 3)

> Ms Sierra: (*When asked how children find the transition from Years 3 to 4*) Quite hard at the beginning but slowly getting there. Sitting with a book and a pen, using a ruler, something new to them, sitting down and ruling a book. (Early Year 4)

> Ms Fell: (*Commenting on the children's current skills*) With BSM they don't know how to set things out, they have not added vertically. (Late Year 4)

For teachers, book work could be used as a gauge of children's maturation. Children were made as mathematical subjects in rituals of this symbolic work. As they

[3]The term *Standard 1* was formerly used for Year 3 of primary school.

shifted from the "play" of junior primary school to the "work" of middle primary school, children were schooled in normalising worker behaviours – sitting at desks and writing in their mathematics exercise books – that marked them as learners of mathematics. Thus schooled they could be recognised, compared, judged and remedied as mathematical workers.

In the majority of the classrooms visited, the teachers spent considerable time in training the children to set out their work in their mathematics books in a precise, standardised format as observed in Jessica's classroom:

> Ms Tyde: (*To children who have been told to take out their maths books*) Quickly, quickly, quickly. (*Begins demonstrating setting out on the board*) Now, we have our side margin, and our middle margin, then we underline our day's work. We put the short date, underline it and put the name and number of the book you're working from … I'm coming around to check that everyone has nicely ruled up, neat books … We have some very snappy-looking maths books here. Well done. I've told you a million times, mathematicians are neat and orderly. (Late Year 5)

Neatness and orderliness are not necessarily traits of a mathematician, yet these were explicitly linked in Ms Tyde's justification for her stringent expectations. Children experienced difficulties with these methods, as Georgina explained.

> Researcher: Do they do maths differently here?
>
> Georgina: Yeah, sorta. 'Cause like they set up their books differently.
>
> Researcher: All right. Can you show me? (*Georgina opens her maths book*)
>
> Georgina: They set it up like this, (*points to ruled margin down the left side and down the centre of the page*, Fig. 3.22) like that, and at my old school … We just, like, put a rule down there (*points to the margin on left side only*) (Early Year 5)

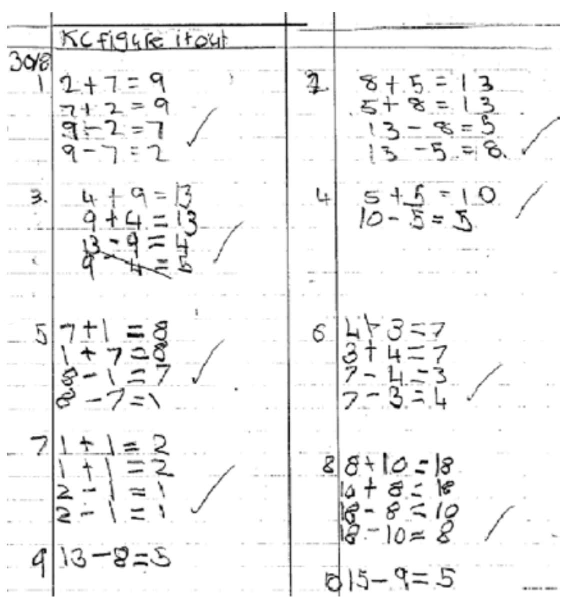

Fig. 3.22 A page of Georgina's mathematics exercise book (Mid Year 5)

The teachers were frequently observed to reinforce the rules of setting out and neatness during mathematics sessions, as shown by the following examples:

> Mr. Loch: (*Handing out the children's exercise books*) I took your books in yesterday. Some of you are doing a really good job of setting out. You got a stamp if your work was good. (*Jessica's book has "Neat work" written in it and she has been given a stamp*) … I want the numbers to be clear, and you have to put up the number of the [text] book… (*To a boy as he looks at his work*) The only problem is setting out neatly… (*To another child)* This is too crowded when I mark it … (*To another child who has brought his work to be marked)* … I don't want to look at this book, it just makes me feel ill! You won't get a stamp … (*To another child*) That's better. I like that setting out … (*Erasing a child's work*) Start again! (Jessica's classroom, early Year 3)

> Mrs. Ponting: Remember how to do it boys? Nice and neat! … You can borrow my ruler, 'cause I like rulers in books … Beautiful work girls – must be all those vegetables you've been eating. (Rochelle's classroom, mid Year 4)

> Ms Fell: (*Roving and checking on children's work. To one child*) I can see a book that's not ruled up. (*To another*) That's not how we set out our books, is it? Rub it out. (Fleur's classroom, mid Year 4)

Specific modes of setting out in mathematics exercise books can be traced back many decades. In a New Zealand Department of Education publication (Duncan 1959) for example, it was stressed that, "children should be required to set out their work neatly" (p. 12). In the performance of mathematics as a particular kind of work requiring specified tools, precise execution of standardised layout and neatness of handwriting, the children were made as mathematical subjects. "Untidy" workers attracted teacher criticism both publicly through comments in class and privately via written feedback in their books. For some children, such standards were difficult to achieve.

> (*Toby was leafing through his maths book explaining the maths work he had done. Two of his classmates were looking on. Toby came to a page where Ms Firth had written beside an exercise*, '*Very neat*'. *Toby and his friends discussed this activity*.)

> Toby: This was really hard [an exercise in copying numbers].

> Marshall: Yeah, she told us she would rip our page out if it wasn't neat enough.

> Researcher: Did anyone get their pages ripped out?

> Pita: No, not that time but three people did in spelling, and this boy, he had his page ripped out two times! (Mid Year 3)

> Georgina: When I first got my book, I did it really neatly and Mr Solomon wrote, 'A really good effort but: 1. Get it marked. 2. Stick your sheet in, and 3'… what was the other thing? … oh yes … 'Needs to be underlined'. And Mum said, 'He's a dickhead,' because I did it really neatly. (Late Year 3)

Children's subjection to teachers' insistence on setting out and neatness was evident in these accounts from the expressions of anxiety and feelings of injustice when attempts to comply were judged to be lacking by their teachers. So strong was Georgina's indignation that she had scribbled over a later teacher comment in her Year 3 mathematics exercise book that read, "Only one number in each square!" Similar comments were found in other children's books.

Mrs Waverley: (*In Peter's maths book*) 'Getting hard to read, Peter'. (*Later*) 'Some lovely work, Peter, thank you – Mrs Waverley.' (Year 4)

Mrs Meadows: (*In Fleur's maths book*) 'Try to keep your work neater.' (Early Year 5)

Mrs Isles: (*In Georgina's book*) 'Please rule your book up correctly – page number!'

Ms Torrance: (*During a mathematics lesson*) Good ruling, Dominic! (Early Year 3)

Most of the children's discussions about their work concerned the form rather than substance of mathematics. This was unsurprising since the greater part of teachers' feedback was focused on presentation. In the classrooms observed, written mathematics tasks usually required children to produce answers without any accompanying justification. Comments referring to the mathematical understanding of the tasks were not mentioned by the children when they described teachers' feedback and difficult to find in their books. "Good thinking!" was seen in one child's book and was heard twice in teachers' interactions with children. In none of these instances did the teacher explain why the thinking was "good." Teachers' privileging of neatness and setting out over thinking mathematically was constituted in the general discourse of teaching young children at primary school – children were to be trained in the arts of the worker.

Completing Tasks

Teachers often cited the ability to work neatly in mathematics books, work quickly, and complete set written mathematics tasks within the specified times, as indicators of the children's overall progress in mathematics.

Mr Loch: I'm finding it's taking time for some kids to settle into a routine. I've inherited some problems I think from other years. Standards haven't been set and kids just don't complete work and they're not used to actually getting through something. Finishing it off. That's something I'm very tough on. I like things to be completed. (Early Year 3)

Completion featured highly when they discussed children's progress in mathematics, in teachers' reporting to parents and in their interactions with the children during mathematics time:

Ms Summers: (*Talking of Peter*) He's quite meticulous about the work he produces, he's quite methodical and I think he settles to a task quite quickly, he doesn't have to be encouraged, and he works consistently to complete a task. (Early Year 3)

Ms Summers: He's methodical, and he's always perhaps a little slow to complete. (Late Year 3)

Mr Solomon: Georgina, I had to separate out from the others, for about four or five weeks I think it was. I gave her a desk over there by herself. (*Points to corner of classroom*) She was just far too distracted and didn't finish or get on with her work. (Mid Year 3)

Mrs Joiner: (*Writing about Rochelle*) She is showing enjoyment with her maths and reading work and she is making excellent progress in these two areas and needs only a few reminders to complete set tasks. (from progress report for parents – Early Year 3)

Ms Summers: (*To Peter*) You've finished! Doesn't it feel good when you've done it? (Late Year 3)

Mrs Kyle: How many finished? (*Looking around at the show of hands*) Most of you didn't finish. You must learn to put 'DNF' – did not finish – at the bottom. (Early Year 4)

Ms Torrance: We have some amazing speedsters who have got on their rollerblades and got their two sheets done already. (Early Year 3)

Because the physical skills required for writing by hand vary greatly in young children, the expectation that all children produce work in their mathematics exercise books to the same standards within identical timeframes could be seen to be a managerial technique that privileged some and disadvantaged others. Work rates became a measure by which children could compare and judge themselves, often heard in their interactions during their lessons as this example shows:

Jessica: (*To Angela, sitting beside her*) I'm up to 10. What are you up to? (Early Year 3)

Teachers expected children's work output to increase year by year, as Jessica noted.

Jessica: We get harder work [this year]. We've got to get it done. (Early Year 4)

Working Solo

When the children talked about whether they preferred to work alone or with others, their responses indicated that they considered doing mathematics as something that should be done alone if possible, unless help was needed in answering questions. It seemed that talking with others was actively discouraged by their teachers.

Mitchell: By myself. Because it's fun by myself. (Late Year 4)

Peter: By myself. Because they're more noisy. (Early Year 5)

Liam: By myself, unless it's hard, then someone can help me. (Early Year 5)

Dominic: Probably with someone else, so they can help me. But that's only sometimes that I need to ask someone for help. (Late Year 5)

Fleur: Well I don't really cooperate that good. When it's something hard, I like doing it with someone who knows how to do it. If someone's, like, really poor at it, and I know I'm really poor at it, well I don't want to do that, I want someone who knows what they're doing, or if they've just got a tiny bit of an idea. (Mid Year 5)

Georgina: With other people. 'Cause when I work by myself I get really bored. 'Cause I don't really get it, like what … I ask them the question. (Mid Year 5)

Jessica: I like doing it with, um, someone else. Just one person … I don't really like working in groups.

Researcher: Are you usually allowed to work with someone else?

Jessica: No. We mostly have to do it by ourselves. (Late Year 5)

Rochelle: With other people. Every time I don't know the answer, I just ask them. (Early Year 5)

Jared: With someone else, ’cause if I get one wrong, they might know it. (Early Year 5)

Researcher: Do you like maths best when you’re talking about it or writing about it?

Toby: Talking about it.

Researcher: Are you allowed to talk about it when you’re working?

Toby: I’m not sure.

Researcher: Does Mrs Kyle say, ‘I’d like you to talk about the maths while you’re doing it?’

Toby: No, she doesn’t say that. Sometimes she says, ‘People can’t get on with their work so ten minutes’ silence.’ That’s when you *never* get to talk. (Mid Year 4)

The teachers talked of independence as a “work habit” they valued highly in children’s behaviour generally, and particularly at maths time. The expectation that children take responsibility for their own learning is described by Hattie (2008) as a grammar of schooling.

Mrs Joiner: Rochelle is developing good independent work habits (from progress report for parents, Early Year 3)

Ms Torrance: *(Talking of Dominic)* He’s getting work habits that are really … the standard’s really high. (Late Year 3)

Ms Summers: I think Peter’s very focused, a very focused learner and he’s able to work independently. (Early Year 3)

Mrs Ponting: I’m using this new resource – “*Figure it Out*.” It’s great because it gets them doing work for themselves. (Late Year 4)

By “independence” teachers meant the ability to sit alone in silence, concentrating on the prescribed task, asking few questions, and completing work within the time allotted. Chatting with classmates was viewed as being “off task,” and teachers expressed the belief that talk during mathematics time would distract others or prevent them from thinking, as their comments on the children’s progress illustrate.

Ms Torrance: He’s [Dominic] quite happy to talk about [mathematics] and he enjoys the hands-on, but the recording thing much less so. I think he would prefer working in a group, but he can work well on his own. I would prefer him to work on his own. Independent tasks, he’s not the best; he’s very chatty. (Mid Year 3)

Mrs Ponting: She [Rochelle] works better sitting away from her little friends. She’s got it in her but lets others do the thinking for her. (Late Year 4)

Mr Cove: He [Toby] sits in that corner over there with three other boys. Let’s say I have to have my eyes on that corner because they’re very sociable. (Mid Year 5)

Toby’s mother: The only problem I hear [from the teacher] is sometimes he chats a bit with his mates. (Late Year 3)

Classroom observations showed that talking while working on their mathematics tasks was often actively discouraged by the teachers.

Mrs Ponting: Excuse me! (*To two boys who are sharing one textbook because there are not enough to go around, and whose ‘talk’ has been observed by the researcher to be entirely involved in the mathematics of the task, with extremely effective exchange of ideas to clarify and reach solutions to the questions*) What are you two boys doing together? I want to

> know what you can do on your own! (*To another child*) Here's another boy who didn't do his own thinking and copied off his neighbour. (Mid Year 4)
>
> Ms Sierra: You're supposed to do your own work, OK? … I don't want you talking, I want you to concentrate. (*Later*) (*To the group who have been sent to work independently*) You are getting too loud. Well done to you people who are sitting at your desks doing your work. (Mid Year 4)
>
> Ms Fell: If you're busy chatting, you can't be working. (Mid Year 4)
>
> Mrs Waverley: Do your own, please. It's your brain. (Late Year 4)

The sign on the Keeping Skilful Box in Rochelle's classroom (Fig. 3.23) provided a direct message about the rules of engagement (silence and neatness) in the mathematics classroom. Taking up the discourse of independence as their own, children were sometimes observed to object to sharing with others, interpreting this as "cheating."

> Joel: (*Angrily, to Liam whom he suspects of looking at his worksheet*) Don't copy off me, you cheater!

This unwillingness to share (or be exposed) sometimes extended to children's shielding of their written work with their free arm.

Although children were usually grouped for mathematics, the purpose of the groups appeared not to be to enable children to work collaboratively; rather it was to allow for the teaching of homogeneous ability groups who were set to work on common tasks but as "independent" individuals. Children's working together at maths time was not an everyday feature of most of the classrooms.

Fig. 3.23 The sign on the Keeping Skilful Box, Bridge School (Mid Year 5)

Working to the Text

The use of textbooks was encountered by all of the children in the study. Introduced into some of the classrooms as early as Year 3, they had become a regular feature of eight of the ten classrooms by Year 5, often used for children in a particular group to practise a skill they had been learning. At other times the teacher would direct the whole class to work from a page in the book, as the following example shows:

> Ms Tyde: (*After she has demonstrated a place value concept on the board*) Turn to page one hundred and seventy-one, and you can do these in your books this time. Have a look at the numbers in the book. (Late Year 5)

Teachers explained the place of these specialised texts in their daily enactments of doing mathematics.

> Mr Cove: (*Explaining what he would do after he had taught the children a new concept*) Then maybe they would have understood it and I would be able to say, 'If you get that book out, on page 21 there's the next part of what we did yesterday', and they'd be able to do it. Then I'd try to find another book or some more sheets for children who needed some extra pushing, or maybe some children who were having trouble. (Mid Year 5)

> Mrs Ponting: I quite like the old *MSMs*[4] for pages for practice, mm, and quite a few worksheets. (Early Year 4)

> Mr Waters: They love using the books [textbooks], you know, those old books I would have used at school. It does sort of trick them into learning maths and then you give them a book and they think now they're actually doing some maths. (Early Year 5)

While most teachers justified the use of textbooks as providing reinforcement of new concepts, Mr Waters showed that the use of the textbook was an iconic practice carried across generations; textbooks signalled to the children that such work was "actually doing maths." Teacher and children alike were captured in this "trick" as mathematical subjects.

The following classroom scenes from Jessica's Year 3 class, Rochelle's Year 4 class and Fleur's Year 5 class, illustrate the different ways in which textbooks were used and the questionable effectiveness of textbook work in children's learning of mathematics.

Jessica's Classroom: "School Mathematics 2": A Group Activity

From video recording, Lake School, Mid Year 3

> *Jessica's group is working on the concept of multiplication on the mat with the teacher. Jessica is working with a partner placing plastic counters into circles drawn on small chalkboards. Mr Loch asks the children to write the 'adding' sentence to match the arrangement of counters in the circles, then the 'times' sentence. At first he records these on the board then asks the children to write on pieces of paper. Jessica's partner does the writing. Mr Loch hands out copies of the School Mathematics 2 textbook and asks children to turn to page 74. He then asks them to turn to the next page in their maths books. He checks that they have ruled off after their last work, and gets them to write SM2 and the date at the top of the next section of work. The children then return to their tables. They have to sit in the same place each day. It would seem that moving around is not encouraged as their places at the table are marked with stick-on name tags. The first examples from page 74 of School Mathematics 2, match the activity that the children were doing on the mat. Jessica quickly completes the addition, then the multiplication sentences that match the pictures of bottle tops in circles in the book. (Questions 1 – 10) From question 11 onwards, the pictures change. Groups of coloured blocks are shown on a number track. Jessica is clearly confused and unable to continue. She looks at the work of Angela, the girl opposite, who is writing quickly, now up to number 15. Jessica then looks at the book of Charles beside her, who has also reached number 11. Harry on the other side has figured out how to continue and is*

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[4] *Modern School Mathematics*: Department of Education (1983).

working busily. Jessica, still unsure of how to proceed, marks time by writing the question numbers 11 to 17 down the page. She looks around once more, then places circles around all the question numbers. Still uncertain, she records the questions themselves beside each number, but leaves out the answers. She looks once more at the others' work.

Jessica: (*To girl opposite*) Angela, can you do that? (*Indicates the picture of the blocks*)

Angela: Yeah, it's *easy*. I'm up to there. (*Points to question 18 in the book and goes back to her work*).

Jessica reads the instructions in the book, frowns, mutters to herself, looks around, plays with her eraser drops the eraser on the floor and picks it up, talks briefly to Charles next to her, looks at her book once more. Jessica has been stuck now for 15 minutes. Arlo who has been working alone at another desk comes over to tell Harry that he has finished. By this time, Harry has almost finished as well, although Charles is also stuck at the same place as Jessica and losing focus. At no stage does Jessica directly ask for help from other group members or the teacher. Helping one another does not appear to be either encouraged by the teacher or practised by the children. Mr Loch, who has been working with Group 2 on the mat during all of this time, does not ask Group 1 how they are getting on, or come to check their work. Jessica has become restless and appears bored.

Mr Loch: OK, I want Group 1 to pack up now please. (*Jessica looks relieved and quickly closes her books*)

In this instance, Jessica's teacher appeared to be using the textbook as a managerial device, enabling him to concentrate on teaching another group. Not all the children could understand the textbook task or follow the written instructions. It may have been more productive for the group to continue their exploration of multiplication using the chalkboards and counters, recording their addition and multiplication sentences on paper for later discussion or display. Instead, their work, or lack of it, remained concealed inside their books.

Rochelle's Classroom: "Figure It Out": A Whole Class Activity

From field notes, Bridge School, Late Year 4

10.00 AM. *The children have finished the daily starter activities of Quick 20 and individual computation cards. Mrs Ponting now asks the whole class to take out their "Figure it Out" Level 2–3 Algebra textbooks, and get on with page 6. This page is entitled "Fair and Square." There are 5 different sequential coloured tile patterns drawn in boxes on the page, with questions based on the relationships between the coloured squares. There are five questions on the page. Mrs Ponting does not introduce or discuss the ideas.*

Mrs Ponting: Those clever ones, when you've finished page six you can go on to page seven.

Rochelle is up to number 3 on page 6. She has solved numbers one and two by drawing pictures. She now stares at the book, frowning. Number 3 involves a pattern of blue and pink square tiles orientated with their corners pointing to the top and bottom of the page. Three elements of the pattern have been drawn, and underneath it says: 1 blue square, 2 pink squares; 2 blue squares, 3 pink squares; 3 blue squares, 4 pink squares. If there are 21 pink squares, how many blue squares?

10.10 AM:

Rochelle is still puzzling over number 3. Emily beside her has now almost finished, and shields her book from Rochelle with her arm. The teacher has been helping a group on the other side of the room, with a commentary that can be heard around the class, for example:

Mrs Ponting: (*To a boy*) Excuse me! You're not even thinking to make a stunning error like that.

10.20 AM:

Rochelle: (*Looks at Emily*) Emily, would you show me how to do it? (*Emily briefly uncovers her book so that Rochelle can see it, but says nothing. Rochelle now draws some squares like Emily's. She then rubs them out*)

10.25 AM:

Mrs Ponting: (*Roving around to see how children are progressing*) Right Rochelle, how are you going?

Rochelle: (*In a whisper*) I can't draw diamonds.

Mrs Ponting: You haven't got enough room? Never mind. Have a go at that one (*Points to number 4. Loudly to the class*) Well, some people have finished that page. Rory, wake up!

10.26 AM:

Researcher asks Rochelle if the class has any coloured squares blocks, pointing to the top of the page where it says: 'You need: – Square tiles'. She says they don't. At researcher's suggestion, Rochelle rotates her maths book so the squares on the page now look like 'diamonds.' She can only draw 13 pinks/12 blues across the page. Researcher asks Rochelle how many blues she thinks there would be if she could keep drawing until there were 21 pinks.

Rochelle: Twenty!

10.30 AM:

Mrs Ponting: Right everyone, put your books away now would you? It's playtime.

Without the researcher's interaction, Rochelle would have achieved little during the 30-min independent work time. By maintaining a work pose – head down, not talking, looking at the book – she had convinced the teacher that she was able to do the task. Conversations with Rochelle showed how textbook work presented issues for her.

Researcher: Which of these three ways helps you learn maths best do you think? Writing it, talking it through or using real things?

Rochelle: Talking with other people about it.

Researcher: Are you allowed to talk to other people about your maths?

Rochelle: Sometimes.

Researcher: Would you rather do maths with other people?

Rochelle: Yes.

Researcher: What real things have you used in maths this year? (*Pause*) Have you used any?

Rochelle: Um … (*Thinks*) No. (Late Year 4)

Researcher: What do you do when you don't understand something in maths?

> Rochelle: I don't ask the teacher. I take it home and ask Mum … Because it's embarrassing asking the teacher. (Early Year 5)

Without the opportunity to copy and continue the tile pattern with coloured squares as the instructions suggested, or to talk it through with a partner, Rochelle could not access the mathematical ideas involved in the problem. Throughout the 3 years of the study, Rochelle was seen to adopt a "head down" approach during mathematics lessons and received praise from the teacher for her work habits. Mrs Ponting described her as "a quiet little mouse" and while noting her reluctance to engage in discussion at maths time was generally very satisfied with her progress.

Both Rochelle and Jessica came to a standstill when faced with textbook questions which they could not interpret alone. In both cases, because working collaboratively and using real materials were not accepted modes of working in their classrooms, the children lacked strategies to allow them to continue. These events were by no means isolated. Throughout the study, many similar situations were observed where children who had been instructed to work independently using textbooks or worksheets experienced difficulties in comprehending the tasks. Their teachers were often oblivious to the children's difficulties.

The purpose and format of mathematics textbooks have changed little in more than a century. As cultural artefacts, mathematics textbooks are not only produced within the social worlds of schooling, but also productive of their young users as mathematical subjects whose task it is to engage in recognisable modes of work. Textbooks support and perpetuate assumptions about doing maths, both reflecting and reinforcing traditional protocols of mathematical work. They are created on the assumption that children will read and interpret instructions and diagrams as the author intended. Santos-Bernard (1997) cited in Harries and Spooner (2000) found that children interpret textbook illustrations differently from adults, leading to confusion where children take illustrations literally, rather than as the representations intended. This confusion was well illustrated by the experiences of Jessica and Rochelle, who were bewildered both by the language and the diagrammatic representations of mathematical ideas in their textbooks. Rochelle was baffled because she viewed the squares in her textbook as diamonds. Jessica could not make sense of the picture of rods in a number track, having never seen them used to model the concept of multiplication. As Bishop (1991) noted, "The control by the textbook … effectively prevents the teachers from knowing their learners and thereby prevents them from helping their learners effectively" (pp. 10–11).

Dowling (1998) argued that mathematical text books "constitute in their reading, *voices*, and in particular, authorial and readerly voices" (p. 122). He saw them as constructive of a hierarchical relationship between the learner (acquirer) in an apprentice position and the teacher/authority (transmitter) in the expert position. In the same way, a teacher assumes authority in the classroom by positioning her/himself in a particular place and using comments, statements, instructions or questions to establish and maintain that position in relation to the learners; the textbook uses the voice of written statement, comment, question and instruction to take on a similar authoritative and didactic role as surrogate instructor. The authoritative "voice" of the textbook can therefore be seen to echo, support, legitimise and strengthen the teacher as authoritative subject.

The *National Curriculum Mathematics* (NCM) textbooks and *Figure it Out* series (Ministry of Education 1999a, 2000a) used by children in this study replicated the format of textbooks from the early twentieth century. Although more colourful and including occasional *investigations*, these texts preserved the concept of "maths work" as numbered lists of *exercises* in the form of questions for the children to answer. By the end of Year 5, this constituted the bulk of children's mathematical work. Children were trained, as Jessica and Rochelle demonstrated, to record the question number in the margins of their exercise books, with corresponding answers alongside. As questions and answers become separated in the process of textbook work, it was difficult for children to crosscheck in the marking process, let alone retrieve the thinking that produced the answers.

The children described their views of textbook work:

Georgina: We can go to the back of the book and we say, 'There's the answer.' (Mid Year 5)

Jessica: It's like the book's already there and all you have to do is write the answer. (Mid Year 5)

Researcher: What's the most important part of maths time do you think?

Dominic: I would say the most important part is *Figure It Out* or NCM.

Researcher: Why is that, Dominic?

Dominic: Because that isn't like games or easy stuff, it's getting right into it.

Textbooks signalled to the children that they were "getting right into" mathematics, the familiar question/answer exchange structure of the teacher's interactions simulated in symbolic form, and children disciplined in its disembodied, authoritative presence.

Worksheets: Tasks for Mathematical Workers

Worksheets from a variety of commercial sources or designed by the teachers themselves were found to be frequently used in the research classrooms. In the manner of pages of the textbook, worksheets were usually composed of lists of closed questions. Children were expected to write their answers directly onto the sheets in the spaces provided. In some of the classrooms, worksheets were used almost every day. The following comments typified the children's views of these worksheets.

Fleur: I like those … Usually they're fun. (Late Year 3)

Georgina: Worksheets? Good, 'Cause some are easy. (Late Year 3)

Researcher: Which is the most important bit [of maths]?

Jared: Worksheets … Because it gives you more to learn.

Researcher: OK. So how do you learn off those worksheets, Jared?

Jared: They don't say the answers and they test you.

Researcher: And what if you don't know?

Jared: We just put in an answer. (Early Year 5)

Like textbooks, commercially produced worksheets were not tailored to take account of the interests, experiences or even the physical characteristics of the children in the classrooms. As a result, problems arose, as the following observation illustrates.

From field notes, Island School, Mid Year 4

Mrs Cayo has given the children in Georgina's group a worksheet instructing them to draw the 'mirror image' of a snowman. The snowman is pictured on the left-hand side of the page with a dotted vertical line separating it from a space on the right-hand side where the mirror image is to be drawn. The teacher has provided the children with small rectangular mirrors. Holding the mirror on the line Georgina tries to draw the reflected image behind the mirror but abandons this method and draws freehand. Mrs Cayo approaches.

Mrs Cayo: (*Sharply, to Alan who is sitting beside Georgina)* Put it there. (*Places the mirror on the dotted line*) Keep it there. (*To Georgina*) That's not the way to do it. Rub that one off please. (*To the whole group, demonstrating*). Hold it with one hand and draw with the other one. You *must* hold the mirror there all the time.

Mrs Cayo moves on to another group and Alan is now crying. It quickly becomes apparent why this exercise is so difficult for him. He is left-handed as is another boy in the group, who is also finding the task virtually impossible. The worksheet has not been designed with lefthanders in mind, and the teacher has not picked up on why these children are unable to complete the task as instructed.

Worksheets were often assigned to particular groups of children to complete independently while the teacher was engaged with another group. Little guidance could therefore be provided, and, as the earlier example shows, even when teachers checked, the underlying mathematical ideas were rarely discussed. Teachers had not always come to grips with the mathematics of commercially produced worksheets and were sometimes observed to be struggling to understand the tasks.

From field notes, Spring School, Late Year 5

Each of the children in Jared's class have been given a worksheet (Fig. 3.24). Jared ignores the instructions and looks at the work of the boy sitting next to him who has started to draw a hexagon to the right of the top one, with only corners touching and sharing no sides. Jared copies this. He repeats this process all the way across the grid and then does the same with the other two hexagons. The three rows of hexagons he has drawn are touching only at the corners and the spaces between the hexagons are not of a regular shape. Because the design he has produced does not follow the instruction 'fill in the shape with hexagons' it is not the tessellating hexagon design intended but a repeating pattern created by horizontal linear translation of the hexagon.

Researcher: (*To Jared*) Is that the only way to do it do you think?

Jared: Yes.

Most of the others have done the same, including the teacher, who is helping one of the children. One child, Danielle has begun to draw hexagons dovetailed together, creating the beginnings of the tessellating pattern. Noticing that the work of the three boys at her group is different, she begins to erase her design, no doubt believing that her method is wrong. The researcher asks her a question.

Researcher: (*To Danielle*) Which is better, your pattern or theirs do you think?

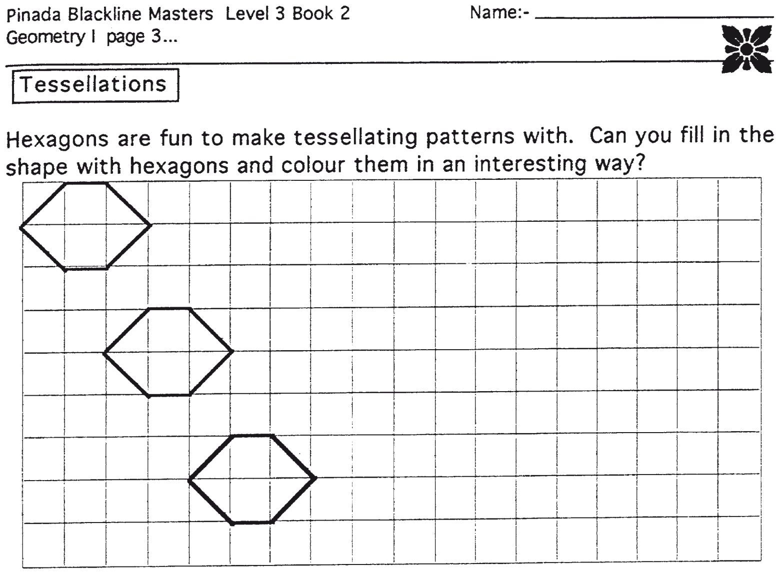

Fig. 3.24 Tessellation worksheet used in Jared's class

Danielle: (*After some thought, pointing to her own*) This, because there's no gaps.

Researcher: What might your pattern look like if you keep going?

Danielle regains faith in her method and starts once more to dovetail the hexagons. Soon she has finished the design of tessellating hexagons and is visibly excited at the honeycomb effect. Other children come to look at it.

Sarah: Oh cool!

Jared goes over to look at Danielle's design. When asked how his compares with hers, he doesn't respond. By this time he has finished the worksheet and seems unwilling to reflect on what he has been doing. Jared takes his work to the teacher who directs him to colour it in.

There were problems for both children and teacher with this worksheet. Neither the worksheet nor the teacher suggested that the children experiment with tiles or blocks to develop an understanding of *tessellating* and the properties of polygons that allow tessellation. Without the opportunity to trial different hexagon configurations, the children were limited to the difficult process of drawing and erasing their attempts.

By Year 3, worksheets such as this were such familiar fare for Jared that they had become synonymous with doing mathematics, as his drawing showed (see Fig. 3.1). His view of the purpose of the worksheets is shown in the following responses.

Researcher: What was it you were doing this morning? [a worksheet on addition]

Jared: Filling in gaps.

Researcher: (*Later*) What do you do when you don't understand something in maths?

Jared: I fill in the gaps. (Early Year 3)

Because worksheets did not encourage or allow for children to record their thinking, Jared had interpreted mathematical activity merely as a gap-filling exercise, a view he continued to hold over the following 3 years. Commercially produced worksheets of this type were designed to by-pass the use of concrete materials. As this example shows, illustrations or diagrams of concrete materials do not provide children with the kinds of practical experience that are more likely to foster deep mathematical understandings. Dominic, Fleur, Liam and Toby were all observed at different times to be engaged in worksheet activities picturing rings on the three-bar abacus. When asked whether they had used the abacus, they said they had never seen one.

> Researcher: (*Looking at Dominic's maths book*.) OK, you've drawn some abacuses. Did Mr Ford get out some abacuses for you?
>
> Dominic: No, we just drawed them, then he just drawed them up on the board. (Mid Year 5)

The children found the illustrations of this unfamiliar apparatus confusing. Georgina had experienced the use of a three-bar abacus as her self-portrait shows (Fig. 3.19). Her enjoyment of the activity produced not only an enduring positive memory but also retention of the mathematical idea she had developed in the process.

Working from the Board

From video recording, Spring School, Late Year 5

> Mr Waters: First of all this morning we're going to put up the title (*Writes* 'Problem Solving' *on the board*) Underline it and miss a line. See if you've got your brains into gear. (*Writes the first pattern on the board:* (*1*) *2,4,6,8,* □, □, □) A nice easy one to start off with. What you're going to do is complete the number pattern. (*Writes:* (*2*) *3, 6, 9,* □, □, □), Fill in the numbers and continue it on. Maths is patterning, that's all it is. Complete the whole number pattern. (*Writes:* (*3*) *5, 25, 45, 65,* □, □, □) They're going to get harder and harder. (*Looking at a child's work*) There's no need to write the boxes, the boxes on the board represent the ones that are in your book. Make sure you have the most important piece and that is the comma between, if you don't, your numbers will represent something else. You must set them out properly.
>
> (*The lesson continues in this way, the teacher explaining and writing examples on the board, the children writing in their books, individually, in silence. When they have finished, Mr Waters calls for answers and the children mark their own work. He comes to a question where two groups of three shapes have been drawn*.)
>
> Mr Waters: Who picked what the pattern was doing?
>
> Afa: Circle, triangle, square – triangle, square, circle – circle, triangle, square –triangle, square, circle.
>
> Mr Waters: (*Doubtfully*) Hm. Someone else?
>
> Ian: Circle, triangle, square – triangle, square, circle – square, circle, triangle – circle, triangle, square … you move one each time.
>
> Mr Waters: (*Looks pleased*) Ah, good man. Afa's right, though. You can't fault his logic because there were only two [elements of the pattern] to go on. But the others thought a little deeper. (Mid Year 5)

Some ambiguity had been discovered in this particular question. Mr Waters implied when he said "who picked the pattern?" that there was only one to be picked. Although Mr Waters accepted Afa's answer, he valued Ian's more highly by describing it as having required "deeper" thought.

This lesson was typical of those observed. In the mathematics classroom, the *board* (either blackboard or whiteboard) acted as a surface of authority upon which the face of mathematics was projected in emblematic symbols. As illustrated in the example from Jared's classroom, it was through its use – and control – that the board produced the teacher as taskmaster, expert, and judge. Besides emphasising the protocols of setting out, Mr Waters was reinforcing the specific procedures and nature of mathematical learning as particular kind of "work" through his use of the expressions "*you're going to*," "*you must*," "*you don't*," "*make sure*." All the children were expected to follow the same very particular rules and their application of these was closely monitored. In the manner of other exercise regimes in which the (un)fit are made, the teacher began with easy tasks and increased the difficulty – "harder and harder." This was typical of an overall approach to learning found in the children's classrooms, which presumed that in presenting a task that was easily accomplished and then incrementally extending the cognitive challenge, the children would be stretched, shaped, and conditioned. But more than this, in the seemingly sound practice of presenting children with a sequence of tasks in order of increasing difficulty, children could be distinguished as individual learners, their capabilities made visible – those who could keep up and those who could not.

Working with Manipulatives

Children's reports of frequency of work modes were relatively consistent across the ten classrooms. The activities they identified as experienced most often were individual written work, raising hands to answer questions, and teacher-led sessions. The use of manipulatives was found to be very limited, even though *Mathematics in the New Zealand Curriculum* (Ministry of Education 1992) made a strong statement about the value of using of concrete materials at all levels.

> The importance of the use of apparatus to help students form mathematical concepts is well-established. Using apparatus provides a foundation of practical experience on which students can build abstract ideas. It encourages them to be inventive, helps to develop their confidence and encourages independence … Junior school teachers are used to choosing an appropriate range of apparatus to focus students' thinking … such an approach is equally valid with older students and should be used wherever possible … At all levels, students should be introduced to new ideas by having their attention drawn to examples occurring in their natural environment, and then modelling them with apparatus. (p. 13)

Contrary to this directive, use of concrete materials was restricted or almost absent in 8 of the classrooms in the study. Peter and Liam's Year 3 classrooms were found to be well-equipped with mathematical apparatus which was well organised and readily accessible, but in the other classrooms mathematics equipment was scarce, worn, unattractive, or poorly organised. Where concrete materials were used, it was mainly during the teacher-directed group learning sessions. Use of physical objects was a work mode commonly cited as preferred by the children, but there was a gradual disappearance of equipment from mathematics work times as the children grew older, as Dominic noted:

> Dominic: We don’t use them [concrete materials] much any more (Late Year 5)

While a number of the children said that they preferred to work with equipment, they often associated use of manipulatives with children who were not good at mathematics.

> Rochelle: Ms Linkwater has a working group, and that’s the people who aren’t so good at maths, but I’m not in that, and they work with blocks and all that. (Early Year 5)

> Jessica: When we were in Ms Maine’s [lowest group] we did, [use concrete materials] but if you’re in Ms Mere’s, [middle group] I doubt we will. (Mid Year 5)

On the occasions where children were seen to be working with equipment, there was almost always an accompanying written component to such lessons. As their reflections show, teachers believed that the written form of mathematics was the most important part, or even that this *was* the mathematics, and the materials merely a motivational tool or vehicle by which children would arrive at the symbolic, and by implication more sophisticated or advanced representation of the mathematical ideas modelled and explored with physical objects.

> Mr Solomon: There’s that smaller group [Georgina’s] which have never really seen the sort of [mathematics curriculum] strands before, or don’t relate to them in terms of the more structured maths that we’re doing, so that’s the group that I’m using lots of resources, you know, hands-on resources with. (Early Year 3)

> Mr Solomon: She [Georgina] enjoys hands-on stuff, like blocks, but she doesn’t always use it in the way intended. She is still counting on her fingers – I’m trying to get them to put the biggest number in their head –she’s still at the concrete stage, abstract is not part of her repertoire. (Late Year 3)

> Mrs Linkwater: I have concrete materials for maths. Now Rochelle doesn’t need this but it’s always available if children actually need it to prove, and just to work through what they’re actually doing. (Early Year 5)

> Mrs Ponting: (*Complaining that so many children in her class need their fingers to work out basic facts which they should know*) I suggest the ruler so they can see the relationship rather than fingers because what’s going to happen when you run out of fingers? Use my toes? (Early Year 4)

> Ms Summers: In their junior years it’s almost a developmental session most of the time, a lot of tactile, kinaesthetic learning that goes on and I guess at Year 3, suddenly the children are starting to use those experiences, to give them that meaning. It’s got to be in a really supportive way but also quite a structured way, so they actually have that time and are able to focus. I’ve seen situations where they are busy in little groups all over the place all the time. I actually feel with maths they do need some quiet time to actually process. They are learning to record, I think that it’s important to be able to record your ideas. There are a lot of skills to be taught at this level. (Early Year 3)

> Ms Flower: [The Year 3s] are starting to use their books more. Year 1 and 2 seems pretty much hands-on. (Early Year 3)

> Mrs Matagi: Some children love to be making things or just love geometry. Liam, he does enjoy the success that he gets out of, you know, writing a page of work and finding it's correct. (Early Year 5)

Written mathematics in formalised and prescribed form was seen by many of these teachers as "structured," a perceived advance on using concrete materials that were necessary only for the children who were slow to catch on. To them, a child's "needing" concrete materials was a sign of an earlier (lesser) state of mathematical proficiency. This indicated that teachers viewed children's mathematical learning as a linear sequence of developmental stages. Teachers frequently based their understandings of children's mathematical learning on their observations of behaviour during individual work time and on their assessment of the child's written product. Throughout the lessons, children's mathematical thinking seemed to receive the least attention from the teachers. It appeared that teachers did not regard concrete materials as necessary, believing that children should be able to do mathematics without them.

The children's view of concrete materials differed from that of the teachers.

> Researcher: What suits you best – writing your maths, using equipment or talking it through?
>
> Georgina: Using equipment.
>
> Researcher: Why do you like using equipment best, Georgina?
>
> Georgina: 'Cause it makes it easier. (Mid Year 5)
>
> Fleur: Equipment makes it easier so I like that.
>
> Researcher: Do you use it very much?
>
> Fleur: Well, no, not much. (Late Year 5)
>
> Researcher: Do you like it best when you write your maths or when you do things like you did this morning using rulers and string and things? [Perimeter measurement activity with student teacher]
>
> Peter: Using rulers and string and things. (Mid Year 5)
>
> Researcher: Would you rather do writing in your book, or be using some equipment like blocks or rulers or string – those sorts of things?
>
> Rochelle: Using the blocks or the string. (Mid Year 5)
>
> Researcher: Do you use equipment much in maths?
>
> Peter: No. (Early Year 5)

In using the term "easier" the children were indicating that using equipment made mathematical ideas more accessible and working on tasks more enjoyable.

Home Work

By Year 3, most children in the study were receiving regular written homework tasks that usually included some mathematics. The mathematics homework activity most frequently cited by the children and teachers was learning basic facts, especially the "times tables."

> Miss Palliser: Usually they just have some basic addition and subtraction and multiplication they do each week. (Early Year 4)

> Mrs Ponting: It's usually just, um, quite basic, something they know. On a sheet with other work. It's basic facts and tables and …at the moment it's simple addition.

> Researcher: Is that school policy?

> Mrs Ponting: Yes, and the parents like to see their homework. (Early Year 4)

> Fleur: (Remembering some recent maths homework activities) We've been doing magic squares, we did Ten Quick Questions which had things like big pluses like five hundred and three plus eight hundred and fourteen, and we had division… and there was place value and then we had writing whole numbers like sixty-three and ninety-five. A whole lot of maths questions, piles of everything and the questions How much would it cost for three hot dogs if they were two forty cents each. (Late Year 5)

> Georgina: Times tables and stuff like that (Early Year 4)

> Dominic: It'd usually be tables. We have to practise our times tables. (Mid Year 4)

Most parents reported that homework was a regular activity in their households. They believed that homework was good for their children and that it was important that their children develop homework routines.

> Ms Flower: [Parents] always ask about times tables and that sort of stuff, and I just tell them they can do that easily by themselves at home, they don't need me to do it. (Early Year 3)

Most parents reported that their children put considerable effort into completing mathematics homework tasks, perhaps because failure to complete homework generally resulted in some form of penalty at school. Some children found homework a positive experience, especially where parental support led to feelings of success:

> Georgina: 'Cause at the start of the year, Dad showed me all of my [mathematics] homework. He showed me how to do one then I did it all by myself and I got them all right.

> Researcher: How did that make you feel?

> Georgina: Really good when no one was helping me. (Mid Year 5)

For others, the experience of doing mathematics homework was less positive.

> Peter's mother: I leave him well alone but when he got his first times table to do, he has to sit here (*indicates the kitchen table*) and we'd hear nothing from him until he started whimpering, then we'd work out, yes, he was having problems with it. (Late Year 3)

> Dominic: I hate homework.

> Researcher: What is it you hate about homework, Dominic?

> Dominic: Like, when I just get back from school I have to do like about four questions of homework and that really pisses me off. (Late Year 4)

Mathematics homework reinforced children's views of doing mathematics as a solo endeavour consisting of producing written answers to externally imposed questions. Family members reported that the children mostly worked alone on mathematics homework tasks and that parents or siblings became involved only when asked for help.

"Doing Maths" as a Discursive Practice

The mathematics classrooms of these children could be seen as discursive sites scripted in common rules of specificity by which the children were able to recognise mathematics and themselves as mathematical learners. Doing mathematics was constructed as a kind of regular work distinguishable from that of other subjects, occurring within a designated time, requiring seating at desks or tables, consisting mainly of writing on paper or in a special maths book where work was to be done neatly with correct setting out, and completed on one's own with minimal assistance. This specialised work consisted mostly of providing answers to questions from the board, textbook or worksheet. The use of equipment was reserved for those children who were slow to learn mathematics.

Archival material was found to endorse these rules. Schools strongly emphasised children's generic work skills. The progress report for parents of Pukeiti School for example listed attributes that were found to be typically valued in the research schools. Under a heading *Personal and Social Growth* eight of the thirteen categories related to work habits. These categories were as follows:

- Is organised and prepared for learning
- Responds to instructions promptly
- Completes set tasks on time
- Completes homework effectively
- Works well independently
- Displays perseverance
- Takes responsibility for own learning/work
- Works well with minimal supervision

For each child, teachers were to place C (commendable), S (satisfactory) or N (needs improvement) beside each category when reporting to parents.

In the context of the mathematics classroom, teachers' focus on developing children's work habits as described on the school report above often took precedence over the teaching and learning of mathematics itself, reinforcing a wider recognition of the nature of academic "work" and the position of the child. "Work" in the mathematics classroom was therefore subservient to wider regulatory practices in schooling, which governed the management of the self. In such practices the desired child/citizen is one who works hard, obeys instructions, maintains unwavering focus, completes tasks, and is self-supporting.

Mathematics in the New Zealand Curriculum (Ministry of Education 1992) strongly advocated children's verbalising of mathematical ideas in the belief that it is an essential process in the learning of mathematics. It stated that children must be provided with opportunities to, "become effective participants problem-solving teams, learning to express ideas, and to listen and respond to the ideas of others" (p. 23). Many studies have examined the place and effects of student discussion and collaboration in learning mathematics (e.g. Wood and Yackel 1990; Yackel and Cobb 1996; Yackel 2000; Hufferd-Ackles et al. 2004). These researchers believe that effective discussion depends upon the quality and requirements of the tasks and the establishment of norms that promote the kinds of talk including argumentation that enhance mathematical learning. Research suggesting that cooperative group work has significant positive effects on children's learning in mathematics (e.g. Slavin 1988; Leikin and Zaslavsky 1997) had made little impact on the way mathematics was presented in the research classrooms.

The children were inscribed as mathematical subjects in their daily enactments of *doing maths* according to a commonly accepted vision of the model mathematical worker. This ideal was produced in teachers' expectations, surveillance and judgements surrounding the production of mathematics work. Children's actions were monitored, recognised and rewarded (or punished) with reference to this ideal. As they became increasingly accountable to the discourse of the ideal worker, the children were positioned by the teacher, by each other, and by themselves as self-regulating subjects.

In their efforts to comply with the expectation that good mathematics learners are silent solo workers, children attempted to curb their interactions with classmates. The children generally valued working with others, particularly when they were unsure of the answer or method. The discouragement of peer support in most of the classrooms could be seen as a form of subjectification implicated in the mathematical subjectivity of students such as Georgina and Jessica who were keen to talk as they worked. In explaining the development of mathematics anxiety in three case studies, Seaman (1999) reflected that "math has often been treated as a solitary subject" in which one is "relegated to working in relative personal isolation" (p. 2). Lemke (1990) also noted the ways in which teachers "ignore students' needs to communicate with one another" (p. 78) and added that "viewing learning as an essentially individual process, and ignoring social dimensions, helps rationalize holding individuals solely accountable for their own right and wrong answers, their own success or failure at learning" (p. 79). The insistence on the part of the teachers that talk would inhibit rather than enhance the children's learning is not supported by the views of learning theorists such as Vygotsky (1978) who observed that, "children solve practical tasks with the help of their speech, as well as their eyes and their hands" (p. 26). He believed that for children there is a "fundamental and inseparable tie between speech and action in the child's activity" (p. 30).

The children often described talking as a "distraction" from the real task of doing mathematics. Heibert et al. (1997) were strongly critical of the *work alone* tradition.

> Traditional forms of instruction often encourage, and even require, students to work alone. Working together or using the suggestions of a peer has been discouraged. Students are supposed to do their own work and not rely on others. This concern may result, in part, from the importance that has been placed on individual performance. We believe this concern, which has sometimes become an obsession, has had a destructive effect on the climate and culture of mathematics classrooms … doing mathematics is a collaborative activity. It depends on communication and social interaction. (p. 44)

Displays of children's mathematical work were rare in the classrooms visited. This lack of visual reinforcement of children's mathematical thinking contrasted sharply with the work they produced in other learning areas. Children's writing, art, and topic work (science, social studies, and health) could be seen prominently and colourfully exhibited on classroom walls. The few displays of children's mathematical "products" seen in over 90 classroom visits included statistical graphs, models of 3-D shapes, and geometrical and algebraic patterns. These were seldom labelled with the mathematical ideas involved in their production. Evidence of children's mathematical thinking such as writing about their understandings of mathematics, or recording their methods and solutions in various ways, were almost non-existent. The majority of the mathematics work that the children undertook was not considered as something that could, or should, be shared.

The Curriculum View of Doing Mathematics

In the 1980s, a change took place in the teaching of written language. The focus shifted from learning language as a repetitive performance based on exercises and "stories" neatly written into books to a purposeful *process*, where children were encouraged to "brainstorm" initial ideas, then create and edit drafts. Only in the final publishing stage was presentation such as setting out or neatness considered important. A corresponding change was not observed in mathematics classrooms, despite the emphasis "process" received in *Mathematics in the New Zealand Curriculum* (Ministry of Education 1992). Working strategically and systematically were stressed, but at no point did the curriculum indicate to teachers that written work in mathematics exercise books, particularly neatness or setting out, was desirable or even helpful in the learning of mathematics. On the contrary, it stated:

> Students learn mathematical thinking most effectively through applying concepts and skills in interesting and realistic contexts which are personally meaningful to them. Thus mathematics is best taught by helping students solve problems drawn from their own experience … The characteristics of good problem-solving techniques include both convergent and divergent approaches. These include the systematic collection of data or evidence, experimentation (trial and error followed by improvement), flexibility and creativity, and reflection - that is, thinking about the process that has been followed and evaluating it critically. (p. 11)

Teachers were provided with practical examples in the handbooks *Implementing Mathematical Processes* (Ministry of Education 1995) and *Developing Mathematics Programmes* (Ministry of Education 1997) of how this process might be developed in their classrooms. Baker and Baker (1990) also presented a strong argument for a "process" approach to mathematics teaching, as found in the teaching of writing.

> On the whole, the process by which they [mathematicians] arrive at results or methods of finding a proof, the rough calculations, the data generated to find examples of a theory, the diagrams drawn and discarded, are all hidden. What is presented is the finished, polished result. This near obsession with hiding the process used to pervade maths teaching. Layout and presentation, at least in our day, used to score as highly as correctness – always the prize – and rough work was rubbed out, even discouraged. (p. 26)

As shown earlier in this chapter, attempts to shift the focus from product to process had not succeeded for these teachers; layout and presentation still figured most highly in teachers' feedback to students, indicating the enduring nature of this pervasive tradition of mathematics classrooms. This will be further discussed in Chap. 6.

Classrooms as Surfaces of Emergence

Starting from Year 3 of the children's schooling, and increasingly through subsequent years, mathematics exercise books, worksheets, textbooks and questions on the board became the managerial tools of the classroom practice. They represented "doing" mathematics for teachers and children alike. The children came to accept that mathematical knowledge and competence were to be gained primarily through their conscientious application to solitary written work, circumscribed by the authoritative directives of teacher, textbook, and worksheet. Teachers' actions at mathematics time were concerned with regulation and repetitive reinforcement of those discursive practices such as setting out, neatness, completion, and working "independently" that signalled and constituted mathematics as a specific mode of work. Those children who performed tasks in a manner that most resembled the ideal mathematical child normalised within such discursive regimes were recognised and rewarded.

Foucault was particularly interested in the ways in which institutions such as schools sought to standardise and manage human action, controlling not only human thought, but also the human body, producing a corporeal docility through privileging compliant behaviours and denying actions considered to be deviant or defiant. In the typical classroom in this study the mathematical worker was found to be physically restricted; she/he sat very still, listened attentively to the teachers' explanations and instructions, remained silent unless invited to answer a question, and changed position in the classroom only when instructed to do so. Movement of the body was minimised, consisting mostly of turning of pages, writing and using the ruler. Where manipulation of mathematical apparatus was permitted by the teachers, this was closely regulated. Children's discussion at mathematics time was generally discouraged since children were expected to act as unitary, self-regulating and self-reliant – that is individualised – bodies/minds. So convinced were the teachers of the benefit to children of the "structure" of this kind of work that they devoted a significant proportion of their teaching time to training, monitoring, and correcting children's work behaviours. Indeed, the establishment and maintenance of working to rule superseded the teachers' concerns about children's engagement with mathematical ideas. Rather than fostering processes of exploration, experimentation, and creativity in which ideas and possible approaches might be generated, trialled, presented, evaluated, and recorded in a variety of ways as suggested in *Mathematics in the New Zealand Curriculum*, the regimented management of bodies obstructed such teaching and learning of mathematics.

As mathematical subjects inscribed in the performance of *doing maths*, the children were also *doing mathematical subjectivities*. Their self-perceptions as mathematical subjects were mediated through the teacher's normalising gaze and measured in specific accomplishment of work as a way of acting. Georgina, Mitchell, and Jared routinely pathologised for actions that were not sufficiently recognisable as "doing" maths, – talked of how the isolation, tedium, and difficulty of written mathematics tasks served to increase their feelings of alienation and inadequacy. *Maths time* became a period of the school day in which they were frequently subjected to relegation to the margins despite their best efforts to comply. Deviation from usual work routines was reflected in the children's subjectivities. These children experienced a surge in confidence for example when able to manipulate and view mathematical objects, models, and materials in their own ways. For children like Toby, Dominic, and Rochelle, written work was reassuring and satisfying since rewards could be gained for exemplary application and presentation and pleasure derived from the subjectivity of "good student." The children wrestled to curb discussion with classmates, to complete their written tasks in the allotted time and to create written "artefacts" to the required standards.

This management of work in classrooms is consistent with the observations of Doyle (1983) who explained "doing mathematics" as an induction into the world of academic work. He estimated that, "in general, 60 to 70 percent of class time is spent in seatwork in which students complete assignments, check homework, or take tests" (p. 179). He described work in mathematics classes as a process in which, "teachers affect tasks, and thus students' learning, by defining and structuring the work that students do, that is, by setting specifications for products and explaining processes that can be used to accomplish work" (Doyle 1988, p. 169). He argued that, "such work creates only minimal demands for students to interpret situations or make decisions within the content domain" (p. 173) and that "meaning itself is seldom at the heart of the work they [students] accomplish" (p. 177).

Oakes and Lipton (2003) observed such modes of classroom interaction as culturally derived:

> Most teachers striving for quiet and efficient classrooms organise their instruction to control or minimize activity and social interactions … after a short time in school, students decide that real learning is what they do by themselves … traditional modes of classroom interaction are supported by beliefs that each student must do his or her own learning and that the benefits of education accrue through individual accomplishment. These individualistic practices and norms reflect powerful cultural traditions and learning theories. (p. 228)

These traditions are more than merely cultural; they are productive of subjectivity. Teachers and children are made as mathematical subjects in the normalisation of these forms of doing mathematics. The children experienced mathematical knowledge and competence as something only to be gained through conscientious application to solitary written work defined through the directives of teacher, textbook, and worksheet and board. The teachers' valuing of specific acts such as setting out, neatness, completion, and working independently created not only a system of practices considered to be normal in the mathematics classroom, but also a way of measuring children as more or less capable of performing such acts. It was assumed that by a certain age, children would benefit from the "structure" of this kind of work. In privileging the skills that normalised the "good" mathematical worker, teachers overlooked children's engagement with mathematical ideas; in short, in many classrooms doing maths was not taught or learned as a process through which mathematical ideas and possibilities might be posed, explored, trialled, presented, evaluated, and recorded in a variety of ways.

For some of these children, mathematical subjectivity was bound up in the acts of subjectification created through the isolation, tedium, and inaccessibility of written mathematics tasks, which they experienced as alienation, frustration, and boredom. For others the visible structuring of mathematics in patterned actions and signifying artefacts was lived through a sense of control and accomplishment that mastery of such "work" produced.

Such findings indicated that for many of our young learners "doing mathematics" as specified in the discourse of contemporary curriculum frameworks where mathematical learning is portrayed as social, dynamic, active, meaningful, and purposeful had not been realised in classroom practice. In their panoptic apparatuses of identification such as observing work habits and marking books, teachers' managerial approaches were found to manifest and mask at the same time, that is, produce and manage doing mathematics as the performance of particular kinds of teacher-directed tasks, and "good" and "bad" learners as particular kinds of (compliant) workers, subsuming contemporary views of working mathematically as actively investigative, and the ideal mathematical subject as a complex and creative thinker.

Mathematical Workers Subjected

Winter (1992, p. 90) provided an insight into children's subjectification in task-oriented classrooms in reporting his conversation with a 5-year old who explained that the, "opposite of *choosing* is *work* … but you can choose to work." He argued that work is what adults choose to do for themselves, and what teachers tell children to do. Thus, work can be seen to operate as a system of power in the mathematics classroom in which the children are variously constituted and constitute themselves. Walkerdine (1988) discussed the work/play opposition in her investigation of early childhood settings where child-centred and play-based approaches had been adopted. She argued that work was aligned with the old discourse. "In the new, children learn through doing, activity and play" (p. 206). In such discourse, work is constructed as something to be avoided for its interference with children's acquisition of real understanding.

The children in this study did not always choose to work in the ways their teachers expected and play featured in their conversations about doing mathematics, particularly those of the boys as shown when asked how maths time could be made better for them.

> Dominic: Just playing a bit more games.
>
> Jared: Easy work … Playing games. (Late Year 3)
>
> Liam: I wouldn't really do it [maths work] I'd just play the games. (Late Year 5)
>
> Peter: Um, probably more maths games and, um, more drawing things. (Mid Year 5)

The children were often quite clear about what it was about "doing maths" that they liked least. Some imagined that an increase in the frequency of the types of mathematics activities they most enjoyed would improve mathematics time for them. The activities they cited were mostly social or creative in nature. A number felt that they needed greater individual teacher assistance.

Fleur: Mrs Meadows helping me individually 'cause she doesn't really help us. (Late Year 5)

Jessica: If there's only one person that needs help then the teacher should help them even if it's until the end of the maths session, at least the other people have learned something new and that person is up to that stage. (Late Year 5)

Mitchell: Help.

Researcher: Get some more help?

Mitchell: Yeah.

Researcher: Who would you like to have helping you?

Mitchell: The teacher. (Early Year 5)

The isolation and pressure of individual work was cited as off-putting for some.

Jessica: I'd like it if we did it together, like, not every single person because you don't get a turn to say something, but, like, three people and you all get a turn … that's what I would like to do and if that happened I think it'd be quicker and easier. (Late Year 4)

Georgina: Have more time, like we have half an hour on maths and we don't hardly have any time to do it. (Mid Year 5)

Two of the children did not suggest any positive changes, indicating either that they were comfortable with the conventions of doing mathematics in their classrooms, or that it was difficult for them to imagine doing mathematics in any other way.

Researcher: How could maths be made better for you, Rochelle? (*No reply*) Could it be made better?

Rochelle: No. (*Shakes her head and smiles*).

Researcher: How could maths time be made better for you, Toby? (*Wait for answer*) Could it be made better?

Toby: No!

Researcher: You pretty much like it like it is?

Toby: Yep! (Late Year 4)

The children's subjectivities were constituted in the discourse of labour, diligence and rewarded effort which pervaded the daily enactment of doing mathematics. Caught in their classroom systems operating as sites of subjectification and control, children took up the subject positions that were made available in the discourse of doing maths as a particular kind of work, such as "independent," "chatty," "distracted" or "off-task." Rochelle and Toby who appeared to enjoy the structure, predictability, and authorising mode of "doing maths" as their teachers instructed were typically produced as "diligent" and "successful" students, Dominic, Jessica, Fleur, Liam, and Jared as increasingly "independent," Georgina as "trying hard," Peter as "slow but methodical" and Mitchell as "uncooperative." Their subjectivities were governed not so much by their engagement with mathematical content, which had given way to the everyday business of administration and surveillance of children-as-workers, but by the extent to which they entered into the demonstration of desired work habits. The following chapter looks at the ways in which cultures of competition were entwined with protocols of "doing maths" to produce subjectivities not only as workers, but as winners/losers.

Chapter 4
Tests and Contests

Researcher: How do you feel about the Quick Twenty?

Liam: Good …'Cause it's a competitive thing and I like to compete.

Liam, 8 years

The Fast Start: Fleur's Classroom

From field notes, Pukeiti School, Mid Year 4

The mathematics lesson is about to begin. On the whiteboard at the front of the classroom, Ms Fell has written in red marker, as reproduced in Fig. 4.1.

Ms Fell: Get out your maths books everyone. Turn to the back of your books and put up the date. (*Ms Fell now reads through the questions)* [Fleur later tells me Ms Fell does not usually read the questions first, and often calls them out rather than writing them on the board]

Ms Fell: You have two minutes. Go! (*Children look at the questions on the board and some begin to write answers in their books while Ms Fell moves around the room*)

Ms Fell: (*To a child who has not yet written the date*) Quick put the date up.

Ms Fell: (*Looking over a child's shoulder*) We've got some times. Look at the sign carefully. (*After about one minute, looking around*) Do the ones that you can do first, everyone should get eight, nine or ten because they're easy peasy ones we're doing. (*Children continue to work in silence – many seem uncomfortable because they are jiggling in their seats, looking flustered, or frowning. Ms Fell continues to rove, checking on children's progress*)

Ms Fell: (*Looking at a child's answers*) Good boy…didn't even need to give you any clues.

Ms Fell: (*To Fleur, pointing at her book*) What place is that?

Fleur: Ones?

Ms Fell: No. (*Waits for a response then prompts*) Ones…tens…and…?

Fleur: Hundreds?

Ms Fell: That's right. (*Continues to move around the room while Fleur writes the correct answer*)

F. Walls, *Mathematical Subjects: Children Talk About Their Mathematical Lives,*
DOI 10.1007/978-1-4419-0597-0_4, © Springer Science+Business Media, LLC 2009

Checking Up		Maintenance	
1.	6x2	1.	$\begin{array}{r} 360 \\ \underline{+\ 25} \\ \underline{\quad\quad} \end{array}$
2.	$\frac{1}{2}$ of 22		
3.	Total value of $\underline{6}842$		
4.	Place value of $9\underline{8}73$		
5.	\$2.50 - 25c	2.	$\begin{array}{r} 967 \\ \underline{+\ 835} \\ \underline{\quad\quad} \end{array}$
6.	Digital time for half past eight		
7.	$\frac{3}{4} + \frac{1}{4}$		
8.	19 - 6		
9.	20 + 11		
10.	5x6		

Fig. 4.1 Questions on the blackboard, Pukeiti School, Mid Year 4

> Ms Fell: (*When the 2 minutes are up*) Pencils down! Let's see how good our memories are. (*Some children raise their hands. Fleur does not*) Half of twenty-two? Who got that one correct? … (*Ms Fell selects a different child to answer each question, even if their hand is not up. Fleur only puts her hand up for the place value question. As the answers are being called out, the children 'mark' their own work with ticks or crosses)*
>
> Ms Fell: (*When the marking is completed*) Who got ten? … (*A few children raise their hands while everyone looks around to check whose hands are going up*) Very good. Who got nine? Good. Who got eight? (*Fleur raises her hand. I can see her score was seven*) We know if you're being honest. OK, who got less than eight? You have to work a bit harder, you people. Now turn to the front of your books. Numbers one and two. (Two vertical form addition algorithms are written on the board under a heading 'Maintenance'). You have thirty seconds each. Go! (*The lesson continues*)

Used as a daily starter, the activity described above followed a pattern of symbolic actions which produced teacher and children as subjects within the ritualistic anatomy of the lesson. The teacher supplied the questions, started, timed and stopped the activity, roamed the room inspecting children's responses, selected children to provide the answers and judged children's performances; the children sat at desks in silence, wrote their answers in numbered columns in their books, raised their hands only during the answering time, assigned ticks or crosses to their answers, recorded their totals as fractions out of ten and raised their hands to indicate their scores.

Through this daily activity, the mathematical scene was set: expectations were established and reinforced, patterns were constructed and repeated and for the children and the teacher, mathematics and mathematical competence were defined. There was nothing in the activity to suggest that children's mathematical thinking was considered important or even relevant, no suggestion that equipment should or could be used, that answers could be derived using diagrams or other written strategies and no expectation of estimating and checking answers for reasonableness. The children were not asked about their difficulties, no attempt was made to analyse their responses and they were not invited to collaborate or share strategies. In spite of the energy devoted to the activity, no discernible teaching or learning of mathematics took place.

Speed activities were found to be a significant feature of the daily presentation of mathematics in Ms Fell's classroom, as shown in her description of what usually happened at "maths time":

> Ms Fell: Normally we start off the day, there's ten questions on the board. (Later) We have a few maths games that we play, they really love. We play this one called *Knock Down* that they absolutely love. There's sort of five children and it's quick-fire questions. With those two who are playing we might say, 'Three plus four!' and whoever says 'Seven!' first, they stay up and the other one sits down and then it's those two, until you get down to one person and then they go out and you have a final. It's really quick but the kids love it. And then we have *Pipped at the Post* and they really like that, and we have another game [Loopy] where there's a whole lot of cards and we have a stopwatch and it's all addition, so it's like there's a start card and a finish card so someone's start card might say 'Ten plus five' and someone's got a card that says 'Fifteen' and then the next problem…and someone has the stop card. And we time it and we're trying to beat our time and that's a really good Term 1 game, they really get into that.
>
> Researcher: How does Fleur seem to enjoy those games? Is she an eager participant?
>
> Ms Fell: No. I think she's a bit…a little bit worried about, you know, about looking silly.

Stating that the children "absolutely love" such games, Fleur's teacher overlooked subjectivities made in her daily routine such a "looking silly", because the speed test was an essential tool in her management of mathematics. Fleur's description of herself as a mathematical learner reflected the routine use of speed in this classroom.

> Fleur I'm a bit of a slow learner. They're quick [other children]. There's like two seconds to know [the speed questions].
>
> Fleur (later) Sometimes she [Ms Fell] goes too fast and I get a little bit sad. She usually goes, (*speaking quickly in imitation of the teacher*) 'Three times two! Three times four!' and stuff like that, and it's a bit too fast.
>
> Researcher How many can you usually get out of 10?
>
> Fleur Well, if she goes a little bit slower I can usually get 10 out of 10. [identifies excessive speed, rather than lack of knowledge, as the barrier to her success] (Mid Year 4)

During the same interview, Fleur rated herself 0 out of 10 for enjoyment of maths and between 4 and 5 for competence. The regular morning "checking up" and other speed activities signaled to Fleur that she was "a bit of a slow learner" because she was not as fast at producing answers as others. Not only did the daily speed questions define mathematics for Fleur, but they also acted as a potent signifier in her mathematical subjectification.

The Monthly Basic Facts Speed Test: Georgina's Classroom

From field notes, Island School, Early Year 3

> *The class is about to undergo the monthly speed test. It is school policy that all Year 3 to Year 8 children are tested on their basic facts every month. The Year 3 children have 6 minutes to complete the questions.*
>
> Mr Solomon: Today we are going to do basic facts. All you'll need is a reading book and a pencil. (*Children go to reading corner and take a book back to their desks. They prop the*

> *books open on their desks to screen their work from other children. They take out their pencils and wait*)

> Mr Solomon: You need to work absolutely silently to give everyone a chance. (*The teacher walks around and hands out the Basic Facts Speed Test*[1] *papers, one for the Year 3s and one for Year 4s. The teacher asks several children to move to other desks, apparently to minimise the possibility of cheating*)

> Mr Solomon: Put your name and date then turn it over. (*When all the children are ready, looking at his watch*) You may start now. (*Children turn over their papers and begin to write answers. They work in complete silence, some including Georgina, using fingers. Many, including Georgina, appear strained and uncomfortable. The teacher has written the time for the test in half minutes on the board. He crosses off each half minute to indicate to the children how much time has elapsed. After three minutes, she has completed nine of the sixty questions. She looks up to see how much time is left and appears anxious. She bends over her paper, frowning. I can see she is selecting the questions she is able to answer most easily, bypassing the others*)

> Mr Solomon (*After six minutes*) Year 3, turn your sheets over please. (*Georgina has now completed twenty-three questions. She has avoided all the multiplication and division questions but completed all the questions involving addition or subtraction of zero. She turns her paper over with a frustrated look, flicking the pages of her reading book and glancing around at others to see what they are doing. After two more minutes, Mr Solomon stops the Year 4s*) OK everyone, when I call your name, bring your sheets up here and put them on my chair face down please. (*He proceeds to call out the children's names one by one. They walk up to his chair, deposit their papers, which will he will mark, and return to their seats*)

Within the regulating gaze of the test, language, actions and objects combined to distinguish teacher as examiner and children as examinees. Monthly school-wide timed basic facts tests were introduced early in Georgina's third year of schooling, inducting the children into an educational tradition in which tests and examinations would play an increasing part. Teacher and children accepted this as a necessary and naturally constitutive component of school mathematics. Georgina had developed an aversion not only to the tests, but to mathematics in general, her subjectivity as a failing student acted and re-enacted within the daily and monthly tests in her classroom. Before our first conversation Georgina volunteered:

> 'I hate maths.'Cause I hate it when we do tests. I only get three or four or five or something,'Cause it's really hard.' (Early Year 3)

The Timed Public Performance: Jared's Classroom

From video recording, Spring School, Mid Year 3

> *The mathematics session is about to begin. The teacher sits on a chair at the front of the classroom a digital watch in hand. The children are seated on the mat at her feet. Jared sits hunched at the back of the group. Attached to the front wall of the classroom is a cardboard*

[1]Basic Facts Speed Test # 3, +, −, ×, ÷ from Pinada Publications, 1996 – there are six lists of ten questions with Year 3 = 6 min at the bottom of the page and a place to record total /60 at the top.

'clock face' with the numerals one to ten placed randomly around its rim. In the centre is the numeral '6'.

Ms Flower: OK, six times table. Hands up for their second turn. These people…(*reads from the assessment book on her knee*) Briar, Tim, Henry…Henry. OK, Henry, you got fifty seconds last time. See if you can go faster. (*Henry walks over to the clock face and looking at it, waiting expectantly*) OK…(*looks at her watch*) Go!

Henry: *(Looking up at the clock face and speaking so rapidly that he is barely comprehensible*) Six twos are twelve, six sevens are forty-two, six nines are fifty-four, six threes are eighteen, six fives are thirty, six elevens are sixty-six, six fours are twenty-four, six sixes are thirty-six, six tens are sixty, six twelves are seventy-two, six eights are forty-eight! (*Looks expectantly at the teacher and beams with pleasure at his obvious success*)

Ms Flower: Woo hoo! Thirteen seconds! (*Children in the class gasp and talk excitedly. Henry sits back down on the mat where some boys congratulate him*) Well done! *(Records the time in her book*) That wasted your last score. OK, who's next? Ah…Amy. (*Amy walks over to the clock face and stands in front of it, waiting as Henry did)* And … (*teacher pauses while looking at her watch*) … go!

Amy: (*Quite slowly compared to Henry*) Six times two is twelve, six times seven is … (*pauses for at least ten seconds, looking helplessly at Ms Flower who does not respond but looks at the clock face with an expectant expression – some of the children begin to murmur and fidget*) Twenty? (*Looking at Ms Flower for confirmation. Ms Flower does not respond. Amy continues*) Six times nine is…(*pause*) six times three is eighteen, six times five is thirty, six times eleven is sixty-six, six times four is…six times six is thirty-six, six times eight is forty eight.

Ms Flower: Good girl. Well done. (*She records the time in her book, but does not announce it*) I can see you've been practising this time. And that's your first go. I'm sure you can improve on that. OK anyone for their second go? (*Looks around)* No one? We've had Briar, Tim, Henry… (*reading from the class list in her recording book*)

Jared later explained the turn system.

Researcher: What about that game I saw you playing? People would stand up in front of the times tables clock and they would have to go as fast…

Jared: (*Interjecting possibly because I had erroneously called it a 'game'*) They had to learn their times tables.

Researcher: Okay, how did you like that?

Jared: It was hard.

Researcher: How did you feel when Ms Flower said it was your turn?

Jared: I hated it!…I know the ten times table, that's all. (Mid Year 3)

In this situation, the pressure was intense. Amy's answer of "twenty" for "six times seven" indicated that she had tried to memorise these facts by rote with little sense of their meaning. Given time to do so, Amy could not access unknown facts in any way. The teacher failed to correct her, to revisit the facts that were unknown or to ask her whether she could work them out. This activity had been a regular lesson starter for most of the term. Although there was much evidence of testing of children's automatic recall of these facts, little actual teaching of the multiplication facts appeared to be happening in this or any of the other of the research classrooms. Instead, the children were given lists to chant, to write down, and to take home and commit to memory.

Jared began his third year at school as quite positive and confident about doing mathematics but his feelings had changed by the end of the year and were seen to be to be linked to the speed activities that were a regular feature of his classroom. Jared was identified as one of two children in the class who were such “slow” mathematical learners that they were placed in a separate catch-up class the following term. In the case of Henry who was considered to be as good at maths, there was no evidence of his comprehension of the facts he was able to recall with such alacrity.

Mathematical Combat: Jessica’s Classroom

From field notes and photographs, Roto School, Late Year 5

> *It is a Monday. The lesson is nearing its end. It has consisted of a starter of a list of commercially-prepared basic facts questions timed with a stopwatch, followed by checking of the homework task, then the measurement unit starter activity in which the children worked in groups, then on their own from a worksheet.*
>
> *Ms Tyde:* We might have a quiz to finish. When you’re finished, close your books and put it away. Be really quick. (*Children are finishing marking their worksheets*) In a moment you’re going to pack up and when you have done that, get a partner who was in the same group as you last time [ability groups for the previous unit]. I want the groups to be even. [Intensifying competition in the guise of ‘fairness’]
>
> *Ms Tyde stands on a chair in front of the whiteboard, holding some cards in her hand. The children arrange themselves into two lines of pairs. The first pair is standing directly in front of the teacher. Ms Tyde flicks down two cards at once, one in front of each child. On each card, written vertically is a multiplication question (as in Fig.4.2). The child who first correctly answers the card in front of them, gets to keep that card, and the pair goes to the back of the line)*
>
> Ms Tyde: (*To a child who was whispering the answer to another child*) Don’t forget you lose a card if you say. *(The pairs file up to the front for their turn and Ms Tyde continues showing cards until all the pairs have had a turn)*
>
> Ms Tyde: OK, next round…(*Children are now shouting answers in excitement. To a child in front of her*) Calm down, dear…(*To a child who ‘lost’ because she didn’t say the answer quickly enough*) You know that!
>
> Ms Tyde: (*When the cards have all been won*) OK, let’s see who the winner is this time. (*Collects the cards from each line and counts them*) Fourteen, fourteen. It’s a draw. (*A mixture of groans and cheers from the children*)

Jessica, who lost in both rounds, was later asked about the game.

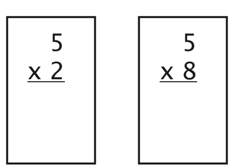

Fig. 4.2 Cards for team game

Researcher: Do you usually finish with a game like that – a quiz or something?

Jessica: In Ms Tyde's [class] we do, we always finish with that.

Researcher: (*Later*) How do you feel about games like the one you had today? What is that one called?

Jessica: Ah, it doesn't have a name but we're put into teams.

Researcher: I saw that. How did you feel?

Jessica: Not that great.

Researcher: Why not? Some people seemed to be enjoying it didn't they?

Jessica: I was with this girl called Angela because she was in the same maths group as me. And, um, I'm not sure if she's that good at her times tables, I didn't think that she was, anyway I was quite glad that I was with her and not one of my friends, because then they would find out how bad I am.

Researcher: So there are still some times tables you don't know yet?

Jessica: Yeah, like, I know my eights, I'm kind of struggling on my nines and kind of struggling on my sixes, everything under five, and I'm sort of OK on my sevens, sort of on my eights, um, it takes me a little while to work out the nine and ten.

Researcher: OK. What helps you learn your tables the best?

Jessica: Look at them then go, OK, whoever says them is going to do them in a mix so it's important not to just add on from the next, so what I do is I may start from five and go to four then go to seven then skip one every time then just go up and down.

Researcher: The list? Testing yourself?

Jessica: Yeah. Really mix them up as much as I can.

In this activity, not only were the children expected to recall their basic multiplication facts at speed in front of their classmates but also they were engaged at the same time in competition. "Saying" was banned under the rules of the game. Jessica practised the times tables with these kinds of randomised questions in mind. She had developed a strategy for learning based on her need to be able to recall discrete and jumbled facts which she recognised as not altogether successful. Anxious about her perceived shortcomings, she worried that her friends would find out. In the same conversation, she said that she found maths boring and rated herself between 4 and 5 out of 10 for her enjoyment of the subject. Contrary to their stated purpose as a "fun" way to practise the basic facts, speed games were a worrying experience for children such as Jessica. She concluded she was "bad" at it.

The Maths Race

These four examples illustrate a genus of activities observed during the majority of the classroom visits, in which speed and competition were combined to make children visible as mathematical subjects for the comparisons that could be made between them. The quick start, variously named *Quick Ten*, *Quick Ones*, *Quick Questions*, *Daily Twenty*, or *Checking Up*, was seen in almost all the classrooms.

Timed basic facts tests had also became a regular feature of all of the classrooms by Year 5. Over the 3 years of the research, five of the schools were observed to be using commercially produced *Basic Facts Speed Tests* as in Situation 2. Other schools had devised their own tests. The number of questions increased with the age of the children. The questions were almost exclusively of the *result unknown* problem type, e.g. 3 × 4 = (Carpenter et al. 1999). The research showed that it was around Year 3 of the children's primary schooling that most teachers began introducing children to the "times tables" which they were expected to "know". *Mathematics in the New Zealand Curriculum* (Ministry of Education 1992) did not suggest that children should be able to recall the basic multiplication facts at Year 3. This did not become a requirement until children were working at Level Three (about Years 5 and 6). Teachers' methods of introducing multiplication and "times tables" and their expectations of children's recall varied considerably between the schools in the study.

Within the small sample group of 10 children, 3 were found to have experienced individual oral performance of basic facts, and a number of different competitive basic facts games were observed or described by the children. The most common of these was a game called *Around the World*, in which one child was selected to stand beside another. The teacher called out a basic facts question and the child who responded first with the correct answer, stayed "in" [the game]. The loser remained seated while the winner moved to stand beside another child for the next question and so on. The object of the game was to remain standing for as long as possible and the ultimate challenge to go "*around the world*", that is, to beat every other child in the class. In the four games observed in four different classrooms, some children were never "in" and appeared to give up trying.

Dominic described a similar game regularly played in his classroom called *Shoot Out*, where contestants were eliminated for slow or incorrect answers. He also described a game played regularly as a starter activity in Year 4.

> Dominic: *Maths Challenge* it's called.
>
> Researcher: Do you have to answer basic facts questions?
>
> Dominic: Yeah, you get a winner.'Cause there are four people standing up and the rest of the class are sitting down. They challenge the people that are up there and the people that sat up there all the time [because they get the answers right].

The game of paired contestants played in Jessica's classroom was also popular. Three of the teachers were regularly using variants of this game. Jared described how the game was played in his class:

> Jared: We play *Shoot*, it's a maths test and two people are up there [in front of the class at the whiteboard] and Mr Waters writes something [on the board] and you're looking at the people [facing the class with backs to the board] and Mr Waters says, 'Shoot!' and they've got to turn around and get the answer right, and then the other person goes out if they get it wrong. (Early Year 5)

Jared called this activity a game and also a "test" as though the two were inseparable.

Buzz was another commonly practised speed game. Taking turns around a circle, the children were expected to rapidly recite numbers in sequence, either forwards or backwards, with particular numbers indicated by the word buzz. Those children who produced incorrect terms in the sequence were eliminated. Helping others was forbidden, and those who answered incorrectly exposed. Another speed game *Loopy* was observed in Peter's Year 5 classroom. Fleur's teacher Ms Fell also used a version of this game. The aim was to produce the fastest class time for loop completion. Those children who were slow to answer were seen as weak links in the loop, preventing the class from achieving a record time. Other common speed games observed were versions of Lotto or Bingo, where the children would select their numbers and write them in their books. Liam describes the variation of this game called *Cross Out* played in his classroom.

> Liam: You put down the numbers one to twenty and then she [teacher] calls the numbers out and does them quite fast so that some people can't hear…and the first one to get all the numbers, they win and they put their hand up and, um, the teacher normally puts their name up on the board for Star Student. (Early Year 5)

Emphasis on instant recall of "facts" featured prominently in teachers' descriptions of how their mathematics lessons began.

> Ms Flower: To start, a game, we mostly do a game…they really, really like the game that we played [the competitive game I saw while observing the class] so I play it heaps – yeah, basic facts all through, pretty well. (Spring School, early Year 3)

> Mrs Joiner: The structure is always the same – some sort of whole class activity to start with like *Basic Facts Speed Tests*, *Bingo*, *Buzz*, chanting tables, looking at factors, addends, patterning… (Bridge School, early Year 3)

> Ms Fell: Normally we start off the day, there's ten questions on the board (Pukeiti School, mid Year 4)

> Ms Seager: We start off with some, um, basic facts recall. This morning I just did the *Quick Ten*, other mornings I do problems on the board, word problems and things like that, so some sort of recall of basic facts. (Roto School, early Year 4)

> Mrs Waverly: We come and we have *Quick Ten* which is so basic and easy, but that's really just to settle down. (*Imitating herself*) 'Get your books out, turn to the back, do those'. (Beach School, early Year 4)

> Mrs Ponting: It's a very busy time. It's heads down and we work really hard. We have our *Daily Twenty*, then *Computation*. You're really working hard to get them into their basic facts of addition and subtraction, from memory, recall. I think that's important. They've got to know it. So many with their fingers! (Bridge School, early Year 4)

> Ms Linkwater: I tend to usually run, um, fairly structured programmes, with basic facts tables at the beginning, might be a maths game, um, some computation, then new learning… (*Later*) Basic facts tests, this one I'll often throw at them. I'll give them this one once a month. (Bridge School, early Year 5)

> Ms Matagi: We usually start with maintenance of our basic facts. We do our daily drills, they say them, just chant then…then those children I know who feel confident will do it on their own. (Mountain School, early Year 5)

> Mrs Isles: I have 20 quick-fire questions and that's the tables practice, yeah, and the basic facts. (Motu School, early Year 5)

> Mr Ford: Basically it's run the same system most of the days. We start off, we have, Daily Drill, Quick Twenty kind of thing, just basic facts. Whip that through. I put a little grid, they write it down, I put up the time, not so much as a competitive thing, but I've explained…I give it to them and I've explained that it's there for them to monitor how they're going. Yeah, and it's also for those…'cause it's hard to make it something…a motivating kind of thing but if you sell it as something like, 'Hey, what's your time? See if it goes down a bit over the term,' that sort of drives them along a little bit. (River School, early Year 5)

> Mr Waters: In the first term…maths was your *Quick Ten*, you got it in, you got it done, a concept, them maybe a worksheet that we use then straight onto the English. (Spring School, early Year 5)

Speed activities were observed to dominate the discourse of the mathematics classroom. By Year 5, all the children were experiencing daily speed activities, including regular speed tests and speed games. As they engaged in such activities, teachers and children were produced as adjudicators and performers in the maths race.

> Fleur: We usually start with times tables or take aways. She says, like, 'Six take away seven' [sic] and we write them down in the back of the book and sometimes she mixes them all up… She calls it *Quick Ones.* (Late Year 3)

> Fleur: We usually do one of those tests (*points to yellow times tables achievement chart on classroom wall*) or else just questions like five take away five and stuff like that. (Mid Year 4)

> Fleur: We usually do *Quick Questions*. On Friday we do *Fifty Quick Questions*. And there's like two seconds to know them. (Mid Year 5)

> Georgina: Mr Solomon claps his hands and says, 'Get out your maths books and set up one to ten.' (Early Year 3)

> Georgina: Get out our maths books and do our maths. Twenty basic facts in two minutes. And ten for one minute. (Early Year 4)

> Georgina: On Mondays we have to do this thing. It's got eighty questions and it's got, like, eight times nine and stuff like that. And you have to start doing that and you have to do it [in] under seven minutes. (Early Year 5)

> Toby: Usually he (the teacher) says, "Get your maths ready in your Speedy Maths books and do it as fast as you can." (Mid Year 5)

There was ample evidence in the children's mathematics exercise books that such activities were a regular feature of the classroom programme, as shown in Fig. 4.3.

Keeping Up to Speed

Rochelle, Toby, Liam and Dominic reported that they enjoyed speed activities. They usually finished within the given time, scored highly or became winners in these games. Liam, Toby and Dominic were also keen participants in competitive sports as their parents and teachers remarked. The competitive nature of the Quick 10 appealed to these children.

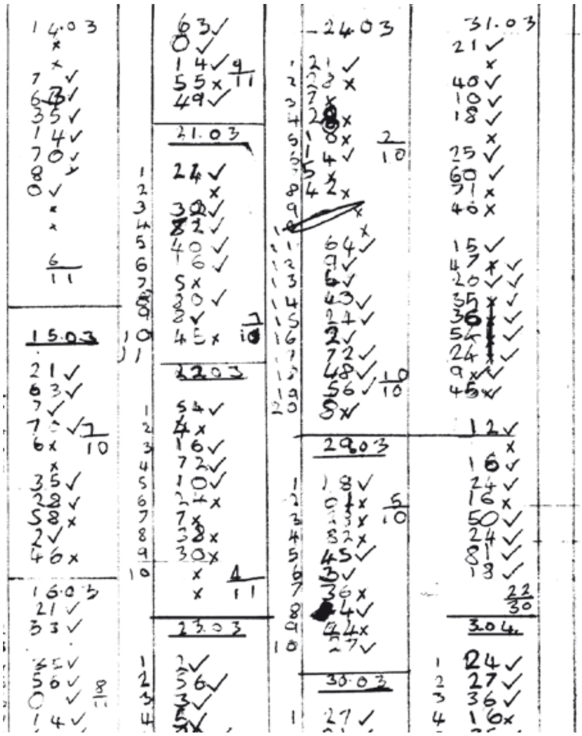

Fig. 4.3 A page from the back of Fleur's maths book, Pukeiti School, Early Year 5

Researcher: How do you feel about the *Quick Twenty*?

Liam: Good.

Researcher: OK. Why do you feel that?

Liam:'Cause it's a competitive thing and I like to compete.

Researcher: What about *Buzz*? You said earlier that you didn't like that as much.

Liam: No, I can't compete with it. (Late Year 4)

Researcher: Have you ever won it? *(Dominic has just described how to play 'Shoot Out')*

Dominic: No I haven't, but I've nearly won it.

Researcher: Do you like that game?

Dominic: Yep! (*very enthusiastically*)

Researcher: What do you like about it, Dominic?

Dominic:'Cause it helps me to learn. (Mid Year 4)

Researcher: How do you feel about those [the weekly basic facts tests]*?*

Dominic: I feel real good when we have those. I always get stickers and stuff. (Late Year 4)

Dominic: We get eight minutes to do the whole thing [weekly basic facts test]. I actually do it in seven and a half minutes. (Mid Year 5)

Toby: We play this thing called *Around the World*. I like it, like when I beat somebody when they come to my desk. (Late Year 4)

Toby: Speed maths that's my favourite part. I like being ahead of other people. (Mid Year 5)

Researcher: What tells you you've got better at maths, Toby?

Toby: Well, I'm much faster.

Researcher: (*Later*) Are there any kids who are better than you at maths?

Toby: Yes.

Researcher: How do you know?

Toby: Because they're much, much faster. (Late Year 5)

Rochelle, who also enjoyed the "Daily 20", seemed to regard it as a reassuring and satisfying measure of personal success and as a pleasing indication of fulfilment of teacher expectations which became her own. Her teachers remarked on how Rochelle was "eager to please"; for Rochelle, getting correct answers fell into this category. Rochelle also enjoyed competition.

Researcher: What do you like most about maths, Rochelle?

Rochelle: *Daily 20*…You get to answer questions.

Researcher: (*Later*) Why do you think you're pretty good at maths, Rochelle?

Rochelle:'Cause in the *Daily 20*, I can get nearly all the questions right.

Researcher: (*Later*) What's the most important thing you do in maths time do you think?

Rochelle: *Daily 20*.

Researcher: Why do you think that's the most important, Rochelle?

Rochelle: Well, you answer questions. (Mid Year 4)

Researcher: What about that game *Around the World* that I saw you playing?

Rochelle: It's fun.

Researcher: What do you like about it?

Rochelle: Because you get to beat people at saying the answers.

Researcher: Do you usually beat people?

Rochelle: Sometimes. I nearly got around the world, but [for being beaten by] Tania, she's quite good at maths. (Early Year 5)

Fleur, Georgina, Jessica, Jared, Mitchell and Peter were less positive about speed activities. For Fleur, it was these activities that shaped her growing relationship with mathematics. Fleur was on holiday with her parents when the class began to learn the "times tables" in Year 3. The teacher described how Fleur had become agitated at having been left behind.

Researcher: How does maths time usually start?

Fleur: We usually start with times tables or take aways. She says, like, 'Six take away seven' [sic] and we write them down in the back of the [maths exercise] book and sometimes she mixes them all up… She calls it *Quick Ones*.

Researcher: (*Later*) Are there any people in the class who are better than you at maths?

Fleur: Ella.

Researcher: How do you know Ella's good at maths?

Fleur:'Cause she can get to finish all her times tables and take-aways and pluses all right most of the time. She's a lot faster than me too.

Researcher: How many do you do?

Fleur: We get a hundred, in fifteen minutes. (Late Year 3)

Ms Fell the Year 4 teacher described how Fleur became tearful on occasions during mathematics tests.

Researcher: Do you usually start with ten questions in the back of your book? (*as just observed*)

Fleur: We usually do one of those tests (*points to yellow times tables achievement chart on classroom wall*) or else just questions like five take away five and stuff like that.

Researcher: I see, and does the teacher call those out?

Fleur: Yes.

Researcher: How do you feel about that?

Fleur: Sometimes she goes too fast and I get a little bit sad… If she goes a bit slower, I can usually get ten out of ten. (Mid Year 4)

By Year 5, Fleur had experienced daily speed activities on a regular basis, with ten quick questions to begin each regular lesson, and 50 questions on Fridays. At the end of their Quick Ten test Mrs Meadows required the children to exchange books for marking and when completed, asked the children to call out their scores which she recorded in her assessment register. After one such event in which Fleur had scored seven out of ten, the following discussion took place within Fleur's desk group.

Joshua: Maths? I hate it.

Zac: Maths is my favourite subject.

Researcher: What do you hate about it, Joshua?

Joshua: It's hard. The times tables. The eights.

Researcher: You can do those can't you, Fleur? (*Fleur nods*)

Zac: I know them all.

Researcher: How did you get so good at them?

Zac: I practise them at home

Researcher: Did you have to practise a lot?

Zac: Yeah.

Joshua: I only do them at school.

Fleur's homework notebook contained lists of multiplication facts at the back. In Fleur's class, it was expected that the tables be learned at home rather than at school. This had been possible for Fleur and Zac but not for Joshua.

Teachers' relinquishment of responsibility for teaching the times tables clearly created problems for some children. Georgina was one such child. Daily speed tests were difficult for her with only slow improvement over Years 3, 4 and 5. The rear section of her mathematics exercise book told the tale. She regularly achieved less than 50% of correct answers. Daily *Quick Tens* served to reinforce her sense of failure and consistently over the 3 years of the study, Georgina expressed her dislike of, and lack of confidence in, mathematics.

Researcher: When the teacher says, 'Ok, it's time for maths now,' how do you feel?'

Georgina: Ugh! (*Grimaces*) We have to do this 20 or 10 question thing and Mrs Cayo calls out the questions and you have to write the answer and she goes really fast now and I can't do it. (Mid Year 4)

As her Year 4 teacher observed, "Georgina has more ability than the assessments show" (Mid Year 4). When provided with physical materials, opportunities to talk about her mathematics, and sufficient time, Georgina demonstrated considerable insight and creativity in her mathematical explorations. With visible excitement, she described in words and diagrams, two activities she had really enjoyed: using a three-bar abacus, and drawing pictures using paired co-ordinates. Despite these demonstrations of sound mathematical thinking, Georgina continued to believe that she was no good at mathematics, citing basic facts speed activities as the primary indicator.

Researcher: What subjects that you learn at school do you think you're the worst at?

Georgina: Maths.

Researcher: What makes you think that?

Georgina: Because I never get my basic facts right.

Researcher: (*Later*) What makes someone good at maths do you think?

Georgina: They learn all their times tables and learn all the, um, take aways and, um, pluses. (Late Year 4)

Georgina: I put my goal to get faster at it. (*She shows me the basic facts self test sheet on which she has written, 'My score this week was 28, my goal for next week is to get faster.'*)

Georgina: (*Later*) Bradon, the person next to me, he's pretty good at it [maths].

Researcher: How do you know?

Georgina:'Cause he just goes like this on the test. (*mimes writing very quickly*) And it's two minutes [to finish]. (Early Year 5)

Georgina was also expected to learn the basic facts at home.

Mrs Isles: But it is, um, I mean, part of the onus is on them too, to learn their tables at home and then come back, and I've said, 'Well you know, you should, up to now, know up to your six times tables, and if you're not feeling confident then you should spend time learning them.' But there probably should be more time allowed [at school] for those children that, ah, at home, they're not always done. (Early Year 5)

Jessica, too, expressed the belief that she was not very good at mathematics. As we have already seen, speed activities were implicated in her feelings of inferiority.

Researcher: Do you think there are people in the class who are better than you at maths?

Jessica: Way better!

Researcher: Okay, how do you know they're better?

Jessica: Well, because we do *Around the World*, things like times tables, adding and dividing and there's this boy, he goes around and he's, like, really, really good. He's made it, like, three-quarters of the way around.

Researcher: How do you feel when he comes around to stand by you?

Jessica: Not Good. I feel kinda nervous. Because there's the whole class there and stuff. (Late Year 3)

Basic facts speed activities compounded her anxiety. Based largely on their basic facts' test scores, the children in Jessica's class had established a hierarchy for mathematics.

Researcher: How do you feel about the tests? [basic facts speed tests]

Jessica: I feel nervous…'cause if you don't get very many, we've got these graphs [of their basic facts scores] and mine starts up there and then it goes down, up a bit, but down and up… So somebody could tell as soon as they saw it, so they can tell you got a low score.

Researcher: Does anyone else see your graph?

Jessica: Some people do but they're not really supposed to look at it.

Researcher: Do people know each other's scores or is it private to you?

Jessica: It's meant to be private but some people go, (*using a wheedling voice*) 'What did *you* get?' (Late Year 4)

Jessica: Sometimes we do these challenges. It's the *Times Challenge* and we've got a clock, with, like, in the middle there's times, whatever the times table we're doing, and then around the inside, the circle, Ms Tyde puts numbers, and you have to go 'Twelve times six is…twelve times eight is…whatever the answer on the outside of the circle is and I've never tried that but I don't want to because we're up to the six times tables in twenty-five seconds.

Researcher: (*Later*) How do you think you're getting on with your tables these days?

Jessica: Not very well, but I've had a few days off, so I'm still on my four times tables. (Early Year 5)

Jessica: Well when we do this numeracy skills mastery programme, some people are doing a different sheet because they're not as up to the others.

Researcher: Why is that?

Jessica: Maybe they're not as fast as us. (Mid Year 5)

Mitchell experienced learning difficulties in all areas of his schooling and tried to make sense of the activities in which he was expected to participate at mathematics time. It was daily basic facts tests that most stood out for him.

Mitchell: We have to do a sheet [of basic facts questions] and Miss Palliser times us and you have to put your hand up and it's really short, like for three minutes. (Mid Year 4)

Researcher: Do you ever play games like *Buzz* or *Around the World*?

Mitchell: *Around the World*.

Researcher: How do you like that game?

Mitchell: Bad.

Researcher: Bad? What happens for you when you play that game?

Mitchell: I always lose,'cause the other kids know and I don't. (Early Year 5)

In spite of support from home, Quick Ten from the whiteboard every morning for 2 years, and a basic facts speed test every Friday for most of Year 4, Peter did not express satisfaction with his progress in learning basic facts. He liked to work methodically, carefully and accurately and the emphasis on speed was unhelpful.

Researcher: Is there anything you've done in maths that you really haven't liked much?

Peter: Um, times tables.

Researcher: What makes the times tables not so good for you?

Peter: Because they're hard.

Researcher: (*Later*) Is there anything that we could do to make maths better for you?

Peter: Um, learn more times tables and learn them all.

Researcher: What would help you to learn them all do you think?

Peter: Just getting a piece of paper and writing them all down then copy the answers and just looking at them for ten minutes or something.

Researcher: Yes? Do you get enough time to do that in class do you think?

Peter: No. (Late Year 4)

Toby was successful at speed activities, but talked of the discomfort speed pressure created for him in learning mathematics.

Researcher: Do you feel comfortable when you're doing maths?

Toby: Well it depends like if we have to get like something done by a certain time, I don't feel too comfortable, I have to hurry up, and well, if it doesn't matter how long it takes, I feel comfortable. (Late Year 4)

Speed activities exerted pressure in their combination of compulsion/coercion, pace, closed questions (creating the chance of being "wrong") exposure to the public scrutiny and lack of learning supports such as materials or peer discussion.

Constituted in these practices, the children had developed strategic behaviours in response to the subjectification of the daily race. Mitchell absented himself from such activities wherever possible. Fleur was sometimes reduced to crying, raised her hand only when she was sure of answers and was once observed to give elevate her score on the *Checking Up* questions. Peter kept a low profile and almost never raised his hand to offer answers. He checked others' books to confirm his answers and worked quietly and systematically, attracting little attention. He explained lack of success as insufficient learning time or provision of support for learning facts. Unlike Peter, Georgina often raised her hand and finished tests early rather than taking the time allotted for her ability group, to give the (self) impression of competence. She sometimes looked for answers from those who were known to be good at maths and adopted them as her own. Although chastised for this by her teacher, she used her fingers or the times tables chart on the wall to access unknown facts. She explained her lack of success as external – a problem with the teacher's going too fast or the maths being too hard. Jessica viewed her lack of success as natural – not all people can be good at everything. She looked at others' work for answers and like Fleur, raised her hand only for known answers. Jared devoted his energy to rapid completion of tasks at all costs. He saw little need to check the sense of his answers and avoided reflecting on his lack of success. These accounts speak of the grooming of children's behaviour through everyday practice, of subjectivities manifested in the self-deprecation, fear, anger or eagerness to please, created in the commonplace use of pressure of speed in classroom practice.

All of the children identified *Quick Ten* and similar kinds of basic facts practice and testing as the most important part of their mathematical learning. This concurs with the findings of Flockton and Crooks (1998) who found that 100% of Year 4 children nominated basic facts and tables as one of the most important aspects of mathematics they needed to learn, followed by work and study skills (26%) and classroom behaviours (26%) such as seeking help and paying attention, well down compared with basic facts. By Year 8, "basic facts" was still the most frequent response (67%) compared with personal attributes (26%) such as good attitudes and concentration, the next most popular choice. These findings are revealing. The daily emphasis on basic facts through middle primary school leads children to believe that these facts are the heart of mathematics, that rapid recall is coterminous with "knowing" the facts and that those who can recall all basic facts at speed, are good at mathematics. Thus speed activities can be seen as implicated in the production of power/knowledge in mathematics classrooms, normalising and privileging individual memorisation and recall of disconnected facts while pathologising and marginalising "slower" students.

Speed Activities as Regulatory Practice

Teachers did not directly state their reasons for using speed activities, nor did they question the effectiveness of these practices in terms of enhancing children's *learning.* They seemed to be caught in a web of practice based on a shared understanding that speed and learning mathematics go together, as indicated in their statements about their use of these activities.

> Miss Puna: That's why I'm having a blitz on the times tables. They've just got to know it, they've got to learn it by rote – memorise it – there's no other way. (Late Year 3)

> Mrs Sierra: We have daily drills, either basic facts or whatever, a game or a maths icebreaker. (Early Year 4)

> Mrs Waverley: We come and we have Quick Ten, which is so basic and easy, but that's really just to settle down. (Early Year 4)

> Mrs Kyle: I often think the basic facts are crucial to a lot of what they're doing and once they've cottoned on to those they seem to find maths a lot easier, you know, especially if they can do them quickly. (Early Year 4)

> Ms Fell: Normally we start off the day, there's ten questions on the board…it's reminding them of things we've done. (Mid Year 4)

Ms Linkwater: Yes, the thing that has been my concern is the lack of recall of basic facts and tables which I feel are just so critical. (Early Year 5)

Mrs Isles: It's always the basic facts…because so much hinges on that…I just call them out because the idea is that they give a quick response and they can get them down, because when we were doing partner testing, when they wanted to come to me and say, 'Look I think I know my seven times table now. Will you test me?' I just quickly fired, and they knew that that was what was going to happen. That they've got to be able to give a quick response… (Early Year 5)

Mr Waters: (*Talking of Jared*) His recall, his speed of recall is improving, so the times tables are something you shouldn't have to think about…I missed out on that. My tables are shocking, they really are so I'm learning. I don't dare let [the children] know, so I'm learning with them and that's something that I really want to work on because that's a major thing. (Early Year 5)

Mr Cove: I'm a bit old-fashioned. I believe in the times tables. Where would they be without them? (*Mimes using his fingers to work them out*) I go quite fast because I believe they either know them, or they don't. (Mid Year 5)

Ms Tyde: We generally start off with our mental arithmetic…I call it, and they write. I like to do a multiplication array so the children challenge themselves to do those. I know some teachers don't like them but I do. They're really good for mental agility. So that'd be most days. Friday's basic facts testing which is tables and once a month is the basic facts test which is out of a hundred and they have six and a half minutes to complete it. And so they work their way down in time and up in accuracy. Here they are, (*indicates a commercially produced resource*) and each month it's a different one. (*Looking at her assessment records*) We haven't had anybody who's beaten the 6.30, [time expectation] but if they do beat the 6.30, that's recorded as well. (Mid Year 5)

Fleur: (*Talking of her teacher*) Mrs Meadows is always telling us, 'You don't know maths if you don't know your times tables.' (Late Year 5)

These comments showed the widely implemented discursive practices of speed activities, almost always linked to basic facts and other kinds of computation, to be variously rationalised by teachers. Where they were used to start a lesson, classroom management ("to settle down") or setting the scene for the lesson ("ice breaker") appeared to be the main purpose. Some teachers seemed to be suggesting that the activities were providing necessary rote practice for the children. ("I'm having a blitz", "daily drills", "reminding them of what we've done"). Some apparently viewed the activities as a stimulating kind of exercise for the brain ("good for mental agility") while others perhaps regarded their use as a means of making transparent those children that knew and those that did not ("they either know them or they do not"). For some, automation of recall was the chief aim ("the times tables are something you should not have to think about").

The schools had often developed specific policies regarding the learning of basic facts and while these differed from school to school, they appeared to be based on home and school expectations rather than the learning needs of particular children or requirements of the curriculum, as the following example shows:

Our survey revealed a level of concern from some parents regarding aspects of our programmes in maths and particularly at the Year 3 level, with regard to transition to maths education in the senior school. In response to this, and as a normal part of our ongoing review programme we will review the emphasis currently placed on basic facts and basic operations in our Year 3 maths programme, continue with the basic facts emphasis started in 1999 for the Year 4, 5 and 6 classes and reaffirm the goal of children knowing all addition/subtraction facts by the end of year 4, and all multiplication and division facts by the end of Year 5. (From *Development Plan 2000*, Pukeiti School)

Having been similarly produced as mathematical learners within school discourses of rote learning and speed of recall, parents supported their children's endeavours to memorise the basic acts by providing practice at home. This underlined the privileging of instant recall of facts over most other mathematical skills. In the first interview early in Year 3, parents were asked to nominate the most important part of mathematics for children to learn. "The basics" featured most highly, as did the need for mathematics in everyday life.

Georgina's mother: Addition, multiplication, fractions. Because it's an everyday occurrence. You use a mathematical equation every day. (Early Year 3)

Rochelle's mother: Just the basics, basic facts, yeah, I think would get her going in the right direction. Just the very basic stuff. If they've missed out on it, they've missed out on everything, they just won't pick it up… Just being able to add and subtract and, um, just that type of thing…deal with money… They need to understand what they're doing. They need to just understand the basic concept of maths and then they should be right all the way through. Yeah, it's the basics I missed out on. (Early Year 3)

Jared's mother: Basically number concepts of how to add and subtract. They get too reliant on a calculator. I just learnt it, no arguments. No calculators, nothing! You just learnt it, end of story. (Mid Year 3)

Liam's mother: I still believe in the three R's, reading, writing and arithmetic…

Researcher: So what do you think in maths is most important? You talked about arithmetic.

Liam's mother: It sort of means everything, multiplication, your take aways, division. Everything you've got to have a grasp of these days. I find it's not one thing really, as long as you've got a grasp of the basics of all of them, you're going to be OK. (Early Year 3)

Peter's mother: We think maths is the most important subject at school.

Researcher: What is the most important part of maths to learn, do you think?

Peter's mother: Probably the practical maths questions that have to occur. I mean I can't imagine not being able to compute things. (Early Year 3)

Sibling rivalry in mathematics and parents' testing of their children were found to be a feature of family life which served to strengthen the children's beliefs that automatic recall of basic facts was what learning mathematics was all about.

Rochelle: Sometimes I do it [maths] with my Mum. She asks some questions when she's doing the ironing. She asks us the times tables and me and Cheyenne [older sister], we do the quickest who can answer them. (Mid Year 4)

Liam: Me and my sister have competitions. I ask Mum if I can have some questions and she [older sister] goes 'I'm better than you' and I go, 'OK, we'll have a competition then'. (Late Year 3)

Toby: Mum, she made up a big sheet of multiplication questions and I had to do every single one of them in the fastest time I could. (Late Year 5)

Dominic: I would get Mum to test me, like while we're in the car coming to school and things like that. (Late Year 4)

Georgina: Sometimes my Dad tells me, 'What's 12 plus 12?' and I try thinking. (Late Year 3)

In these examples, the questioning activities had sometimes been initiated by the children and sometimes by the parents. The development and perpetuation of beliefs about the importance and desirability of a child's being able to speedily answer mathematics questions provided at random by an adult can be seen as a two-way interaction between school and home.

Looking to the Archive

The prevalence of speed activities indicates widespread faith in them, enshrined in everyday enactment. Historical sources such as teaching manuals, syllabi, curricula and oral histories provide evidence that speed activities have been practised for decades in various guises. Atkinson (1996) for example, reflected on her schooling in Britain: "For many of us, we realise that we were brought up on a rather monotonous diet of mental arithmetic every morning (where we wrote down the answer and had them marked out of 20), arithmetic from a textbook every day, 'problems' (usually work sums) about twice a week… and arithmetic tests every Friday. Riveting stuff!" (p. 42).

In spite, or perhaps because of, the sheer ordinariness of speed activities in mathematical pedagogy, surprisingly few detailed descriptions of them exist in mathematics education literature, although a number of passing references can be found. Davis (1996) for example noted the "Mad Minute" in North American classrooms, where students are expected to complete as many computation questions as possible within 60 s. The history of mental arithmetic and memorisation of basic facts recall at speed and competition can be traced to the likes of Thorndike (1922) who believed that children learned through a "stimulus-response bond" and that regular repetition was essential for habit formation and connection making that contributed to memorisation (p. 70). He wrote: "Learning arithmetic…is in some measure a game whose moves are motivated by the general set of the mind toward victory – winning right answers" (pp. 283–284). Other mathematics educators stressed the need for understanding rather than mere recall. Wheat (1937) for example, criticised "the resort to drill" at the expense of comprehension, stating that, "reasonable speed and reasonable accuracy…are the proper goals of drill…[but] the pupil's progress must be measured in terms of what he understands, not in terms of accuracy and speed" (pp. 158–159). It would seem that the Thorndike approach has proved particularly compelling and enduring in mathematics classrooms.

Pedagogical texts show that speed in mathematics has been emphasised for many decades. Burn (1968) for example provides lists of quick-fire questions for children to use as practice, with introductory instructions for teachers such as: "The aim is to help children be quick and accurate with calculation" (p. i). Children are urged to, "Work as fast as you can and race yourself every day" (p. 2). The *Macmillan Mathematics Children's Recording Book Level 2b* (Beesey and Davie 1991) instructs students to, "Fill in the [basic facts] grid at two different times during the year. You will need a stop watch, or a clock with a second hand, to record how long it takes you to complete the grid" (pp. 52–53). The *New Wave Mental Maths*[2] workbooks are another example of the promotion of mathematical speed activities through commercial texts. This teaching resource provides a list of questions for every day of the school year, and a timed test for each Friday. Many instances were found in the study classrooms of the use of similar commercial texts that supported speed and competition in the learning of basic facts.

In its introductory pages, *Mathematics in the New Zealand Curriculum* (Ministry of Education 1992) supported a problem-solving approach to the teaching and learning of mathematics stating that, "students need frequent opportunities to work with open-ended problems… Such problems encourage thinking rather than mere recall" (p. 11). There was no suggestion in the introductory section that speed in any of the forms described in this chapter is desirable in the teaching of mathematics. On the contrary, concern was expressed that girls and Māori are under-achieving and/or losing interest in mathematics and in the case of Māori, there was special mention made of the need for a wider range of assessment techniques than, "traditional time-constrained pencil and paper tests" (p. 13). The curriculum later stated that students should be, "developing *instant recall* of basic addition and subtraction facts through a programme of regular maintenance" (Level 2) and "demonstrating the *instant recall* of basic multiplication facts" (Level 3) [Italics added]. "Instant" meaning "at great speed", suggests that the curriculum writers considered this skill to be very important. A tension exists within this curriculum between advocating a teaching approach that will remove the undesirable pressure of traditional methods, while continuing to value speed in the recall of basic facts.

In a Ministry of Education teachers' handbook *Developing Mathematics Programmes* (1997), practice and maintenance of basic facts was discussed in a special four-paragraph section called *Basic Facts*, under the general heading *Providing for Maintenance*. While the word *instant* was not used, it was stated that:

> …students must have *rapid* recall of the basic addition and multiplication facts. Being able to recall these facts *quickly* and easily through knowing them 'by heart' increases students' confidence, allowing them more time to concentrate on the higher-order thinking and communication skills they need to solve problems relevant to their level of development. Even when students understand the basis for addition and multiplication facts, they need lots of practice to make their recall *automatic*. (p. 25) [Italics added]

A list of possible strategies for learning and practising these facts was provided with the comment that, "Whatever strategies are used, they must be enjoyable and provide positive and immediate feedback to the students". While there was no suggestion that speed pressure be used as a means to teach or maintain the basic facts, in stating that students must have "rapid" or "automatic" recall of basic facts, the writers seemed to be suggesting that it is the rapidity of recall that determines whether a child "knows" a fact or not. Structural understanding of the facts, being able to derive unknown facts from known facts, and appropriate application of the facts in

[2]R.I.C. Publications (2000).

authentic contexts appeared to receive far less attention than speed of recall. Issues of understanding and memory are explored in Nuthall (2000) and Anthony and Knight (1999) who both stressed that “learning” and “recall” are complex cognitive processes and that meaningless rote memorisation and drill are ineffective. Nuthall argued that the quality of the activity itself is significant in the child’s development of understanding of the subject matter.

Mathematics was found to be the only school subject where speed of task performance was overtly valued through the official curriculum. While the Department of Education School Mathematics Booklets published in the 1980s did not emphasise speed in learning basic facts, more recent government mathematics texts overtly encouraged the use of speed activities. The *Figure it Out* series (Ministry of Education 1999a, 2000) in common use in many of the classrooms observed provided a vivid example of the linking of mathematics, speed and sporting competition in the activity *Beat yourself Down*, which instructed children to:

> Choose an addition or subtraction section and write down the answers in your exercise book as fast as you can. Use a stopwatch to time yourself. Your aim is to answer correctly all the equations in one section in the shortest time possible. Try a new section each day. Aim to increase your speed and accuracy each day. (*Figure it Out*, Level 3, Basic Facts, pp. 2–3)

Lists of questions were placed on a background featuring photographs of a boy in sports gear with stopwatch in hand and six pairs of children’s sports shoes placed around an athletics running track.

New Zealand was not alone in valuing speed in mathematics teaching and learning. In England’s *National Numeracy Strategy* (Department for Education and Employment 1999) implemented to raise children’s achievement in essential mathematics skills, a clear directive was given for teachers’ use of speed in everyday mathematics pedagogy: Rapid recall was frequently stipulated for example, “Year 1 pupils should…Respond rapidly to oral questions phrased in a variety of ways” (p. 30). Although *Quick Tens* and competitive speed games were not explicitly specified as effective teaching practice, pace was emphasised in the way lessons were expected to proceed. “In the first part of the lesson you need to: get off to a *quick start* and maintain a *brisk pace*; target individuals, pairs or small groups with particular questions” (p.13). The aim appeared to be to create an atmosphere of businesslike urgency through timekeeping and tempo. In USA, the National Council of Teachers of Mathematics principles and standards (2000) avoided all mention of speed, but speed was implied in statements suggesting that students should develop *efficiency* and *fluency* with basic number combinations (see p. 35).

Emphasis on speed continues to appear in revised primary mathematics curricula, as shown in the use of the words “automatic recall” in a curriculum report (National Mathematics Advisory Panel 2008) which stated that:

> Computational fluency requires the automatic recall of addition and related subtraction facts. It also requires fluency with the standard algorithms for addition, subtraction, multiplication and division. Fluent use of the algorithms not only depends on the automatic recall of number facts but reinforces it. (pp. 17–18)

Such statements serve to legitimise and endorse teachers' pervasive use of speed activities in mathematics classrooms.

The prevalence of mathematics speed activities as a dominant pedagogical device indicates a genre of practice embodied in and validated by the regulatory practices of school, supported by commonly used mathematical texts, reinforced in the home and reproduced by successive generations of adults who sustain this pedagogical device. Competitive games and written tests provided an immediate, tangible and quantifiable indication of a child's success or failure; at the same time they make the child visible as a mathematical subject. Evidence showed that the results of basic facts tests were the most recorded of teachers' assessments of children in mathematics. Teachers rarely expressed an awareness of, or concern about, - subjectivities created for children through routine use of basic facts tests and games. Because some children in the class displayed enthusiasm for such activities, teachers assumed that *all* the children loved them.

Speed Activities, Power and Control

In his analysis of mathematics education as a "culture" Bishop (1991) isolated what he believed to be its underlying values. One of these he called *control* saying, "there is no doubting the fact that when mathematics is understood and mastered it develops strong feelings of control, security and even mastery in the adept" (p. 71). Conversely then, it is likely that lack of mastery will develop strong feelings of powerlessness, insecurity, bewilderment, and failure in the inept.

Others have suggested that the exertion of pressure in mathematics teaching is linked to wider cultural practices surrounding power and knowledge. This feature of mathematics education has been noted by Bibby (2002) and Cotton and Hardy (2004) who looked particularly at the way competition is encouraged through standardised testing, and Boaler (1997b) who described ability grouping as survival of the quickest. Appelbaum (1995) linked popular televised quiz shows that echo the function of the test in mathematics education. Many of the teachers conducted speed activities in a remarkably similar fashion to the question–answer format of the quiz show producing children as contestants, who became winners or losers.

Parallels can also be drawn between the ways in which children were expected to perform during speed activities in the classroom, and popular culture surrounding competitive sport. In New Zealand, as in many other countries, competitive sport has become a significant part of everyday life and even of national identity (McKay 1991). Competitive sport values performance under pressure created by time constraints, difficulty of task and strong opposition. Winning is paramount. Winners are hailed as heroes and seen as powerful and masterful, while losers receive little respect or tolerance. Significantly, "Loser!" is commonly used as a common term of abuse.

When mathematics activities in the classroom resembled sporting competition, as in games such as *Shoot*, the same values were seen to apply. Arithmetical skills and knowledge in mathematics lend themselves to competition because mathematical subject positions – winners and losers – can be created through imposing time limits in which to produce correct responses to single-answer questions. Teachers' invention of games like *Around the World*, *Shoot* and *Buzz*, has harnessed the motivational nature of competition to endow learning mathematical "facts" such as the times tables, with what they believe to be worth and purpose in the eyes of their learners.

The belief that pressure motivated children to learn, was shown in teachers' statements such as Mr Cove who said, "I go fast because they either know them or they don't", indicating not only that speed of recall was the chief criteria for "knowing", but implied that going fast would sort out those who knew them and those who did not. By subjecting their pupils to the intense pressure of speed activities camouflaged as "check ups" or "games", teachers were able to exercise control. For children who succeeded at these activities, such as Liam, Toby, Dominic and Rochelle, their sense of worth as mathematical subjects was increased. The value attached to the winning position was derived from the ways in which winning was structured in such games as reserved for a few and won at the expense of others. Teachers in the study were observed consciously or otherwise, to manipulate speed activities in order that only a small group of children could ever be "winners". They did this by increasing the pace, decreasing the time limit or increasing the difficulty of the questions. By limiting access to success, they created and maintained an elite group. The bar was always set too high for a significant proportion of the children in the classrooms.

Fleur, Georgina, Peter and Jared needed more time to process their thinking than those who were most successful on these tests. Peter either knew or could derive most basic number facts as his accurate though incomplete test papers suggest, but he "failed" in some speed tests only because he did not produce answers as quickly as they demanded. For those children in this study for whom the expected speed of recall was unrealistic, high-pressure competitive activities not only produced them as failures and thus reduced their confidence, but also prevented these children from improving either their knowledge of the facts or their speed of recall. For those who were made visible as "too slow", the subjectification of these activities was profoundly negative. Fleur, Georgina, Jessica, Mitchell, Peter and Jared provide us with disturbing insights into the social worlds of children who fail, literally, to come up to speed in mathematics.

Speed as Mathematical Discourse

The research revealed that the speed pandemic in mathematics classrooms is resistant to change. Ms Fell's self-reflection on her use of such activities provides important insights into the social mechanisms by which these activities are perpetuated.

> Ms Fell: I went on a maths course where the lady said, 'Don't do it. Don't put questions on the board because if they don't know it, they're going to feel like they're failing, and if they do know it, they don't need to practise it.' And I thought, 'Oh, that might be a really good point,' and

> I came back and thought about it and then I thought, ‘But often it’s reminding them of things we’ve done’. (Mid Year 4)

Ms Fell was reluctant to alter her daily routine that began with ten speed questions. While she could appreciate the reasoning of the adviser, she rationalised her current practice as beneficial for the children because it “reminded” them of things they had done in previous lessons. The potency of this practice as a signifier for children as mathematical subjects was taken as natural. Justification of habitual behaviour can be explained as a process of discursive subjectification. For Ms Fell, the Quick Ten produced her as a subject – the mathematics teacher – and the children as mathematics students. Ms Fell perhaps discarded the advice from the adviser for its potential to undermine the social positions and truths created in the mathematics classroom. Ms Fell knew of no alternatives with which to replace this highly signifying event. Without a Quick Ten, teaching mathematics could become risky, unmanageable and lacking in an enacted “reality”. How could she be sure that children were “reminded” of what they had done without *Checking Up*? How else could she begin mathematics sessions without the familiar “opening scene”? How else could she control the whole class without her pressure system? How else could she “see” who was struggling and who was not?

Used as a managerial technique in the mathematics classroom, speedy recall of facts produced fast and slow learners. The frequency of speed activities in the classroom and children’s daily (self) production as mathematical subjects was demonstrably implicated in their subjectivities. They identified class members whom they believed to be good at mathematics by the speed at which they could produce answers and the scores they achieved in timed tests. The children were compulsorily subjected to speed activities, which for Toby, Liam, Dominic, Rochelle and Peter became a prime source of their achievement and confidence in mathematics, but for Fleur, Georgina, Jessica, Jared and Mitchell produced feelings of deep anxiety and inadequacy.

The research did not reveal evidence of any significant challenge to the entrenched use of speed tests and competition in these mathematics classrooms. Velocity appeared to be a deep-seated motif by which teachers taught and children learned mathematics, sanctioned within the wider discourse of mathematics education, and productive of mathematical subjects who can be measured, classified and positioned in the language of speed. This pedagogical apparatus of management shaped the mathematics classroom as a discursive site in which children as subjects were wrought in a power/knowledge bond. Learning the basic facts became a form of coercive labour, and *knowing* the facts, motivated and regulated in competition with others, a practice which overtly structured inequality through its creation of winners and losers. As this chapter has shown, the children made themselves accountable to this discourse in differing ways, some with pleasure, and others out of fear, as emergent subjects caught in its thrall. The following chapter looks to the ways in which mathematics constituted the children as mathematical subjects made visible in a *right* and *wrong* dichotomy, which intensified subjectivities enacted in contests and solo work.

Chapter 5
Error and Correction

When we were doing fractions it was really hard for me and I didn't get it and [the other children] were just going, 'Oh yeah, I know that one!' and they got it straight away and they were correct.

Georgina, 9 years

In this description of how she felt when the others in her class "got it" and "were correct" while she was still grappling to understand a new mathematical idea, Georgina spoke of the power that the "possession" of a particular skill or fact can produce. This chapter looks at how, in the children's experiences of school and home, mathematics was constructed as a specific way of operating with mathematical ideas, and how this not only safeguarded and procreated culturally derived views of what constitutes mathematics and its doing, but also structured and perpetuated the inclusion/exclusion signifiers by which children could be recognised (or not) as mathematical learners. Walkerdine (1998) described the development of the mathematics education debate in recent times as focused around perceptions of the purpose of teaching mathematics – whether it is useful on the one hand, requiring knowledge of rules and procedures that can be applied in appropriate situations, or whether it is a way of thinking, reasoning, proposing and testing on the other, requiring and leading to understanding of mathematical principles considered to be important for intellectual development applicable to life in general. She saw this as a procedural-propositional distinction in which the "basic skills" approach appealing to the certitudes of following rules to produce right and wrong answers is counterposed with approaches that emphasise investigation of a range of possibilities and where understanding is built and applied in the process. In this dichotomy, reason and logic are privileged in contemporary curriculum frameworks over the expedient everyday following of mathematical rules that may be effectively applied but scantily understood.

In the following sections, examples of everyday approaches to teaching mathematics in the children's classrooms are used to illustrate the ways in which the children as subjects were produced and positioned within the pedagogical discourses of mathematics Walkerdine described.

F. Walls, *Mathematical Subjects*: *Children Talk About Their Mathematical Lives*,
DOI 10.1007/978-1-4419-0597-0_5,

The Algebra Lesson: Georgina's Year 3 Classroom

From field notes, Island School, Mid Year 3

> *All the children are seated on the mat while Mr Solomon explains the mathematics work to be done by each group for the rest of the lesson.*
>
> Mr Solomon: I need Tapatoru [Georgina's mathematics group] to stay on the mat.
>
> *Seven children including Georgina remain on the mat while the others move off to their desks to complete the tasks allotted. Mr Solomon places a box of coloured blocks on the mat and asks the children to sit in a circle. He sits on the mat with the children. He explains that they are to model the sequence of counting numbers 1,2,3 … using the blocks. All the children take some blocks. Georgina arranges first one block in front of her, then two blocks behind them (further away from her), then three behind them etc (see* Fig. 5.1*) while Mr Solomon and most of the other children have made their arrangements from left to right as in* Fig. 5.2.
>
> Mr Solomon: *(To Georgina)* You need to get yours the way we've got ours.
>
> *Georgina either fails to hear or ignores the instruction and begins to rearrange her blocks, experimenting with vertical stacking arrangements for the sequence. No other children are doing this.*
>
> Mr Solomon: How many more in this set than that? (Points to the first block in his model, then the group of two)
>
> Georgina: (Touching her own blocks). There's one in that set, and two in that so that makes three.
>
> *Georgina rearranges her blocks to standardise the colours for each term of the sequence, thus emphasising the pattern. Mr Solomon and the other children find they are running out of room by representing the sequence in a left-to-right line, so some of them begin to adopt Georgina's system or similar. Mr Solomon appears to give in. He stops trying to make Georgina change hers so it looks like all the others.*

This episode illustrates Georgina's sense of pattern. Her spontaneous creation of a triangular arrangement of the blocks provided the potential for rich algebraic investigation such as "triangular" numbers. Georgina was perhaps beginning to recognise this when she added the first two terms of her sequence instead of

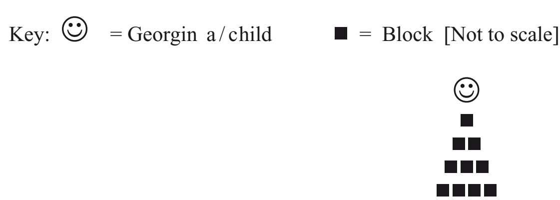

Fig. 5.1 Georgina's representation of counting numbers

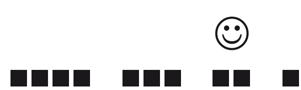

Fig. 5.2 Mr Solomon's and the other children's representation of counting numbers

simply stating the difference between them, as Mr Solomon had asked, although Walkerdine's (1988) study found that words such as "more" can be problematic as used in school mathematics. Georgina was so captivated by her own pattern-making that she continued with it even when the others were working in the "right" way – Mr Solomon's way. She showed keen spatial sense in her creation of a third dimension (height). Throughout this lesson, Georgina was experimenting, discovering, checking, justifying and communicating her thinking. These algebraic ways of working with the materials appeared to escape Mr Solomon's notice. His insistence on uniformity over-rode the possibilities that individual exploration such as Georgina's might have generated. During our conversations Mr Solomon often spoke in an exasperated tone of Georgina's failure to conform to expectations, but his reflections over the year suggested that although he recognised Georgina's difficulties with mathematics, he did not consider her incapable.

> Mr Solomon; She actually enjoyed and did really well on geometry, shapes and things like that so maybe she's a, um, spatial type person. (Early Year 3)

> Mr Solomon: Her negative attitude is not just to maths, it's right across the board. She's definitely capable but there's a blockage **…** She takes a while to pick up a concept and run with it. She needs two or three sessions to catch on. Once she gets it, she's away, but she doesn't always retain it. (Late Year 3)

Mr Solomon did not appear to have considered that if she were a *spatial person*, Georgina may have found the lack of recognition or support of her visual and tangible methods a significant barrier to her learning of mathematics. He viewed her failure to "get" or "retain" concepts as a *blockage* somehow linked to her *negative attitude* indicating that he valued procedure – compliance with the rules – over process.

Practice Questions: Georgina's Year 5 Classroom

From field notes, Motu School, Mid Year 5

> *Georgina's mathematics lesson begins as Mrs Isles, the teacher, writes some practice questions on the whiteboard as shown in* Fig. 5.3*.*

The children take out their mathematics exercise books and begin to answer the questions.

> Mrs Isles*: (Walking around the class looking at children's work*) Don't forget today's date. Head up today's date please. (*To Georgina who is using a ballpoint pen)* Don't do your maths work in pen. (*To the class*) Be careful about what the [operation] signs are saying. (*Georgina write in her book. See* Fig. 5.4)

> Mrs Isles: (*To Georgina, indicating the mistake in adding the digits in the tens column*) What's this? Eight and three and one more. (*Georgina does not reply*). What is this? You haven't answered me. (*After a moment, she leaves Georgina to work on the mistake while she attends to others. Georgina now attempts the second question. See* Fig. 5.5)

1. 439 + 285   2. 736 -265   3. 124 x 5   4. 25 x 32

5. $7\overline{)342}$ 6. Estimate 39 x 24

7. Round to the nearest 10
135, 472, 1,258

Fig. 5.3 Practice questions on the board, Motu School, Mid Year 5

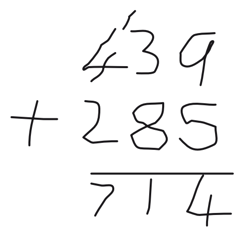

Fig. 5.4 Georgina's addition in vertical working form

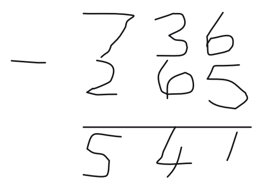

Fig. 5.5 Georgina's subtraction in vertical working form

Mrs Isles: (*Returning to Georgina's desk*) OK, tell me what you've done here (*Points to the 4*)

Georgina: Take seven and put it on the three. (*Indicating she has added 7 and 3 to make ten, from which she has the subtracted 6 to produce her answer of 4 in the tens column*)

Mrs Isles: The whole seven?

Georgina: One ten. (*Now uses her fingers to work out 13 subtract 6*)

This scene provides another compelling illustration of how teachers, children and the subject of mathematics itself are produced within a genus of performances that regulate mathematics classrooms the world over. Within this discursive practice, the teacher's expectation of standardised behaviour was enacted in the daily application of techniques such as the setting out of books, the writing implements to be used, and the placing of examples on the board. Teacher and children became visible as mathematical subjects in a normalising pattern of interactions. Standardisation extended to the algorithmic approaches students were expected to use to generate correct answers. Georgina made every effort to reproduce the manipulation of mathematical symbols in the way her teacher had demonstrated. Her "errors" and the teacher's unwillingness to spend too much time helping her since the activity was intended as "practice", were a stark illustration of children's difficulties with such methods. This exchange between teacher and student reflected a relationship in which Georgina was constituted as a "struggling" mathematical subject, her performance of the exercises an act of self-exposure and the teacher's monitoring an act of surveillance, judgment and "correction". Without the aid of a context which might have given meaning to the practice questions, the cognitive support of concrete materials to model the relative magnitudes and composition of the numerals and the operational processes involved in their addition and subtraction, or classmates with whom to discuss and clarify her thinking, Georgina did the best she could to replicate the pattern of manipulations as she had seen demonstrated.

Mrs Isles enacted a model of teaching written calculation methods that has been used for decades, reinforcing an accepted vision of the good teacher of mathematics as one who demonstrates and explains techniques, then tests and corrects children repeatedly until they reach a stage of fluent mimicry. Her comments, "What's this?" and "Tell me what you've done here," implied a mistake. Because Mrs. Isles did not probe Georgina's explanation of, "putting the 7 on the 3," and her incorrect naming of the "one" she was to take from the 700 as "one ten", this exchange emphasised correct replication of the rule rather than comprehension of the numerical concepts involved in the algorithm's invention and application.

In our conversations, Mrs. Isles spoke about Georgina as a mathematical subject whom she could position in the class according to her performance, which could be accurately gauged by means of written work.

> Mrs Isles: She's really not competent … generally with maths tests and things, I mean we have pre-tests and mastery tests and there you can see she's struggling. (Early Year 5)

> Mrs Isles: She does struggle. She needs a bit of a boost but she's not really lagging behind. At this school she would be in the middle of the bottom half … Her best [maths] topics are ones that don't involve too much problem solving and reading. She prefers hands-on maths more than written … she is quite good orally – doesn't show what she knows in written work. (Late Year 5)

Georgina was not the only child in the class observed to be experiencing such difficulties. While some children in the class appeared to be good at mathematics because they could "get their sums right", they may well have lacked any appreciation of the mathematical principles involved in carrying out the procedures they reproduced with such accuracy. Georgina explained her difficulties as a need to spend more time thinking about new ideas than classroom routines allowed.

> Georgina: I need time to like think about it. I can't just do it in, like, two minutes or a minute like the rest of the kids … (Mid Year 5)

For Georgina, "getting it" or not became a powerful indicator in her mathematical subjectivity as her opening statements in this chapter showed. Far from supporting the frequent claim that mathematics is a culture-free, universal and neutral body of knowledge as illustrated in the statement "mathematics provides a means of communication which is powerful, concise and unambiguous", (Ministry of Education, 1992, p. 7), classroom practice privileged particular ways of mathematical communicating to the exclusion of others (de Abreu 2002), and the children came to equate mathematical capability with the symbolic manipulations that produced right answers, as defined and validated by teachers, parents and textbooks. The children's beliefs about mathematics developed within the social contexts of home and school where authorised versions of the correct answer or procedure endorsed or negated their existing mathematical intuitions.

New Learning

As discussed in Chaps. 3 and 4, a typical mathematics lesson consisted of starter, followed by an activity related to the current mathematics topic. The teachers introduced new mathematical concepts either to small groups of children differentiated by age or ability, or to the class as a whole. In describing a regular lesson in his classroom, Mr Cove drew the distinction between a *teaching* lesson and a *practising* lesson and described his role as demonstrator in introducing children to new mathematical concepts:

> Mr Cove: If it's a teaching lesson then I would take step one of something and teach them that and I might say first of all, 'We're going to learn something new today,' and then I'd probably do it on the blackboard, or with blocks or whatever, depending on what it is, and then after going through it maybe myself, then I'd say, 'Why don't you sort of see if you can do it?' and they try and repeat what I've just done. (Mid Year 5)

This approach to the presentation of new mathematical ideas followed a well-defined pattern that was typical of the teaching practice observed in most of the classrooms. The following example from one of Jessica's Year 5 lessons highlights the taken-for-granted features of this phase of the teaching process.

The Tree Diagram Lesson: Jessica's Classroom

From field notes, Roto School, Mid Year 5

> *Jessica's teacher was conducting a statistics unit over several weeks. In the previous session, she had taught the children to record possible outcomes using an array, and at the beginning of this lesson, she revisited this procedure to illustrate the possible outcomes for two tosses of a coin. She then introduced the new learning.*
>
> Ms Mere: Have you seen a tree diagram?
>
> Alice: (*Calling out*) First we have a stem and leaf graph, now a tree diagram! I've seen one but it's hard.

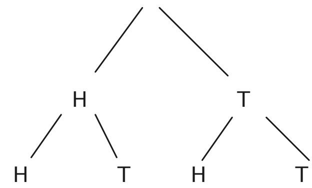

Fig. 5.6 Tree diagram 1 on the blackboard, Roto School, Mid Year 5

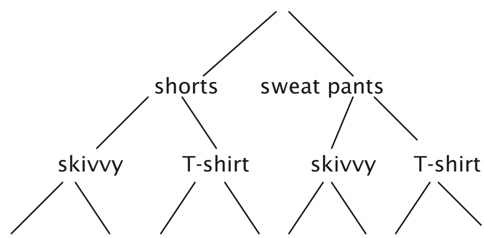

Fig. 5.7 Tree diagram 2 on the blackboard, Roto School, Mid Year 5

Ms Mere: Well, this is what it looks like with our heads and tails. (*Draws on blackboard,* Fig. 5.6)

Ms Mere: So you just follow the branches. (*No demonstration given*) This is just a different way of doing it. Now we're going to do the same for the clothes problem we did yesterday. (*Drawing on the blackboard as in* Fig. 5.7)

Ms Mere: Any questions? *(Child raises hand)* Yes, Lettie?

Lettie: Could you have more things?

Ms Mere: Of course. *(Adds sneakers and sandals to the bottom of the diagram)*

Alice: It looks like mountains.

Tess: No, houses.

Ms Mere: Right, now we're going to practise. (*The children take out the worksheet they were using the day before*) Please, quiet now, have a look at the worksheet I've given you so you don't have to ask unnecessary questions. It's very important to notice that you can either do it top down or from the side like there (*Indicates example on the worksheet that runs horizontally*) I didn't do that on the board.

(*The children are now expected to work alone. Appearing unsure of what to do, Jessica glances at the book of the child on her right, and then raises her hand. The teacher does not respond. She is helping others who have also raised their hands. Jessica puts her hand down. She draws the diagram sideways in her book as depicted on the worksheet. Because the page is already ruled into two narrow vertical columns, the diagram does not fit so Jessica rubs it out and reduces its size. When finished, she is unable to list all the possible outcomes because reading the 'branches' was not clearly demonstrated by the teacher. It is evident that Jessica has not understood the concept*)

As this extract shows, not all the children understood the mathematical ideas or procedures the teacher had demonstrated. Jessica was one of these. The lesson following the same sequence of actions as that of Mrs Isles and Mr Cove, beginning with teacher exposition during which children were to watch and listen, asking questions only when invited to do so, followed by children working alone applying the same procedure with a different example. During this time the teacher checked, assisting individual children where "necessary".

Typical of the teaching practices observed, this pedagogical style operated on the understanding that mathematical knowledge consisting of eternally fixed and universally reliable facts, rules and procedures can be transmitted from teacher (expert) to child (novice) without the interference of social static. As shown in Chap. 1, Ms Mere reinforced the widely accepted reliance on formal written forms of representation in mathematics to the exclusion of modelling, acting out or student discussion. In a relationship constructed in practice, this mode of teaching and learning of mathematics created the subject positions of teacher as instructor/taskmaster and child as apprentice/worker. The reason for using tree diagrams was never established, nor was any attempt made by the teacher to link the worksheet contexts to real life experiences of relevance to this particular group of children. As with many of the mathematics lessons observed, purpose and *mathematical meaning* were therefore overshadowed in this lesson by the *procedure* which produced teacher/learner as subjects and the subject of mathematics at the same time. Had Ms Mere behaved in any other way, it was possible that neither she nor the children would have been able to recognise themselves, or the mathematics they were attempting to teach and learn, in this unfamiliar social act.

Noted by Brousseau et al. (1986), this way of presenting new mathematical ideas to students followed a *cultural script*, which Stigler and Hiebert (1997) described:

> Teaching is a cultural activity. Cultural activities often have a 'routineness' about them that ensures a degree of consistency and predictability. Lessons are the daily routine of teaching and are usually organised according to a 'cultural script' … In the acquisition phase, [in a typical Grade 8 classroom in the USA] the teacher demonstrates or leads a discussion on how to solve a problem. The aim is to clarify the steps in the procedure so that students will be able to execute the same procedure on their own. In the application phase, students practise using the procedure by solving similar problems to the sample problem. During this seatwork time, the teacher circulates around the room, helping students who are having difficulty. (p. 18)

The reading of classrooms as cultural sites in which (prewritten) scripts are followed, diverts attention from the role of the power/knowledge dualism as constituted in socially scripted practice, to inscribe and position teachers and learners in their localised and contingent acts of inter-subjectivity. In the tree-diagram lesson, the spontaneous vocalisations of some children in response to the unfamiliar nature of the terminology and diagrammatic representations used in the lesson – "first we have a stem and leaf graph, now a tree diagram!"; "it looks like houses"; "no, like mountains" - demonstrated how the children were actively engaged in taking on the new information, personalised in their links to familiar objects.

In making connections for themselves where the teacher's approach was failing to make sense, these students were positioning themselves as agents in their own learning. Jessica was less confident about creating or asking for such connections.

Playing the Question/Answer Game: Dominic's Classroom

From field notes, River School, Early Year 4

> *The children are seated on the mat in front of the board. Mr Swift writes some instructions on the whiteboard (*Fig. 5.8*).*
>
> *Mr Swift then begins a lesson on place value with a series of questions for the whole class. This question-answer session is designed to revise concepts introduced the previous week. The questions are asked in such a way as to give the impression that there is one correct answer for each and Mr Swift fires the questions in a 'brisk' voice as though he expects rapid answering.* [The expected answers are shown in brackets].
>
> Mr Swift: What we are doing in number at the moment? [Answer: place value] What did we do last week? (*Pause*) … beginning with [the letter] 'a'? … [Answer: abacus] (*Chooses a child to come up and draw a three–bar abacus on the whiteboard*) Those little stick things, what are they for? *(When the correct answer is not forthcoming)* What do they do? What are they? What are the upright pieces on the abacus for? [Answer: for showing hundreds, tens and ones] What's after the thousands? [Answer: Tens of thousands] Which arm would you use for the number of people in a car? [Answer: the 'ones' arm] *The children are then directed to do the questions on the board.*

[Note: These children were never shown an abacus, much less given the opportunity to use one.]

The discourse in this typical teacher–student exchange was characterised by a distinctive kind of questioning. Almost every one of the teachers' questions heard during the 3 years of observations of mathematics lessons were *closed*, that is, required one correct response, as this example shows:

> Mr Swift: How many times does five go into fifteen? (Mid Year 4)

One, ten, hundred, thousand, million.

Put these numerals in written form.

15, 48, 480, 4800, 75,641

Put these numbers in numeral form.

Seventy six, fourteen thousand, seven hundred and fifty-six, two hundred and five, seven thousand and seventy seven, nineteen thousand, one million two hundred thousand.

Place these in order from biggest to smallest

Fig. 5.8 Blackboard tasks, River School, Early Year 4

This kind of questioning implied that there is only one correct answer to mathematical questions, that such an answer is a non–negotiable "fact", and that matching the correct answer to an externally posed question is indeed the point of mathematics. Mr Swift's question above ignored the children's many ways of knowing, learning, understanding or justifying this "fact". On a later visit, another exchange was observed between Mr Swift and his pupils. In order to revise and consolidate mathematical knowledge introduced in recent lessons, Mr Swift again posed a series of quiz–like questions, in response to which the children attempted to provide correct answers.

Mr Swift: What is statistics?

Tina: (*With a questioning inflection implying, 'Am I right?'*) Gathering information?

Daniel: What we did yesterday?

Mr Swift: When we do a graph, what do we put across there?

Daniel: You've got to put the 'x' and the 'y'.

Mr Swift: What do we call those lines that we've called 'x' and 'y'?

Daniel: (*Calling out*) The 'y' goes down and the 'x' goes across.

Dominic: (*Invited to answer*) I know what the bottom one is – axes.

Mr Swift: They're both called axes. Good boy. (Late Year 4)

This pattern of teacher questioning and child answering is well-recognised (Bussi 1998; Maier and Voigt 1992; Edwards and Mercer 1987). Their analyses showed that in a typical mathematics classroom, the teacher *initiates*, eliciting pupil *response* and the teacher evaluates the response through *feedback*. Edwards and Mercer, citing Stubbs and Robinson (1979) referred to this dialogical structure as the I–R–F exchange. Lemke (1990) who examined discursive patterns in science classrooms, called this "triadic dialogue", and elaborates on the structure of a typical sequence:

[Teacher Preparation]

Teacher Question

[Teacher Call for bids (silent)]

[Student Bid to Answer (hand)]

[Teacher Nomination]

Student Answer

Teacher Evaluation

[Teacher Elaboration]

The bracketed steps are not always included in the exchange. (p.8)

Possible disagreement or alternative views in mathematics were either tacitly negated and/or overridden in Mr Swift's interaction above by the powerful use of *we* statements. *We* statements presume an authoritative voice speaking from beyond the classroom, and a non-negotiable group agreement about mathematical language and procedures to be used. This characteristic of the traditional dialogue of mathematics classrooms was examined by Pimm (1987). Shared understanding of specific knowledge and one correct answer or procedure, was implied by the use of *we* or *us* in many of the teachers' questions in the classrooms observed, evident in the following typical examples:

> Miss Fell: [Place value] What do we call this place? (Pukeiti School, Mid Year 4)
>
> Miss Field: [Working form addition] What's the first thing we have to do? (Hill School, Late Year 4)
>
> Ms Seager: [Fractions] What does the top number tell us? (Roto School, Mid Year 4)

Teachers also frequently used *me* in their verbal interactions, reinforcing the I–R–F exchange structure in which, in a controlling role, they unwittingly defined the purpose of mathematical activity as pleasing the teacher:

> Mr Waters: Can anyone tell me what the pattern is? (Spring School, Mid Year 5)
>
> Ms Summers: Who can tell me about a rectangle? (Beach School, Early Year 3)

Dillon (1985) describes how questions of this sort, rather than fostering a rich exchange of ideas, foil such communication. Worksheet and textbook questions replicated the I–R–F exchange structure in a written form with closed questions requiring correct answers which were often provided at the back of the book. Teachers usually evaluated the children's answering in terms of accuracy alone, as in the following situation:

> Mrs Meadows: (*To a child who approaches her with her maths exercise book for feedback on her work*) You haven't got this one right, and you haven't got this one right and you haven't got this one right. (Pukeiti School, Mid Year 5)

In the case of textbook questions, evaluative feedback was supplied not only by the teacher's marking, but also by the presence of the *authoritative other* in the form of answers provided in the back of the book. Within the classroom climate of closed questions, teachers were often heard to fish for the one correct answer and then praise the child who could produce such a response. In many instances, teachers did not recognise alternative mathematical approaches or understandings for what they were. The following story illustrates how Peter's teacher inadvertently rejected a mathematically sound and legitimate method of arriving at the "correct" answer she was seeking.

Getting it Right: Peter's Classroom

From video recording and field notes, Beach School, Mid Year 3

Peter's group is participating in an activity where five and six-digit numbers are to be placed in order. This requires an understanding of place value. Peter's group is sent out to the school car park where each child is to collect ten different numbers from the registration plates of the parked *vehicles. Peter carefully looks around at the cars, before selecting and recording his ten numbers.*

When he returns to the classroom he finds that other children have already started on the next part of the activity – ordering the numbers. The teacher has explained to the children that the numbers are to be placed in ascending order. On a large piece of paper, Peter carefully begins to write his numbers in order. Unlike the other children who have all started with their smallest number at the left-hand side of their pages and are writing their numbers in increasing magnitude in a horizontal line towards the right, Peter begins at the top of his paper with the largest number and works downwards, the numbers decreasing in magnitude one beneath the other.

When he is about halfway through this process, some of the other children have finished, and Ms Summers, the teacher, comes to check their work. She then approaches Peter. All the placements of his numbers are correct at this stage demonstrating a sound understanding of the mathematical concepts the task requires. However, Ms Summers does not accept what he has done.

> Ms Summers: (*Looking at Peter's work*) No, Peter, I said you were to put them in *ascending* order.
>
> *Peter looks bemused. He may have been thinking that that was surely what he was doing. His method was more literal than that of the other children, because when finished, he would be able to read his numbers from the bottom of the page, to the top in ascending order.*
>
> Ms Summers: (*Seeing the confusion on Peter's face*) Simon, could you help Peter please?
>
> *Simon, proceeds to take Peter's pencil, another piece of paper, and rapidly write Peter's numbers from left to right from smallest to largest, while Peter looks on.*
>
> Simon: (*To Peter*) You getting the hang of it?

Had Ms Summers taken a moment to consider Peter's approach, she may have made some discoveries: that her instructions regarding the way the numbers were to be presented on the page were ambiguous, that there was no mathematical reason why the numbers *must* be written horizontally from left to right to represent ascent, or that Peter's mathematical thinking in performing the task was sound. Her preconceptions about how the task should be done were likely to have been based on the familiarity of convention. "Left-to-right" was no doubt the way that she was used to seeing a written sequence of numbers. While understandable, her inflexibility when confronted with an alternative response denied Peter the opportunity either to choose a method of representation that made most sense to him, or to explain his method. In turn, this denied the other children a learning experience through seeing that there was more than one way to arrive at an appropriate arrangement of the numbers. Most importantly, it denied Ms Summers, an important opportunity to assess Peter's understanding of place value, which lay at the mathematical heart of the task.

In the 3 years of observation, it was noted that Peter was a child who worked at mathematics tasks methodically and systematically, exhibiting a strong sense of logic and order. These would seem to be most useful mathematical skills. He worked quite slowly compared to classmates, seldom completing mathematics tasks before the lesson was over. His teachers remarked that he was quiet, shy, and reluctant to communicate. In all the time he was observed, he was rarely seen to voluntarily share his ideas or answer questions in classroom discussions of mathematics, consequently his teachers often had little idea of what, or how, Peter learned.

Researcher: Do you usually put your hand up when the teacher asks questions?

Peter: No.

Researcher: Why is that?

Peter: I'm not sure.

Researcher: How do you feel when the teacher asks you a question and you haven't got your hand up?

Peter: Sort of bad.

Researcher: Why is that, Peter?

Peter:'Cause I won't know it.

The place value lesson perhaps helps to explain Peter's reluctance to communicate his mathematical ideas. While Peter had developed his own ways of working things out, he had learned to have little faith in them since they were routinely unrecognised or devalued by his teachers. Other children in Peter's classes were also observed to offer mathematically sound ideas only to have them rejected by his teachers. Within the classroom climate of closed questions, all but the most confident children were put off answering questions for fear of being "wrong".

From video recording, Beach School, Late Year 3

Mr Ripley is a pre-service teacher on practicum. He is marking a maintenance question in the daily Quick Ten. Shape A has been drawn on the board, as in Fig. 5.9*)*

Mr Ripley: What is the reflection of this shape?

(*Nadine puts her hand up and is chosen to draw her answer on the board. She draws shape B beneath shape A)*

Mr Ripley: No. Someone else?

(*Peter is watching intently but keeps his hand down. Jack is now chosen. He draws shape C*)

Mr Ripley: (*To Jack*) Well done. That's exactly what I was looking for. (Late Year 3)

Mr Ripley was expecting a specific response. He appeared to hold a fixed idea that the line of reflection should be vertical rather than horizontal, and was therefore unable to consider alternatives. In this case Nadine's response was likely to have been mathematically justifiable. While Mr Ripley may have interpreted her answer as illustrating translation rather than reflection, had he asked Nadine to explain and justify her

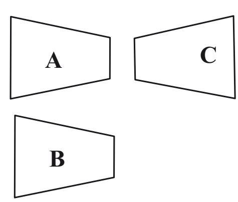

Fig. 5.9 Reflections of a trapezium, Beach School, Late Year 3

answer, he may have discovered that she had developed an excellent understanding of the concept of reflection. He could then have asked whether there were any other ways that the trapezium might be reflected. The following exchange provides another example of teacher expectation failing to recognise logical responses.

From field notes, Beach School, Early Year 4

> Mrs Waverley: What would I see wrapped around a cylinder? (*To a child with his hand up*) Yes James?
>
> James: A rectangle.
>
> Mrs Waverley: (*Crossly*) Don't be so silly, James. When you can give me a sensible answer, then I will ask you! (*Peter listens, but does not raise his hand*)

James appeared bewildered. His answer seemed to be mathematically logical, demonstrating spatial visualisation and knowledge of the properties of a cylinder. Mrs Waverley did not ask him to explain. By means of hinting and prompting she elicited from another class member the anticipated answer of *Gladwrap*, a brand of plastic film used for wrapping food. Again, Peter remained silent during this episode. Like many of the other children, he appeared to have adopted the protective strategy of keeping a low profile.

Skemp (1978) distinguished between what he termed *instrumental* and *relational* understanding. He described instrumental understanding as "rules without reasons" (p. 9), and relational understanding as "knowing not only what to do, but the reason why". He argued that these ways of knowing differ so fundamentally that they can be almost be regarded as different kinds of mathematics. Neyland (2009) similarly distinguished between *ideas* and *facts* in teaching mathematics – ideas being something that can be discussed and considered from different angles and facts as static and non-negotiable. Skemp also believed that from a young age, children develop conceptual structures ("schemata") or internalised representations of the world, many of which are well developed before children reach school, and continue to develop throughout their lives. These may include representations of mathematical ideas, such as the sequence of counting numbers. Where the methods of representation that are modelled or expected in the classroom, for example numbers always being represented in a sequence from left to right as in Peter's lesson with Ms Summers, do not match with or admit expression of, children's unique and personal schemata, there is potential for confusion, bewilderment or even conflict. Children might, for instance, visualise numbers arranged in order in one of many possible ways including in a zigzag pattern such as found on a Snakes and Ladders board, from bottom to top as found on a thermometer, (Peter's way) or from foreground to background as though viewed down a street, the magnitude of house numbers increasing with distance from the viewer. Dehaene (1997) and Lakoff and Núñez (2000) investigated the development of individuals' mental images of number representation, describing these as "cortical maps" or "cognitive metaphors". It appeared that none of the teachers in the study were aware of the many possible ways individuals might conceptualise numbers, and of the contradictions or cognitive disruption that may have been created for the children through restricted conventional representations.

Many other instances of teachers' rejection of mathematically sound alternatives in favour of one correct answer were noted during classroom observations.

Toby's group has been called to the mat. They have been estimating the cost of a list of groceries listed on a worksheet.

> Mrs Kyle: Who's got a really good way of estimating and working it out? I've got a really good way. (*Toby keeps his hand down. To a girl who has her hand up*) Yes Laila?
>
> Laila: You could see how many things were the same [price] then how many of those there are. [Suggesting multiplication as a strategy?]
>
> Mrs Kyle: (*Not responding to Laila's idea*) Angus?
>
> Angus: You could do rounding.
>
> Mrs Kyle: Excellent, Angus. That's what I was thinking of. (Bay School, Mid Year 4)

By failing to respond to Laila's suggestion, Mrs Kyle dismissed it, considering only her "really good way", as the correct one. Extracts from the classrooms of Dominic, Peter, Georgina and Toby also show how the teachers' interactions with children followed the same I–R–F exchange structure. This style of questioning seemed to be less about finding out how the children were thinking, than deployed as a strategy for deriving, legitimising and reinforcing the teachers' ideas of one correct answer or procedure. This pattern of classroom discourse constructed mathematical knowing as dichotomous: right or wrong. Mathematical learning was in turn constructed as a process of recognition, memorisation and reproduction of correct answers and procedures brokered through teachers' questions and their selection or rejection of children's responses.

Error and Correction

Through everyday interactions in the classroom, right and wrong were in constant definition and reinforcement. Getting correct answers was verbally praised, rewarded and hailed as a sign of success.

> Miss Fell: Who got that all correct? Give yourselves a big clap. (Mid Year 4)

Teacher reinforcement of correct answers consisted of comments such as *yes, perfect, correct, right, well done, absolutely, excellent, spot on, good girl/boy.* Incorrect answers received teacher responses such as *wrong! no, someone else?, not quite, nearly, good try, but …, who can help her?, you weren't listening, have another go.* During 3 years of observation, teachers were almost never heard to ask children how they had arrived at their answers or to explain why an incorrect answer might be incorrect.

The classroom routine of marking written work as right or wrong was observed in every one of the classrooms visited. This practice operated as a powerful symbolic act in the learning of mathematics, one which appeared to be related to social gains of success measured in comparison with peers, and dependent on extrinsic signs such as ticks, crosses and scores. Children became so habituated to this form of evaluation, that they relied almost entirely upon the teacher or textbook to verify their answers (Frid 1993; Boylan et al. 2001). The possibility of alternative or multiple answers to any given question was seen to disturb both teacher and child as illustrated in the following example:

From field notes, Pukeiti School, Mid Year 5

The children have been working through some questions on data interpretation from the NCM textbook. The teacher has called them to the mat for marking. The teacher asks a child to provide the answer to a question involving a dot plot of people's activities in the weekend.

Damien: Four.

Mrs Meadows: That should be the first answer.

Fleur: I wrote sentences.

Mrs Meadows: Well that's good but takes time.

Damien: I counted the dots.

Mrs Meadows: That's what you've got to do. That's correct because one dot represents one person.

Olivia: I thought someone could have done more than one thing.

Mrs Meadows: (*Studying the graph for some time. Finally.*) That's correct. You can't tell.

Nathan: Our answers are wrong then, because you can't just count the dots. So what *is* the answer? (*He looks frustrated and turns to the answers at the back of the book where the answer of '4' is given. Nathan marks his answer* [4] *as correct)*. (Early Year 5)

Without Olivia's noticing of the ambiguity of the situation on which the textbook question was based, and her confidence in challenging the answer that was so clearly validated by both teacher and textbook, the soundly reasoned suggestion that a number of answers to this question might be possible, might never have been raised. Nathan and other children became visibly agitated at the thought that the question might have no *single* correct answer, since this situation had most likely never arisen in their experience of learning mathematics. They were more intent on marking their work than on discussing mathematical meanings.

Not only were correct answers reinforced, but also the correct methods of production. The teachers were often quite insistent about the precise way things were to be done.

Mrs Field: (*Speaking of data representation*) You must put the title 'Pictograph' on your graphs. (Hill School, Late Year 3)

Mr Swift: (*Speaking of data representation*) You've got to put the 'x' and the 'y'. (River School, Late Year 4)

The children were also observed to keep one another on the straight and narrow.

Emma: (*To Jessica who is creating a problem for others to solve and including the answers)* You've done a mistake. You're not supposed to write in the answer. (Mid Year 4)

Tony: (*To Georgina who is drawing a picture in her maths book in answer to a money question)* Why are you doing that? You better rub it out or you'll get in trouble. (Late Year 4)

These comments show that the children had come to believe that doing mathematics in the approved and uniform fashion as prescribed by the teacher, was more important than finding their own methods or developing viable variations. Alternative approaches, regarded as transgressions, were likely to result in "getting in trouble".

Teachers' endorsement of responses they considered to be the best was seen as another taken-for-granted of the dominant teaching approach. The terms "*clever*", "*efficient*" or "*sophisticated*" were commonly used by the designers of the New Zealand's numeracy initiative to describe the kinds of answering methods that children should be encouraged to adopt. The project coordinators were quoted as saying, "the framework aims to support children to solve numerical problems in the *cleverest* ways," "to empower children to use more advanced strategies" and that it is about, "children's ability to think more cleverly and efficiently" ("What is the Learning Framework?" 2001, p. 4). As discussed in Chap. 4, *efficiently* generally meant *speedily*; for a number of the children, this expectation was unreasonable and created anxiety. The numeracy project strategy stages were arranged in a sequential progression from bottom to top, in which *cleverness* was presented as an increasing demonstration of abstract thinking. Children were to be trained to produce correct answers to increasingly difficult questions without recourse to the mental imaging or modelling with manipulatives that less clever strategies engaged. In Chap. 6, altitude metaphors and the differentiating effects on the children's mathematical identity of the hierarchical view of learning will be further discussed. Cleverness and efficiency may appear to be both sensible and admirable aims. The danger of this approach lies in the teachers' privileging of only those behaviours recognised as "clever" and the subjectification of children implicated in such recognition. When cleverness and efficiency are combined as classifiers, those children in the class whose answers can be judged by teacher and classmates as laborious and/or superficial in comparison with others, are produced as less able mathematical learners.

Introducing Written Algorithms: The Right Way to Calculate

In Years 3 and 4, teachers began to introduce formal written procedures for multi-digit calculation, firstly addition, then subtraction and by Year 5, multiplication and division. Of all the mathematical procedures the children learned, these were especially significant for the children since they were the most often cited as the mathematics skills they had been learning. Mr Ford provided an example of the way teachers taught such procedures.

> Mr Ford: (*When asked whether Dominic found anything in maths difficult*) Just recently, they've done work like longer multiplications, just the structure, you know, the format of how it works, it's something I'm teaching, anyway, so the first few times that we've gone through it, um, the main problem for Dominic is just getting things out of place, you know, in the columns, and I drill that part of them every day: Keep everything in line, draw the columns, the zero, you put the zero down the bottom, it goes in the 'ones' column', then they're all looking at me, and then I go, 'Shove the zero in, shove the zero in here.' But that's logical, just part of the whole thing. (Early Year 5)

These apparently logical procedures presented difficulties for a number of the children. The following extracts were typical of the children's responses when asked about things they had been learning in mathematics.

Researcher: Is there anything in maths that you can do better now?

Toby: Yes, piling.

Researcher: Piling?

Toby: Like, you pile, um, times tables, so it's like one number here and then there's the times …

Researcher: You could show me here *(giving him a piece of paper.*

Toby: Do an easy one … like, I don't know.

Researcher: Like twenty-three times six or something?

Toby: Yeah, it could be twenty-three times six. *(He writes this in the vertical working form he has been taught)* (See Fig. 5.10). Like that. Then, well, I've got most of them wrong'cause I don't know how to do this and now that I've learnt, six … six threes … um, eighteen. (*He writes 8 below the 6*) And then you put the one up here. (*He writes a very small 1 above the 2*) Six twos. (*Thinks, then writes 11 to the left of the 8*) Ah … I think it's ten and then plus one equals eleven so it'd be … (*Points to answer 118*)

Researcher: One hundred and eighteen?

Toby: Yeah.

Researcher: Thanks. That's great. And does Mrs Kyle call that 'piling'?

Toby: She doesn't, but I do.

Researcher: That's your special name for it?

Toby: (*Smiling*) Yeah.

Although Toby confidently followed the procedure he had been taught, he did not produce the correct answer. Believing the method to be immune to error, he did not check the accuracy of his answer in any other way. He appeared to be so intent on manipulating the numbers in the way that he had learned that the sense of the "question" was obscured. Hart (1986) found that children aged 8 and 9 years became confused and made mistakes when confronted too abruptly with the formalised use of written algorithms. When using materials to represent the situations,

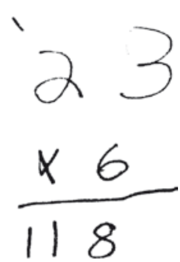

Fig. 5.10 Toby's "piling" (Mid Year 4)

they were less likely to make such errors. Other research suggests that children's learning of calculation routines must build from the personal methods of calculation that children develop based on their understandings of how numbers work (Fuson et al. 2001; Carpenter et al. 1999; Hiebert et al. 1997; Carraher and Schliemann 1985). Recent approaches to teaching early numeracy (e.g. Wright et al. 2006) promote the use of mental calculation before the introduction of methods such as the one Toby had been taught, arguing against traditional approaches to the introduction of these calculation procedures. This had been noted earlier in the New Zealand's numeracy development program: "Many children were not ready [in the past] for the ideas, so learning the vertical setting out ended up as rote learning … the suggestion is to delay the teaching of the written form until children show the mental acuity to be able to solve [problems like] 51–27 mentally". ("What is the Learning Framework?" 2001, p. 4)

Fleur had also learned how to calculate using written working form, and her vocalisation as she demonstrated how to subtract with renaming, shows how she made sense of these procedures by manipulating the numbers following learned rules.

> Fleur: I'll just do my favourite one. Twenty-four. (*Writes 24, then –46 underneath it as in* Fig. 5.11) Oh I haven't learnt how to rename. … *(realising the 4 in 46 is bigger than the 2 in 24), but still believing this 'sum' to be possible, according to the instruction she has been receiving in the classroom, if only she knew how to 'rename'.)*
>
> Researcher: So put 16, say. How would you do that one?
>
> Fleur: (*Changes the 4 in 46 to a 1*) Well I'd put a 1 above the 2, and you'd cross out the 4, um, 14 up here, but if you had a zero you'd put a 10.
>
> Researcher: I see.
>
> Fleur: And you'd put a 1 above the 2 and you'd cross out the top numbers and you'd go 'Fourteen take away six', and you'd go 'One take away one.'

The term "my favourite one" suggested that this particular example had been memorised. Fleur had, in fact, been seen on an earlier occasion to use this sum to demonstrate the skill she had supposedly "learned". However, she made an error in her choice of 24 subtract 46, [instead of 16] which *appeared* possible to her. The only barrier she identified to successfully computing this subtraction was the need for "renaming" in the tens column. For Fleur, the abstract layout and procedure were of far greater significance than the sense of what the symbols and procedure represented.

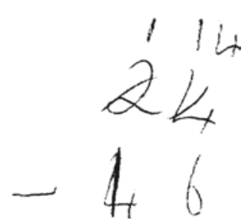

Fig. 5.11 Fleur's "renaming" (Late Year 4)

Rochelle enjoyed learning written mathematical procedures, from which she seemed to gain a sense of satisfaction and security.

Researcher: What do you like most about maths?

Rochelle: Working form.

Researcher: Can you show me some of that?

(Rochelle uses a piece of paper to demonstrate. She works in silence. She writes 45 x 5 in working form, and then moves her pencil to indicate she is multiplying 5 x 5. She records 5, on the right-hand side of the answering space, then a small 2 above the 4. She then appears to be multiplying 5 x 4, and adding two. She produces the answer of 225, as shown in Fig. 5.12*).*

Researcher: That's pretty impressive. So what's this little '2' up here, Rochelle? What was happening there?

Rochelle: That's the ten, you put the tens up the top … and the ones on the bottom.

Researcher: Was it hard for you to learn that?

Rochelle: No.

Rochelle, like Fleur and Toby, was also very taken with such methods. Later in the year, however, Rochelle reported that she had experienced difficulty with the working form involving the multiplication of two double-digit factors and called this kind of multiplication "times tables" as had Toby. For these children the everyday term *times tables*, which originally referred to the multiplication facts to 12 × 12 arranged in "table" form, was used synonymously with every other situation requiring multiplication. Significantly, Rochelle had been taught this procedure the previous year but could not remember how to do it, suggesting that her learning was based on memorisation.

Rochelle: I know how to do everything Mrs Ponting gives me. Except for there's the step thing. I can't do the three-step.

Researcher: Is that for addition, subtraction, multiplication, division?

Rochelle: Times tables. We done it last year but I forgot. (Mid Year 5)

Liam also complained of experiencing difficulty in learning this procedure:

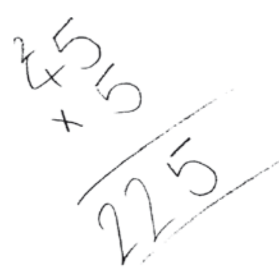

Fig. 5.12 Rochelle's "working form" (Early Year 5)

> Researcher: Is there anything you've really hated?
>
> Liam: Double-digit times. (Late Year 5)

None of the children seemed to incorporate checking or estimating into their learned procedures, although *Mathematics in the New Zealand Curriculum* (1992) emphasised the importance of this skill in learning to compute by repeating the achievement objective, "make sensible estimates and check the reasonableness of answers," in each of the levels 1–4 of the number strand (pp. 32, 36, 40, 44). Edwards and Mercer (1987) described the kind of knowledge presented in this fashion as *ritual* knowledge stating that, "procedural knowledge becomes ritual where it substitutes for an understanding of underlying principles" (p. 97).

Teachers' failure to discuss computational errors as an accepted part of learning and the equal treatment of all errors as simply "wrong", indicated that the classroom practice of training children in computational techniques was not founded on an encouragement of diverse ways of mathematical thinking, but on a form of drill in traditional fail-safe methods by which teachers could recognise themselves as good teachers of mathematics, and children as capable of doing "real" maths. Such algorithms – layout and procedures – for calculating, variants of which are commonly taught in primary schools today, have been in use for many centuries, as Duncan (1959) noted:

> … it should be remembered that a standard setting out [of a sum] is a very refined, condensed form of the process and in the same way that it took a long time for such a form to be evolved in history of arithmetic, so it may take a long time for children to understand completely the final setting out which they are expected to use … the ultimate goal is the establishment of a clear and well-understood pattern which can become a firm, efficient, habitual response" (pp. 11–12).

Because the setting out procedures, as demonstrated by Georgina, Toby, Fleur and Rochelle were used exclusively in all of the sample schools, the children had no idea that these problems could be approached in other ways. It might have been useful for teachers to have introduced alternative methods. Teachers were strongly opposed to this, as Ms Sierra's comments show:

> Ms Sierra: I do renaming, but my concern is that not all teachers are doing that so … I was talking about it this morning during morning tea with the others' cause I want, um, a uniform way of doing it that the children won't get confused. That's all right with the strong ones, but the weak ones, once they change that they think it's a new method but it's just the other method of doing it … The parents, they have their other methods. Kids come back with 'This is how my mum told me to do it'. I feel like ringing them! *(Rolls her eyes)* (Early Year 4)

Ms Sierra did not appear to consider that her insistence on a uniform method might also be confusing and that she could profitably build further understanding on alternative methods children brought from home. Her expressed opinion that only the "strong" learners were capable of exploration of alternative methods, while the "weak" ones were better off being taught one procedure only, indicated that she believed that an appreciation of the mathematical ideas behind such calculations was only possible for a minority of students.

Teachers, parents and textbooks all contributed to the propagation of the view that their singular approach to written algorithms was the only acceptable way to perform such calculations. Difficulties arose when the customary methods of one generation differed from those of the next. Uniformity of procedure appeared to be valued by the teachers for its simplicity and manageability rather than its enhancement of mathematical thinking. In examining the nature and socialising function of students' experiences of everyday school mathematics, Ernest (1998) noted these conventions of the classroom.

> An analysis of the linguistic forms used and the types of mathematical activity most common in school mathematics suggests the overwhelming presence of imposed tasks in which the learner is required to carry out symbolic transformations. During most of their learning career in school…learners work on textual or symbolically presented teacher-set tasks. They carry these out, in the main, by writing a sequence of texts ultimately arriving, if successful, at a terminal text, 'the answer.' (p. 223)

He estimated that over the course of their compulsory education, students carry out tens of thousands of such individual mathematics tasks, and commented that:

> … the sheer repetitive nature of this activity is underaccommodated in many current accounts of mathematics learning, where the emphasis is more on the construction of meaning than on the acquisition and deployment of semiotic tools and, given that the texts are being produced and marked, the rhetorical style of school mathematics. (pp. 223–224)

For the children, because everyday patterns presented mathematics in question-answer form, getting the right answers became not only the purpose but also the substance of mathematics. They were frequently observed to gain pleasure and satisfaction from having produced correct answers, including punching the air triumphantly, or exclaiming, "Yes!" or, "I got them all right!" or, "I got none wrong!" as they marked their work. This was more noticeable among certain groups of boys. At the end of marking sessions, children were observed to compare their results with such comments as, "I got one wrong," or, "How many did you get?" The social significance of this kind of student-to-student feedback in classrooms has been documented by Nuthall (2007). Discussion of solutions was seldom observed, as verified by the children.

> Researcher: Do you ever talk about mathematics with your friends?
>
> Dominic: Well, sometimes we talk about the scores, but that's pretty much it. (Early Year 5)

For some of the children, the classroom emphasis on getting answers right produced feelings of anxiety, particularly when they were asked to come up with answers in front of their classmates. In Year 4, Fleur was observed to become flustered when asked to answer, "three times four", as the class were seated on the mat. She gave the incorrect answer of "ten", and although the teacher was patient and asked further questions to help Fleur produce the correct answer, it was clear that Fleur felt upset and embarrassed. The teacher observed that Fleur rarely put up her hand to volunteer answers to questions. Consistent with the findings of Anderson (2000) and Anderson and Boylan (2000) who investigated the links between teacher questioning and pupil anxiety in mathematics classrooms, Fleur had come to view much mathematical learning as painful, threatening and humiliating.

Within the question–answer, right/wrong environment, many of the children were apprehensive about contributing answers or “having a go” as their comments show, when asked about how they felt about putting up their hands to answer questions:

> Fleur: Sometimes when you haven’t got it right, she goes, ‘Wrong!’
>
> Researcher: Do you usually put your hand up?
>
> Fleur: Sometimes. Sometimes, if I get it wrong, well … but if I’m, if I think that it, that my answer is right, then I’ll put it up. (Mid Year 5)
>
> Georgina: I just say the answer that’s in my book. Sometimes I get them wrong and I don’t like it when the teacher shouts at me.
>
> Researcher: What does she say?
>
> Georgina: *(Mimicking the teacher’s voice)* ‘Sorry! You’ve got it wrong!’ (Mid Year 4)
>
> Jessica: *(About being picked to answer a question)* [I think] ‘Oh no, I don’t know the answer and she’s going to ask me’. Sometimes it gets really freaky and you know, you’re going [to yourself] ‘Don’t pick me, don’t pick me, please don’t pick me,’ you get so freaked out that she’s going to pick you, [I think] I’ll be so embarrassed that she’s going to pick me.
>
> Researcher: Has that ever happened that she’s picked you and you don’t know the answer?
>
> Jessica: Yeah, I think it has probably happened once or twice.
>
> Researcher: How do other people react?
>
> Jessica: They just sit there and stare at you and stare in space waiting to hear the answer and they’re thinking, ‘Oh I know that, that’s easy’. Sometimes I do that when she’s asked someone who isn’t paying attention. (Mid Year 5)

This is consistent with children’s views on public exposure explained in Chap. 4. The work of Denvir et al. (2001) provided accounts of the protective strategies children use when participating in whole class questioning, as advocated by the Numeracy Strategy in the UK. They argued that, “the strong “performative” element … prompts children to adopt classroom behaviours, which mitigate [sic] against them developing good habits as learners” (p. 344). These habits include taking fewer risks, copying others’ answers rather than relying on their own thinking, and abandoning contemplative methods in favour of speedy ones in the competitive classroom atmosphere where correct and speedy answering is valued by teachers and peers. Some teachers noted children’s feelings about right and wrong:

> Ms Fell: (*Speaking of Fleur*) She’s little bit worried to take risks at the moment and, you know, wants to do it right.

> Mrs Matagi: (*Of Liam*) He loves to be right, that's a real buzz for him, quite a big deal for Liam to have success, I think he feels, um, yeah, he doesn't like to get it wrong. (Early Year 5)

> Ms Summers: They [children] have a fear of getting things wrong, so often sort of breaking through that can be a challenge. (Early Year 3)

Parents too commented on their children's feelings about being right or wrong:

> Liam's mother: He's funny. He's confident, then sometimes he's not. When he gets something wrong, he thinks he's silly, he doesn't know what he's doing. When he's doing it right, he's super confident. He likes to know what he's doing. If he struggles with it, he thinks he's stupid. (Early Year 3)

No teacher in the study challenged the view that mathematical answers or procedures were only ever either right or wrong, and no teacher commented on any problems inherent in presenting mathematics as a right/wrong discipline despite the clear directive in Mathematics in the New Zealand Curriculum (Ministry of Education 1992) to teach mathematics in a variety of ways, including problem solving:

> Closed problems, which follow a well-known pattern of solution, develop only a limited range of skills. They encourage memorisation of routine rather than consideration and experimentation… Real-life problems are not always closed, nor do they necessarily have only one solution. Determining the best approximation to a solution, and finding the optimum way of solving a problem when several approaches are possible, are skills frequently required in the workplace. Students need frequent opportunities to work with open-ended problems. (p. 11)

The teachers appeared to view, and therefore teach, mathematics as a body of unassailable truths and methods that they must transfer to the children, and that this knowledge was constituted of a shared and commonly understood set of facts and procedures. Commonly, only one method was believed to be appropriate in any given situation. Teachers implied this in the ways in which they interacted with the children during the learning and practising phases of their lessons. The widespread use of closed questions and specific instructions requiring one right response, were indicators of this. Goldin (2000) described this kind of teaching as the *traditional* view of mathematics education, based on the following characteristics and assumptions:

- Specific, clearly identified mathematical skills at each grade level
- Step-by-step development, abstracted or generalised in higher level mathematics
- That much of mathematics is structured hierarchically, with more advanced techniques presupposing mastery and a certain automaticity of use of more basic ones
- Standards that are measurable
- Expository teaching methods are valued, including considerable individual drill and practice to ensure not only the correct use of efficient mathematical rules and algorithms
- The correctness of students' responses
- Children differ greatly in mathematical ability so that significant numbers of them may not have the capacity to succeed in higher mathematics; for these children, achieving the basics is especially important
- Class groupings should be homogeneous by ability at least after a certain grade level, to permit advanced work with high-ability students and attention to the basics with slower learners (pp. 199–200).

As previous chapters have shown, many of these characteristics could be found in the classrooms visited, the teachers articulating and implementing views and practices of teaching mathematics that were contrary to the intentions of *Mathematics in the New Zealand Curriculum* (Ministry of Education 1992) which stated that:

> Students learn mathematical thinking most effectively through applying concepts and skills in interesting and realistic contexts which are personally meaningful to them. Thus mathematics is best taught by helping students to solve problems drawn from their own experience. (p. 11)

The Universal Language of Mathematics?

As 7-year-olds, the children were becoming increasingly exposed to the conventional language of mathematics. This corresponded with the introduction of formal language in other subjects, for instance writing and science. Mathematical *seeing* was not always tailored to the needs of children or built upon their experiences, and nor was mathematical *saying*. Not only were the children's unique ways of internalising mathematical ideas sometimes at variance with the teachers', there were also difficulties for the children with the language and context in which the tasks were embedded. Disjunction between the child's everyday language, and the specialised language of the classroom was sometimes found to create a barrier for the children.

> Researcher: What's happening in maths for you, Fleur?
>
> Fleur: We're doing our times tables. Factor times factor equals product.
>
> Researcher: Oh? And how do you feel about that?
>
> Fleur: I don't like it.
>
> Researcher: Why not?
>
> Fleur: It's too hard.
>
> Researcher: (*Later*) What's the best activity you've done in maths this year? Anything you have enjoyed? (*Long pause … no reply from Fleur*) Let's look at the next one, the worst activity you have done in maths so far this year. (*On the recording sheet, Fleur writes F X F = P*) Factor times factor equals product? (*Fleur nods sadly*)
>
> Researcher: (*Later*) Are things very different in maths this year with Mrs Heath?
>
> Fleur: Very different…when we were in Mrs Field's class, we didn't know our times tables or anything. Or factor times factor, or what a factor was. We never had face (*pauses*) place (*pauses again*) face value, and products and factor. (Early Year 4)

Children were sometimes found to misuse unfamiliar mathematical terminology.

> Researcher: What is maths?
>
> Rochelle: Numbers … and equations …
>
> Researcher: Anything else?
>
> Rochelle: Factor plus factor equals sum. (Mid Year 5)

Where mathematical terminology was unfamiliar, children would sometimes creatively replace words with something they knew.

> Researcher: Are you on a hard subject [Georgina's word for 'topic'] at the moment?
>
> Georgina: No it's really easy.
>
> Researcher: Oh, what's the subject that you're doing?
>
> Georgina: Cemetery. It was pretty easy because first we had to cut out a picture and copy that side, and there was this worksheet where we had to draw a pattern and on the other side we had to draw the same pattern. We were allowed to use mirrors too. (Late Year 4)

The different strands of the mathematics curriculum were something about which children were seen to be actively constructing meaning.

> Jessica: I think it's called geometry, with all the shapes and everything and like, you know, those equilateral kind of things … (Late Year 5)
>
> Dominic: We're studying algebra.
>
> Researcher: What is algebra, Dominic?
>
> Dominic: I don't know. All sorts of stuff … I think it's sort of like open equations … I don't exactly know. (Late Year 5)

The specialised language of mathematics as used and misused by the children, seemed to define for them the nature of mathematics as a subject comprised of "topics" such as *geometry* and *algebra*, of rules such as "factor times factor equals product", of symbols, such as $F \times F = P$, and of specific terms such as *face value* and *symmetry*. This need not necessarily be problematic, but the teachers seemed unaware of the potential to confuse, and often took insufficient time to explain new terms. *Mathematics in the New Zealand Curriculum* (Ministry of Education 1992) made a distinction between the children's own language and formal mathematical language, and stated that, among other important mathematical processes, the mathematics curriculum would provide opportunities for students to:

- Develop the skills and confidence to use their own language, and the language of mathematics, to express mathematical ideas (p. 23).
- The first of the achievement objectives in the *Communicating Mathematical Ideas* sub-strand of the *Mathematical Processes* strand, and an expectation of all students from Levels 2 to 8 states:
- Within a range of meaningful contexts students should be able to use their own language, and mathematical language and diagrams to explain their mathematical ideas (p. 28).

Recognition of the curriculum stated acknowledgement of the importance not only of "allowing" but also "expecting" children to talk about mathematics in their own words was rarely observed in over 90 classroom observations.

Teachers' Views of Children's Learning and Knowing of Mathematics

When teachers talked about the children's mathematical learning, recurring phrases were heard. One of these was the idea of the child "getting", "picking up" or "grasping" concepts. This seemed to imply that learning and knowing were the child's responsibility, and that if the child failed to grasp a concept as presented by the teacher, this was either a result of lack of attention to the teacher's explanation, lack of effort, or lack of ability on the part of the child. Teachers appeared to judge children's mathematical ability on the speed – interpreted as ease – with which new concepts were "grasped". Where children learned mathematics more slowly, required several explanations of the same idea, needed the aid of concrete materials, or failed to retain what they had learned, teachers regarded these as signs of mathematical incompetence. Faster learners and those who could memorise mathematical skills and knowledge as they had been taught were viewed as more mathematically able.

> Mr Solomon: (*Speaking of Georgina*) She takes a while to pick up a concept and run with it. She needs two or three sessions to catch on. Once she gets it she's away, but she doesn't always retain it. (Late Year 3)

> Ms Seager: (*Speaking of Jessica*) She usually grasps new concepts quickly, although she found measurement harder. (Mid Year 4)

> Mrs Joiner: (*Speaking of Rochelle*) I've got five children that are very quick and can connect ideas very easily. I don't think she'll match the top five, but I think she would be close to them. She does seem to be very quick to pick up number. (Late Year 3)

> Mr Ford: (*Speaking of Dominic)* He picked up division facts quickly. (Mid Year 5)

> Ms Flower: (*Speaking of Jared*) He doesn't actually listen to my instructions. He really rushes and sometimes he makes mistakes. (Mid Year 3)

> Mr Waters: (*Speaking of Jared*) He's a real workhorse. He doesn't grasp it straight away, but once he's got it, it's hard to shake. (Early Year 5)

> Mrs Matagi: (*Speaking of Liam*) With new work he takes a little time to think it through. He doesn't always get it first time. He needs work to consolidate. (Late Year 5)

> Mrs Waverley: (*Speaking of Peter*) He's still taking time to get new concepts but not too long. (Late Year 4)

> Miss Sanderson: (*Speaking of Peter*) He takes a while to grasp new things. (Mid Year 5)

> Ms Firth: (Speaking of Toby) He's very quick to grasp concepts … he's got a very sound base knowledge. (Late Year 3)

> Mr Cove: (*Speaking of Toby*) He's one of those children that it takes one explanation and off he goes and he can do it quite confidently. (Mid Year 5)

When talking to, or about the children, teachers suggested that learning mathematics was something that required considerable brain power as well as a specialised kind of thinking, as evidenced by the following remarks, many of which employed mechanical metaphors such as switches and gears.

> Mr Swift: (*Speaking of Dominic*) He can switch off. (Mid ear 4)

> Ms Torrance: I didn't think you had your brain switched on, Matthew. It's on Mars! … You clever cookies … Oh you switched on girl. (Mid Year 3)

> Mrs Kyle: We're not thinking straight. (Early Year 4)

> Mr Waters: See if you've got your brains into gear. (Mid Year 5)

> Ms Summers: (*Speaking of children's learning of mathematics*) I believe children have some sort of innate … there's something there. It's quite obvious. I mean you can give them those skills that will help them but I think a child has either got it, or they haven't.

> Researcher: And would you say Peter has got it?

> Ms Summers: I think he hasn't really got, you know, that intuitively… lateral thought. (Early Year 3)

Since these kinds of remarks were not heard in lessons for other subjects, it would seem that "brain power" and brains "in gear" were regarded as specific to mathematics, that *grasping* and *retaining* new concepts was contingent on tapping into this mathematical mode of using the brain, and that some brains were simply incapable of mathematical thinking even when the children were *given* the skills.

Children's Perspectives of Learning and Knowing Mathematics

While some of the children talked of mathematics generally as being "hard" for them, this was usually associated with particular parts of mathematics, as most were able to talk about tasks they found easy. The children often spoke of the difficulty of learning mathematics, and the following comments show how they were made as subjects, alienated and marginalised in tasks that they could not perform. Their comments not only show that accessibility of tasks was crucial to their sense of well-being during mathematics time, but also provide insights into the strategies that children used when confronted with the difficulties of mathematical tasks, demonstrating the ways in which their perceived understandings of mathematical learning and knowing contributed to their subjectivities.

> Fleur: I wish I was a bit better [at maths] but I don't exactly mind that much'cause not everybody's good at everything … Because I'm quite a bit slower, because I struggle. They [other people] know a bit more, and what they're doing, they get the point of it all. (Early Year 5)

> Georgina: What do I like about maths? Oh, well, not really much about maths, but sometimes I like it and sometimes I don't … I can do some things, like one plus one, two plus two, and it's just hard to get some other things in maths like sixteen plus sixteen, that's hard! (Early Year 3)

> Georgina: I don't like maths much because we do hard things and we have to do it. I just look at the paper and go 'Hmm' (*Sighs deeply*) and I get told off. (Late Year 3)

Georgina: I sort of hate it when it's maths time. When we're on a hard subject. (Mid Year 4)

Georgina: Well when we were doing fractions it was really hard for me and I didn't get it and they [other children] were just going, 'Oh yeah, I know that one!' and they got it straight away and they were correct.

Researcher: How did that make you feel, that they could get it?

Georgina: I just had to lie and say, like, there was this person, there's this girl, she sits next to me and she gets it right all the time,'cause like when she goes, like, "Seven", I just put up my hand and say, "Seven". (Mid Year 5)

Researcher: What do you like most about maths, Jessica?

Jessica: That it's sometimes hard and sometimes easy, sometimes they [teachers] give you different things to do.

Researcher: What do you like least about maths?

Jessica: When it's always hard. Maybe like one week or something you do something extremely hard. (Mid Year 5)

Dominic: I'm very good at it [maths] and I learn lots of new stuff, like, I know what he [the teacher] means when he says things. Like people that aren't so good at maths don't usually understand … Although I'm real good at it, sometimes I get a bit lazy and can't be bothered … it's interesting, it's just sometimes I'm a bit bored of it. (Late Year 4)

Researcher: How do you feel, Jared, when the teacher says 'It's time for maths?'

Jared: I hate it.'Cause it's hard.

Researcher: So do you feel comfortable at maths time?

Jared: Not really.

Researcher: (*Later*) What things would make maths better for you?

Jared: Easy work. (Late Year 3)

Liam: I like the work usually but some things are boring. Sometimes when I'm stuck and can't do it, it's boring and I go, 'What do you do?' to people and I ask for help but they don't [help] because they say they have to get on with their own work. (Early Year 5)

Researcher: Why is the teacher giving you some work of your own?

Mitchell: Because it's too hard for me [the other children's work]. (Mid Year 5)

Researcher: Anything you've done in maths that you haven't liked much?

Peter: Times tables … Because they're hard.

Researcher: Do you feel comfortable doing maths, Toby?

Toby: Yep … because she asks us quite a few questions, and they're good to answer, they're not, like, too easy for us or too hard for us. (Mid Year 4)

"Not knowing" caused serious difficulties for Fleur, who was absent from school for the 2 weeks when her class began learning the times tables. On her return, Fleur found herself "behind" her classmates.

Fleur: (*Describing how she felt at maths time*) Well not so good because I haven't learnt my times tables'cause I was away when they were doing the times. (Late Year 3)

Notions of “keeping up” with classmates and the of danger of “falling behind” were linked to the way mathematics was framed as in a linear progression of sequenced learning events and the expectation that all children would and should acquire mathematical knowledge and skills at roughly the same pace and in the same order. Those children who faltered at any point along this mathematical learning path fell by the wayside, casualties of dominant approaches to teaching mathematics as a rigid, sequential progression of learning stages.

The Place and Purpose of Learning Mathematics

Mathematics is presented in curricula worldwide as a core or subject, its status rationalised as a life skill as the following examples show: “The need for people to be numerate, that is, to be able to calculate, estimate, and use measuring instruments, has always been identified as a key outcome for education” (Ministry of Education 1992, p. 7); “the need to understand and be able to use mathematics has never been greater” (National Council of Teachers of Mathematics 2000, p. 4); “numeracy is a key life skill” (Department for Education and Employment 1999, Foreword). “Mathematics and statistics have a broad range of practical applications in everyday life, in other learning areas, and in workplaces”. (Ministry of Education 2007, p. 26)

Through the timing, regularity and frequency of mathematics lessons, the pervasive valuing of correct responses, and the recognition and positioning of children according to their production of such answers, the children received strong messages about the worth of mathematics as a school subject. Without exception, the children expressed the belief that mathematics was very important. Table 5.1 shows their responses when asked in years 4 and 5 to nominate which they believed to be most important of all the subjects they learned at school.

Their thoughts about why they learned mathematics suggested that mathematics was something they almost universally viewed as deriving solely from school, a necessary part of every child’s education, and the responsibility of adults to pass on to the next generation. The following examples show the various ways that the children responded to the question, “Why do we learn maths at school?” For some, this was a difficult question.

> Georgina: Um, that’s a hard one. Because we need to learn maths.
>
> Researcher: Any ideas why?
>
> Georgina: No. (Late Year 4)
>
> Toby: Well, just like you are sometimes learning the alphabet, you’re learning numbers too. (Early Year 3)
>
> Fleur: So that when we grow up and have children, the children know they just ask us, and we know the answer. (Late Year 3)

Table 5.1 The school subjects the children believed to be most important in order of nomination

	Year 4	Year 5
Fleur	Handwriting, maths	Maths
Georgina	Maths, spelling	Maths
Jessica	Maths, health	English, science, maths, physical education
Rochelle	Maths	Maths
Dominic	Maths, reading	Reading, maths, science, spelling
Jared	Maths	Maths, handwriting
Liam	Language, maths	Maths, reading
Mitchell	Listening to the teacher	Work
Peter	Maths	Maths
Toby	Spelling, maths, handwriting	Maths, reading

Jessica: (*Who has just rated mathematics 10 on the subject importance scale*) Like when your kid is stuck with their homework and they asked you like, 'Mum we're stuck on this' and they don't know what it is. And you really don't want them to use the calculator, or if you didn't have one, well then you'd have to help them but you won't know how to explain it'cause you don't know how to do maths. (Early Year 4)

Rochelle: To be good at it when we're older. (Early Year 5)

Jared: I don't know.

Researcher: Is maths useful to know do you think?

Jared: Yes.

Researcher: In what ways is it useful?

Jared: For when you're older.

Researcher: How might you use it when you're older?

Jared: In school. (Late Year 5)

Mitchell: Because if they [children] get bigger they won't know anything. (Late Year 5)

The older the children became, the more likely they were to state the purpose of learning mathematics as enabling them to do well in later tests and exams.

Dominic: To help us. Just in case. For like if we have to, like, go through this big test or something, we will probably know all of them. (Late Year 4)

Researcher: Which of the subjects you learn at school are the most important to learn do you think?

Peter: Maths.

Researcher: What is it about maths that's pretty important do you think?

Peter: Um … um.

Researcher: What would happen if you didn't learn maths?

Peter: You wouldn't be able to, like, if at school they gave you a test and you had to get it finished, you wouldn't be able to get it finished. (Mid Year 5)

Only a few of the children were able to see wider uses of mathematics.

Liam: We need to be able to add wherever we go. (Early Year 5)

Fleur: When I go to the shops I use maths. (Late Year 5)

Mathematics, then, was something the children generally felt they were obliged to learn for its usefulness in later life, either in more advanced schooling or as adults. Few children showed that mathematics had any but the narrowest relevance and usefulness for them as children. Because the children believed that mathematics mostly originated from, and was defined by, the enclosed school environment, the only mathematics that they recognised outside of school was that which replicated school mathematics. When asked, “You do lots of maths at school. At what other times do you do maths?” typical replies were:

Fleur: I sometimes do maths games on the computer. (Early Year 5)

Georgina: We only do it in the morning [at school]. (Late Year 4)

Rochelle: We’ve got this times tables book at home. (Early Year 3)

Peter: Only for homework. (Mid Year 4)

Dominic: We do times tables and plus at home. (Mid Year 3)

Liam: When my sister makes some questions for me. (Late Year 4)

Toby: Mum gives me basic facts to answer. (Early Year 4)

The children rarely conceived of mathematics as a body of related yet diverse skills and knowledge that all people, including children, use continually as part of their everyday lives.

Children’s Views of the Nature of Mathematics

Of the things that the children said they had *learned* in mathematics since they had last been interviewed, number skills and knowledge featured most highly. Basic facts, particularly “times tables” were the most often cited followed by “working form” addition, multiplication, division and fractions. When asked what they had particularly *enjoyed* in mathematics, activities involving drawing, working with equipment, co-ordinates, symmetry, and maths games were most frequently mentioned. It is notable that these two lists have few common elements. Although the children could talk about all the things they had done at maths times, when asked what mathematics *was*, some of the children found the subject difficult to define, as their comments show:

Georgina: That’s a pretty hard question.

Researcher: What do you *think* it is?

Georgina: It’s just another subject.

Researcher: What makes it different from reading?

Georgina:'Cause you're counting. (Late Year 4)

Jessica: I think it's a subject like, when you're little you get like, one plus one, but when you're older you can still get one plus one so, like, it's just like every single maths question is like the same. You've actually got to be good at maths to actually enjoy it. (Late Year 4)

Jared: Something we have to learn.

Researcher: What makes it different, from English or sport?

Jared: Sport is where you go outside and maths is when you're inside.

Researcher: OK, so what makes maths *maths* do you think?

Jared: When you do pluses and takeaways … and times. (Late Year 5)

Mitchell: Um … (*Long pause*)

Researcher: Is it the same as reading or writing?

Mitchell: No.

Researcher: What's special about maths? What's it all about?

Mitchell: You have to learn. (Late Year 5)

Other children could more clearly articulate their views about what mathematics was. They almost invariably cited number skills and knowledge as being "mathematics". The tendency for children to view number and the basic operations as the sum and substance of mathematics is widespread (Cotton 1993; Kouba ans McDonald 1991; McDonough 1998; Perlmutter et al. 1997; Spangler 1992).

Researcher: What is maths, Fleur?

Fleur: Adding, subtraction, divided by, division … is that true?

Researcher: Well it's just what you think it is. You do lots of it at school.

Fleur: Well, we sometimes do fractions. (Early Year 5)

Rochelle: Um, numbers … and equations … factor plus factor equals sum. (Mid Year 5)

Liam: It's take away, times, dividing, plus, measuring and things like that. (Early Year 5)

Peter: It's all these sums … and counting. Questions … you answer them. (Late Year 4)

Maths is just like doing times tables, pluses, subtraction, division, fractions and stuff. (Mid Year 5)

Toby: It's when you've got numbers and you can do all sorts of things with them. (Mid Year 5)

By Late Year 5, Dominic was the only child of the group who appeared to have developed any sense of the underlying processes of mathematics and connections between different facets of the mathematics he experienced in the classroom:

Dominic: Um, working things out, and … counting, and … patterns and shapes, different sizes and … yeah. (Late Year 5)

This appreciation of mathematics did not appear to be not recognised by his teachers, who interpreted Dominic's thoughtfulness as "dreaming" (Ms Torrance) or "switching off" (Mr Swift). Dominic stated that neither his teachers nor his parents really knew what he could do in mathematics.

> Dominic: Mr Swift would probably put me at about 9 (*compared with his self-rating of 10*) Because he usually doesn't see things. (Late Year 4)

> Dominic: (*When asked how his parents thought he was getting on in maths*) I don't think they know. (Early Year 4)

Through their definitions of mathematics, the children demonstrated that within their social worlds of home and school they had developed personal understandings of what mathematics *was*. Because teachers and parents were largely unaware of children's views, such perceptions remained for the most part unchallenged and unsupported.

Mathematics at Home

Most of the parents became involved in their children's learning of mathematics through helping them with mathematics homework and their learning of "times tables". While the degree of involvement varied, the production of right answers and application of correct methods were generally reinforced by parents through these activities. In helping their children with mathematics at home, parents replicated the I–R–F interaction patterns of teaching observed in the classrooms.

> Georgina: He [Dad] tells me what to do and then I write it down, and then I tell him what the answer is and he says if it's correct or not. (Early Year 4)

> Georgina: In my maths book the first week there was these really hard working forms and my dad's, like, taught me how to do the first one and then I got to do it and I got all of them right without anyone helping me. (Early Year 5)

> Jessica: Well sometimes my Mum pulls out these cards and there are these questions she asks. (Mid Year 4)

> Toby: Mum, she made up a big sheet of multiplication questions and I had to do every single one of them in the fastest time I could …'cause when you know multiplication, you know division. (Late Year 5)

As already seen from Ms Sierra's earlier comments, teachers worried about lack of consistency in what the children were taught regarding the "right" methods of doing mathematics. So too did parents, as this example shows:

> Fleur's mother: When they did the power of ten. On the first day of that she came home with her homework and couldn't do it, and when I looked at it, I couldn't work out how they'd taught her. I got her father to look at it when he came home. He went through it with her patiently for three-quarters of an hour. With beads. And once she'd done that with two or three, after that she was right. It's the first time I've heard her say, 'This is stupid. I can't do it.' If her father hadn't been able to help her, I would have had to go to the teacher and ask her to show me. I want to make sure I'm saying the same thing as the teacher. (Late Year 3)

Street et al. (2005) explored issues arising in the relationship between home and school numeracy practices, and noted that while families contribute significantly to the mathematical education of children, their role in mathematics education is viewed by the school as subservient. Caught in the crosscurrents between family and school, the children were produced both at home and in the classroom as mathematical subjects whose ongoing mission was to provide correct answers to externally posed questions.

Teachers' Views of Mathematics

As the following extracts show, teachers' personal experiences of learning mathematics contributed significantly to their subjectivity as teachers of mathematics, tied to their views of mathematics itself, and in turn their views of children as mathematical learners.

> Mrs Waverley: I can make reading fun, but I can't make maths fun. … (*Later*) I actually love maths. I think it's because I like the organisation. I take it first thing in the morning for forty minutes because I think 'Oh, I've done that now,' and I don't need to worry, so we take it religiously, and so devotedly. (Early Year 4)

> Mrs Tyde: I failed School Certificate maths twice … Maths is not my favourite [subject to teach]. I try to appear passionate about maths for the children because it's so critical, but actually every day I think 'Ugh!', but doing this [cross-grouping system] with a really good thing to follow [the Wellsford programme] is making me a lot more confident about my maths teaching. (Early Year 5)

> Mr Solomon: I enjoyed maths at school, especially the straight out number problems rather than the lateral thinking. I don't know if I'm a real lateral thinker, so it's just basic number sentences and that sort of thing [that I like] … The hardest [part of maths to teach] is teaching place value. I just sort of found I was banging my head against a wall at times and didn't know where to turn, you know, 'Where do I go from here? The kids just haven't picked up on it through this way, so … ?' Yeah that's the hardest I've found. (Early Year 3)

> Mrs Ponting: I enjoy teaching it [maths] but I didn't really enjoy it as a student. I went into book keeping, I suppose. Hm. Got confused with that too … I try my best to do what the objective [from the curriculum] says. Sometimes I wonder if I'm doing it the right way. (Early Year 4)

> Mr Swift: I used to enjoy it [maths] at primary school but secondary school it, ah, I didn't understand it that much and I failed … Never grasped the concepts of it … I'd like to say it [classroom maths programme] is stimulating, but the proof would be in the pudding. Um, yeah, I try to get hands on, outside, make it real life situations but sometimes it's easier to photocopy out of the book. (Early Year 4)

> Mr Ford: I did a B.A. with Statistics because I needed to, it wasn't something I chose to do … I got into other kinds of maths areas like chaos theory and fractals, how maths relates to all that kind of thing … I'm right into Science Fiction you see. And Stephen Hawking and his black hole theory, so that's why I probably enjoy maths because I like that kind of stuff.

> Researcher: So do you feel your enjoyment of maths helps you to teach it?

> Mr Ford: Sometimes what we're working on in the classroom, is just difficult to make exciting.

Researcher: What things in particular in maths do you find hard to make exciting?

Mr Ford: Place value. (Early Year 5)

Mrs Isles: I do like maths. I always liked that feeling, there has to be an answer, you just have to work the process out, there is an answer there. Yeah, it is, it's logical. (Early Year 5)

There is a growing body of research to demonstrate the links between teachers' experiences of mathematics, their beliefs about its nature, and their competence, confidence and style in teaching the subject (Ernest 1989; Thompson 1992; Haylock 1995; Beswick 2006). As these teachers' reflections show, lack of enjoyment or success in mathematics in their own schooling was a common experience, and for some such as Mrs Tyde, had produced a lasting distaste which they struggled to conceal from the children.

Irrespective of their enjoyment of teaching mathematics, the teachers in this study shared common views about the nature of the subject. The "right answer" and the "right way" were recurring themes that shaped the way they talked about their teaching approaches. While they seemed to believe that "making maths fun" might assist the children's learning, this presented dilemmas for them when faced with certain prescribed objectives, such as place value, that appeared to be impossible to present in interesting ways. This suggests that they viewed the subject as constituting facts and rules that it was their responsibility to pass on to the children through time-honoured pedagogical practices. Voigt (1995) stated that, "according to folk beliefs, the tasks, questions, symbols … of mathematics lessons have definite, clear-cut meanings" (p. 167), and went on to argue that contrary to this belief, detailed studies of classrooms revealed ambiguity and individual interpretation among teachers and learners alike.

The view of mathematics as creative, dynamic and open to multiple ways of knowing was neither apparent in the teachers' statements, nor in their teaching. When the teachers were asked about their inclusion of mathematical processes[1] in their teaching and assessment of mathematics, their responses were revealing.

Ms Torrance: Processes? What are they again? (Mid Year 3)

Mrs Cayo: I'm limited in understanding some of the problem solving. But also linking those processes, I mean there's so many things in it. Maths is not a simple subject, is it? (Early Year 4)

Mr Waters: Problem solving is a great one. Putting equations into sentences, that's something that I keep telling my kids a big one is to read the question before they put their brains into gear. (Early Year 5)

Ms Seager: What we are going to do next term is have a number focus Monday to Wednesday and Thursday more topic-based, hands on, then Friday is problem solving. (Early Year 4)

[1] Mathematical Processes is the first of the six strands of *Mathematics in the New Zealand Curriculum* (Ministry of Education, 1992). "The mathematical processes skills – problem solving, reasoning, and communicating mathematical ideas – are learned and assessed within the context of the more specific knowledge and skills of number, measurement, geometry, algebra, and statistics" (p. 13).

While most were aware of the curriculum emphasis on problem solving many teachers appeared to have interpreted this to mean routine number calculations posed as "story" problems. This narrow interpretation of problem solving contrasted with the definition provided by *Teaching Problem Solving in Mathematics: Years 1–8* (Ministry of Education 1999b): "a problem is a problem when there is something that stops you from immediately going to the answer … it is often unclear at the start what strategy students need to use to solve the problem … a problem should be something that interests the students and that they definitely want or need to solve" (p. 9).

Mathematical processes were not found to be integrated into the teachers' mathematics planning despite the teaching requirements of Mathematics in the New Zealand Curriculum (Ministry of Education 1992). The typical school policy of placing of problem solving on Fridays or during special times of the year signalled to pupils that this was not "proper" maths, a phenomenon noted by Clark (1999). The comments above suggested that teachers were uncomfortable in this area. Counter to the directives of the curriculum, they did not support a multifaceted view of mathematics and its doing, which in turn encouraged pupils to develop similarly limited conceptions of the subject.

Mathematical Subjectivity: Being Right, Being Wrong

The routine privileging of answers over mathematical processes such as conjecturing, reasoning, and justifying as advocated by *Mathematics in the New Zealand Curriculum* (Ministry of Education 1992), was typical of the classroom practice observed. The children came to believe that only one answer or procedure was possible or acceptable and teachers appeared to be unaware that the framing of their questions might limit the range of student responses.

Concerns about the mismatch between children's mathematical sense-making and methods taught at school are reflected in a number of research studies (e.g. Jaworski 1988; Baroody and Ginsburg 1990; Fuson et al. 2001). The socially constructed and taken-as-shared ways of mathematical "seeing", embedded in mathematics worksheet material and textbooks (Dowling 1998), and reproduced by teachers through such practices as task design, questions (Boylan 2002), and diagrams on the board, have been recognised as causing problems in children's learning of mathematics (Bernstein 1990; Cooper and Dunne 1999; Zevenbergen 2001; Goldin 2002). Steffe (1991) voiced these concerns by stating, "I believe that, rather than expecting children to learn how the teacher thinks, mathematics teachers must teach in order to learn how children think … to teach in harmony with children's approach to mathematics" (p. x). Rather than viewing children as active agents producing knowledge, much of this research positions children as thinking or acting in ways that are distinctive to the category child, and as such, should or should not be treated in particular ways. Lave and Wenger (1991), on the other hand, stressed the link between learning and knowing – which they saw as essentially social in nature – and student subjectivity.

> … as an aspect of social practice, learning involves the whole person; it implies not only a relation to specific activities, but a relation to social communities – it implies becoming a full participant, a member, a kind of person. In this view, learning only partly – and often incidentally – implies becoming able to be involved in new activities, to perform new tasks and functions, and to master new understandings. Activities, tasks, functions and understandings do not exist in isolation; they are part of broader systems of relations in which they have meaning. These systems of relations arise out of and are reproduced and developed within social communities, which are in part systems of relations among persons. The person is defined by as well as defines these relations. Learning thus implies becoming a different person with respect to the possibilities enabled by these systems of relations. To ignore this aspect of learning is to overlook the fact that learning involves the construction of identities. (p. 53)

The right/wrong nature of mathematics as presented and defined by teachers, textbooks, families and classmates through social interaction, contributed significantly to the children's mathematical subjectivities. Along with *completion* and *speed* as described in Chaps. 3 and 4, being right or wrong was cited by the children as one of the key indicators by which they gauged and described their own and others' competence.

> Fleur: (*Explaining why she has rated herself 7 on the self-rating scale for ability in mathematics*) Because I don't always get all of my times tables and take aways right. (Late Year 3)

> Georgina: There's a boy in our class that's at my group and he always gets them right. When we do something like divided by, he always gets the right answer.

> Researcher: Why is that do you think?

> Georgina: Because he's brainy. (Late Year 4)

> Researcher: How do you know that you're not very good at it [maths]? What makes you think that you're not very good?

> Jessica: Well sometimes I get everything wrong and stuff like that. (Late Year 3)

> Researcher: How do you know they're [other children] good?

> Jessica: Because they're the ones that are always answering questions [correctly].(Mid Year 4)

> Researcher: How do you know you're getting better at maths?

> Rochelle: Because I get most of the answers right. (Mid Year 4)

> Dominic: I'm one of the best in the class …'cause every basic facts test I get eighty out of eighty. (Late Year 4)

> Jared: (*Reason for rating himself best in the class along with Justin*) Because we both know all the answers. (Early Year 5)

> Liam: (Having rated himself 0 at maths on the self-rating scale) Because I do things wrong. (Late Year 3)

> Mitchell: (*Reason for not being as good as others at maths*) Because they're doing it right and I get some of them wrong. (Late Year 4)

> Peter: (Having rated himself 9 at maths on the self-rating scale) I mostly get everything right. (Early Year 4)

> Toby: (*Explaining his improvement in mathematics*) We have a test each week and you get a certificate if you get them all right.

Researcher: Have you got a few certificates then?

Toby: Yes. (Mid Year 5)

For the children, rightness or wrongness were the most critical criteria of competence, while creativity, or effective methods used to solve difficult or non-routine problems were not, as Frid (1993) also observed. This limited view of *knowing* mathematics, seen only as the ability to reproduce correct answers and procedures, led the children to abandon other forms of thinking. Correspondingly, they came to regard *learning* in mathematics as the process of memorising and reproducing correct answers using correct procedures, and to develop reliance on external validation and verification of knowledge from teacher and textbook.

The children in this study offer us a way of viewing young learners as active participants in discursive learning events in which they are made as subjects as much as they are taught to think in ways that are seen as mathematical. Routine privileging of right answers over the mathematical processes of conjecturing, reasoning and justifying was typical of the classroom practice observed, encouraging children to seek only one answer or apply only one procedure. Teachers seemed largely unaware that the framing of their questions might elicit only a narrow range of interpretations and student responses.

Dominant images of mathematics within the discursive structures of school, home and popular culture, constructed the children as learners whose role it was to answer questions posed by an exterior authority such as the teacher, parent or textbook, rather than by the children themselves, requiring right answers produced through the accepted methods. Their views of *learning* and *knowing* mathematics were tied to the perception of mathematics as either right or wrong.

Mathematics appeared to hold little relevance for children in their lives beyond the classroom, and came to be associated almost exclusively with school or schoolsbased tasks such as homework. In learning environments controlled by the demand for correct answers, children were constituted as subjects in their varying capacities to fulfil such a demand. The combined expectation that mathematical *work* is silent and solitary, the performance of speedy answering in *competition* with their peers is motivating, and the production of *right* answers the purpose of doing mathematics, constituted the children in binaried subject classification: bright/confused, switched on/off, grasping concepts quickly/slowly.

Those children who embraced the judgement and discipline of error and correction and became skilful players of the mathematical truth game, experienced their learning of mathematics as satisfying for its positive subjectification. For the majority of the children, the tyranny of the right answer manifested in subjectivities on constant notice, even for Rochelle, Toby, Dominic, Peter and Liam who were usually able to provide correct answers and deemed themselves to be good at mathematics. Fleur, Jessica, Jared, Georgina and Mitchell were less certain of their standing as mathematical subjects since they took longer to latch onto new procedures and their alternative strategies in engaging with mathematical situations were subject to dismissal and correction by their teachers. The following chapter examines how, within regulatory classroom practices of work, testing and correction, the children were inscribed as able students (or not), and considers the implications of such inscription.

Chapter 6
The Emergence of Ability

They just happen to be better than me at maths. I might happen to be better at, I don't know … it's a gift thing.

—Jessica, 10 years

As the previous three chapters have shown, learning mathematics was also a process of learning self. Through its modes of measurement, discipline, punishment and reward, the discourse of mathematics classrooms made children visible as mathematically (dis)abled subjects. Jessica's reflection above pointed to an acceptance of and explanation for the origins and causes of the success/failure dualism in mathematics, a view that was echoed, as we shall see, by the other children, their teachers and parents. The measurement and classification systems peculiar to specific discursive formations such as schooling in general and mathematics education in particular, could be seen to operate in the children's lives as apparatuses of recognition and normalisation.

In the following sections of this chapter, the experiences of three of the children in this study are used to illustrate the ways in which measurement, categorisation and differentiation operated within the discursive domains of school and home. The first is Mitchell, a pupil so exceptional that he failed to fit within the parameters of expected mathematical achievement. The second is Jessica, a "middle" student who survived, rather than flourished, within the environment of school mathematics. The third is Rochelle, a "top" student, who derived satisfaction and a measure of security from her early experiences of mathematics at school. The chapter explores the criteria by which the children were sorted, grouped and labelled, the prevalence and frequency of grouping systems and the children's views of ability and achievement in mathematics. It is shown how their mathematical subjectivities including their statements about self-efficacy and causal attributions for success or failure were shaped by the differentiation practices of their social environments. The discursive rules that appeared to govern sorting and labelling practices in school mathematics are examined in light curriculum documents and classroom texts.

F. Walls, *Mathematical Subjects*: *Children Talk About Their Mathematical Lives*,
DOI 10.1007/978-1-4419-0597-0_6,

Mitchell: "Behind the Eight Ball"

From Field Notes, Mitchell's Classroom, Cliff School, Mid Year 3

Mitchell is seated on the mat with the other children in his class.

Teacher: Room 6 people go through for maths please.

(Three of the children, including Mitchell, walk to the classroom next door. They sit on the mat where the teacher is already seated in front of the children. The children are chanting rhymes from a big picture book. Mitchell looks bemused and begins to suck his thumb)

Mrs Craig: (*To Mitchell, sharply*) Put your hand on your lap so you can speak out.

(*Mitchell appears more interested in the next chant, Little Puppy Rap and tries to keep up with the chant, but begins to suck his thumb again after a short time, and appears to miss the teacher's instructions when she directs the two groups to their tables. They are working on activities from the Beginning School Mathematics programme. The teacher is working with Mitchell's group today, while a student teacher takes the other group. She takes her group to a table and directs the children to sit around it on their chairs. Mitchell sits covering his nose with his hands*)

Mrs Craig: I want you to do two things today. I want you to draw on the green paper a picture of your house. Then I'm going to get you to take the pink paper and draw a picture of yourself.

(*While others in the group are excitedly discussing what their house looks like, Mitchell is silent. He watches as the teacher demonstrates by drawing her own house*)

Mrs Craig: Mitchell, what's special about your house?

Mitchell: I don't know.

Mrs Craig: Well you have a think in your head. *(The teacher asks other children. Some others also have trouble describing their houses)*. Close your eyes. *(Mitchell does so)* Now draw your house. *(Mitchell takes a brown felt pen and draws a large square that takes up most of the page. He looks at the teacher's picture and draws his picture like hers. He looks around at the other children's drawings. Some children talk as they are working)*

Andre: My house is green. That's why I'm doing it green.

(Mitchell is silent throughout. Some children begin discussing where they live, pointing in the direction of their houses. Mitchell does not join in. He draws a tree beside his house, then sucks his thumb and looks out of the window. He then arranges the felt pens in the tray)

Mrs Craig: (*Looking at Mitchell's picture*) Tell me about your house, Mitchell. What's this?

Mitchell: (*Very quietly*) The shed.

Mrs Craig: *Inside* the house? What's this?

Mitchell: (*Shrugs*) I don't know.

(*The teacher now instructs the children to draw a face on a yellow circle. Mitchell draws eyes*)

Mitchell: What colour's my hair?

Mrs Craig: What colour's your hair? *(Mitchell does not reply)* Go and look in the mirror.

(*Mitchell goes to look in the mirror then returns. He draws a mouth. He goes back to the mirror, returns and works on the cheeks, goes back to the mirror once more and pulls faces at himself. He looks back at Mrs Craig to see whether she has noticed*)

Mrs Craig: I want you to write your name under your face. *(Looks around and sees Mitchell at the mirror*.) Finished looking at yourself, Mitchell? (*He returns to the table.)* You've got a nice cheery smile on your face, Mitchell. (*looking at Mitchell's drawing. Mitchell returns to the mirror twice more to look at himself, oblivious of the other children who are now gluing their houses, faces and pink connecting arrows onto a chart*)

Mrs Craig: Come on Mitchell. (*Mitchell doesn't move from the mirror. The teacher goes over and puts her arm around Mitchell's waist, guiding him back to the table to wait his turn for gluing. Mitchell looks restless*) You could put the felts away. (*Mitchell returns to the mirror then plays with some metre rulers nearby*) Mitchell, come here. I've got a space for you now.

(*Other children who have finished have gone off to the mat and are engaged in mathematics games and independent activities from their BSM box. Mitchell glues his house onto the chart. The teacher gets him to finish another piece of work from the day before, involving cutting and gluing some objects onto paper. The teacher sits beside him. The lesson finishes with the teacher asking the children to pack up, and sending the Room Seven children back to their classroom*)

Mitchell appeared to be engaged in the activity in a manner that differed from that of the other children. His attention wandered after a short time, and there was little verbal communication between Mitchell and the others. The teacher did not introduce the activity by explaining its purpose nor finish the activity by talking about the chart, so it was difficult to tell whether any of the children, including Mitchell, understood why they were expected to perform the task, and why such an activity might be helpful for their mathematical learning. It seemed that Mitchell had tried to draw the shed in front of his house, but it looked as though it were inside. He did not explain this to the teacher, nor did he engage in mathematical conversation with the other children. Donlan and Hutt (1991) linked many problems in mathematical learning to language. Children who are not fluent in the specialised language of the classroom are therefore at a great disadvantage. It was likely that Mitchell's difficulties at school could be traced to a mismatch between his modes of communication and those of the classroom.

Mrs Craig, Mitchell's teacher for mathematics, was perplexed and somewhat frustrated by this "distracted" child who appeared not to behave as other children of his age.

Mrs Craig: He is by far the oldest in the class and I think he's quite capable of working at a higher level but he hasn't got the independence. He's very easily distracted and goes off task and sometimes he will not cooperate and if he is working one to one, eventually he will probably give the answer that you want. (Mid Year 3)

The teachers' concerns were mostly directed at Mitchell's subjectivity. Because he was not taking up classroom routines in the same way as the other children he was cast as "different". In their efforts to create children as autonomous and independent workers increasingly capable of self-monitoring and self-discipline, Mitchell stood out as deficient and a misfit. Although they had sought advice from appropriate agencies about to how to nurture Mitchell's social and cognitive skills, the assistance they had received had been limited. The following conversation reveals the ways in which the teachers strove to accommodate Mitchell within their codes of classification and expectation.

> Class teacher: Of late I have noticed, like this term, he has begun to show signs of maturity, not leaps and bounds but he will sit down and he will listen and he will actually follow instructions but he still needs very close monitoring to make sure he actually follows the task through. (*Later*) I think Mitchell will always be a little behind the eight ball in terms of maturity. I mean, like, there'll probably come a stage when he does actually catch up so it's not quite so noticeable in terms of his peer grouping, but he will always be an individual, he will always be, um, a special child, you know, in terms of his wants and needs, and he'll always be a little bit different but that's fine. (Mid Year 3)

> Mrs Craig: He's a very interesting little boy…He's on a different plane altogether…the eye contact or the absorption, it's not there…fiddles…uncooperative in responding…bewildered and perplexed…his writing is still very untidy compared to the rest…He'll sit down and not be so obtrusive, but he's still not necessarily listening…He's a special needs boy. (Mid Year 3)

In talking of Mitchell, teachers used the language of developmental learning theory to classify and position him, to explain him, in other words. In this language, Mitchell could be recognised as slow to "mature", "behind" and at a "lower" level. The teachers imagined that eventually he might "catch up". Fiddling, reluctance to make eye contact and untidiness were seen as signs of his lack. They read Mitchell's improved "sitting down", "listening" and "following instructions" as signifiers of increasing maturity rather than of subjectification. They spoke of his difference as something to be accepted but viewed it at the same time as a defect, something that set him apart from (behind) other (normal) children. "Special needs" was at once a benevolent and a pejorative term.

The teachers also recognised some of Mitchell's mathematical capabilities, particularly apparent when he was provided with concrete materials.

> Mrs Craig: I was saying to him, 'Are there more or less?' and he was quite lost, so the next day I did an activity with everyone counting out some little BSM toys and he had no problem telling me when he could see them…He's OK when he's got the apparatus there.

> Mrs Craig: (*Later*) The other day we were doing this measuring one, with things we had from the developmental room, they all had a small ruler, and he marked the end of each one (*She shows his work, where objects had been traced around with their left hand ends aligned and whose lengths they were comparing by looking at the right hand ends. Mitchell had drawn little vertical lines from the ends of the objects to help him compare their lengths. One object, a comb, had a curved end so his technique was particularly useful there in finding the longest point of the comb*) I hadn't said that to the children, it wasn't part of my instructions, but he had actually done that…I thought that was particularly clever of him, and I was standing by him when he got down to the toothbrush at the end and he says, 'Oh I think this one's bigger, this is bigger,' and he sat and did that without any of the nonsense that we would have had earlier in the year.

> Mrs Craig: (*Later*) I was distracted for a moment [during BSM assessment checkpoint 5] and when I came back he'd built a big 3-D construction.

> Researcher: Any pattern in it?

> Mrs Craig: Yes, there was. (*Shows her record of it*) He could do it.

Researcher: It looks quite complex.

Mrs Craig: Yes it was. He could spot those missing pieces very quickly. It was very hard to keep him focussed [on the assessment task]. He likes to build all the time, but then he can be difficult, refuse, and reluctant to answer and you think he knows the answer but he just doesn't want to do it. I'm sure he knows lots more than he displays. (Mid Year 3)

Despite Mitchell's demonstrated skills in measuring, patterning and construction with shapes, it was his refusal or reluctance to answer questions that was interpreted by Mrs Craig and teachers later in his schooling as deliberate and wilful acts of defiance, but there was little evidence to suggest that this was the case. Mitchell was unable to explain why he went to Room 6 at mathematics time, although he could name the two children who went with him.

Researcher: How many people go to Room 6 for maths? There's you, and …

Mitchell: Eva and Salili.

Researcher: Why do you go to Room 6 for maths? (*Mitchell looks blank*) So why don't you stay in Room 7 for maths?

Mitchell: (*Looks down at the floor*) I'm really…(*inaudible*) (Mid Year 3)

Mitchell did not readily take up the regulating discourse of everyday Year 3 classroom life. He did not accept the game he was expected to play as "pupil" because he scarcely recognised himself in it; this placed him outside the comfort and protection that such discourses afford. By the end of Year 3 he was aware of mathematics as a distinct subject, but its specialised vocabulary using familiar words in unfamiliar ways such as "more" and "less" was confusing to him in the context of classroom mathematics. The introduction of written mathematics using mathematical symbols for equations and expressions also posed problems:

Researcher: What's maths all about?

Mitchell: Like one plus one or something.

Researcher: Why do you have to learn that do you think? (*Mitchell shrugs*)

Researcher: (*Later*) Is there anything you don't like about maths?

Mitchell: One plus one.

Researcher: Do you think you're very good at one plus one? (*Mitchell shrugs*) What do you do when you don't understand something in maths? (*Mitchell shrugs*) You don't know what to do? (*Mitchell shakes his head*) Do you do maths every day? (*Mitchell nods*) Do you do maths for homework?

Mitchell: Hm.

Researcher: What maths do you do for homework?

Mitchell: One plus one and stuff. (Late Year 3)

Mitchell's Year 3 teachers had identified him as "*different*" primarily, it seemed, because he did not exhibit the pupil behaviours they expected in a child of his age, that is, he did not fit within their normative range of scholastic achievement or expected social and emotional actions and was therefore positioned beyond the scope of their powers to correct or remediate. Although the teachers sometimes interpreted his non-conforming behaviour as deliberate and therefore *deviant* as instanced by their use of words such as “uncooperative”, “difficult” and “reluctant”, Mitchell’s indifference to the expectations of the group and to the demands of the mathematical tasks, suggested that he was oblivious to of the social risks of his failure to conform. He behaved *independently* of the others (sucking thumb instead of chanting, going to the mirror and looking at his reflection instead of gluing his pictures onto the group chart, “in a world of his own”, “on a different plane”), a kind of independence the teachers sought to discourage. The techniques that worked so well to control the other children in the class had little effect on Mitchell.

Because Mitchell did not easily adapt to daily life of school and the classroom, his learning of mathematics suffered especially when the teachers could not provide him with the “very close monitoring” that he needed. In spite of the indications that Mitchell’s understanding of mathematical ideas and his capability to learn were not nearly as underdeveloped as they appeared, his behaviour caused his teachers to search for explanations and strategies in order to accommodate him. Having identified him as “special” and “behind the eight ball”, they decided to place him with younger children for mathematics lessons. This appeared to add to Mitchell’s bewilderment, and he continued to exhibit strategic non-compliance, such as “failing” to follow instructions or maintain focus on the mathematics tasks. The special class contained only 14 children but the higher teacher-pupil ratio did little to address Mitchell’s mathematical learning needs.

As already noted, the teachers recognised Mitchell’s responsiveness to concrete materials, as Mrs Craig observed: “he’s a doing child, he needs to constantly move”; “he loves the developmental time[1]” (Late Year 3). This provided a vital clue as to the methods by which Mitchell was most able to make sense of school mathematics. Whenever the appropriate materials were available, Mitchell demonstrated interest and understanding. The use of whole class chanting on the mat, BSM activities such as the one observed and a growing emphasis on methods of written recording were not ideal learning methods for Mitchell. During Year 3, rather than adapting her teaching approaches to cater for Mitchell, Mrs Craig continued to attempt to “socialise” him into the listening and recording (work-based) culture of her mathematics programme.

When his family moved house, Mitchell attended another school for Years 4 and 5 where he remained with the rest of his class at mathematics time. His Year 4 teacher described her experience of working with Mitchell:

> Miss Palliser: His capabilities I found very poor. You know, just with basic addition and subtraction, he could do them, but he was particularly slow at doing them and would take a long time to do just one. I also found his method of counting very interesting. He was using his fingers. When he counts he puts his finger to his mouth. That is what he was

[1] “Developmental time” is an unstructured, free-choice session designed to develop children’s skills and understanding through a process of exploration and discovery using materials such as water, modelling equipment, musical instruments and toys.

> doing at the start but he's actually started to use counters now so he's kind of moving away from his mouth onto objects…I had him in a group of three to give him some extra help with the magic squares and two of them were saying the answers out loud and Mitchell said, 'Good, I can copy them.' So, you know, he's got this idea of just being able to copy. 'Someone will do the work and I'll just write down the answer.'…I think he's an OK learner, but he does struggle with some of the basic skills. (Early Year 4)

> Miss Palliser: Mitchell gets quite excited by numbers now. He needs instructions repeated a couple of times, and he needs lots of time on one idea. He is now not the most needy in the class and he is expected to work more independently… (Mid Year 4)

> Miss Palliser: He has really settled down but still has his loopy times…He is definitely able. There was a barrier there but it's disappearing. (Late Year 4)

For the whole of Year 5, his teacher Ms Roche separated Mitchell from the rest of the class by placing his desk next to her worktable. All of the other children were seated in groups. Ms Roche explained her view of Mitchell.

> Ms Roche: He'll never be a scholar…underachieves in everything…has an attitude problem…uses avoidance strategies…learned to be helpless…jeopardising others' work…pretends he can't do things this year…If I blackmail him, 'If that's not done you won't be going swimming!' he gets it done…I admit I snap at him but he has to learn…He's getting better. He gets the back of his book ruled up and the date – that's great progress for a kid like him. (Early Year 5)

> Ms Roche: He's doing really well, but he forgets things – his maths, routines… By the end of last term he could rename and carry, but then forgot. It comes to the point where I don't care, just do the mechanics. A student teacher used action learning strategies with him, especially in maths, with some success. He doesn't hide under the desk any more – he just resorts to those behaviours when he's threatened…I've modified Mitchell's programme entirely. But he's really wanting to learn. He is initiating contact with me for feedback, so there are signs that he does want to learn. He's becoming more independent. (Mid Year 5)

> Ms Roche: He's got really independent, he's willing to take risks and he's willing to ask for help. He doesn't do any of that time wasting that he used to do. (Late Year 5)

As the following observation shows, much of what Mitchell was directed to do at mathematics time in Ms Roche's class was a method of managing his lack of comprehension rather than creating access to new mathematical ideas. For Mitchell there was little meaning in these tasks.

> *The class is using the National Curriculum Mathematics Textbook Level 2, Book I, p. 203.*

> Ms Roche: Right Mitchell. (*Mitchell is sitting at his desk sucking his thumb*) Have you headed up your book? Sweetie, it's page two hundred and three. (*To the rest of the class, clapping to gain their attention*) We're going to mark page two hundred and three together at ten to ten, so you've got about five minutes. (*To Mitchell*) Write the numbers down here like this. (*Demonstrates, the first few and Mitchell finishes*) How many days in a year, Mitchell?

> Mitchell: Seven?

> Ms Roche: OK. Write seven down there (*points to the space beside number four)*. Right now you have to go and ask someone how many days in a year.

> Mitchell: (*Mitchell takes his book over to a desk group. To a boy*) How do you do this? (*pointing to question number four*)

> Boy: Three hundred and fifty-six. (*Mitchell goes back to his desk*)

Ms Roche: What did he say?

Mitchell: Three hundred and fifty.

Ms Roche: (*Writing the answer for him*) Right, now go and ask someone else how many months in a year.

Mitchell: (*When he returns*) Twelve. (*Heads off to ask someone else how many hours there are in a day then returns*) Twenty-four.

Ms Roche: (*Writing his answer for him*) Right, minutes in an hour?

Mitchell: (*On returning from asking another child*) Sixteen.

Ms Roche: No, sixty. (*Mitchell writes this*) How many days in a leap year?

Mitchell: (*Returning from asking another boy*) Three hundred and sixty six. I can't do that one.

Ms Roche: Three, six, six.

The activity indicated that Mitchell had yet to learn to recognise two and three digit numerals, to distinguish between the "teen" and "ty" numbers, and to work with units of time without the support of real-life experiences, stories, calendars, clocks and watches. Although he was engaged in the same task as the others and was by this time able to achieve a degree of behavioural conformity, little mathematical learning appeared to be taking place. The gap between Mitchell and the others was widening. At times, Mitchell's difference appeared to attract negative attention from other class members, as the following observation showed:

The teacher asks a question about combinations of notes and coins to make $10.20. Children are selected to write their ideas for answers on the board then the rest of the children vote for the answer with which they most agree. Mitchell, who has his hand up, is chosen to provide an answer. His answer (10c, 10c, 20c) indicates that either he is not yet sure of money combinations or he did not understand the question. When the time comes to consider Mitchell's answer for voting, no children vote for it and some children snigger. One boy sitting close to Mitchell says in a sneering voice, 'Mitchell never does his work.' (Mid Year 4)

Through everyday classroom interactions such as these, Mitchell was both positioned by others and positioned himself, as a mathematical subject:

Researcher: Are there some people in the class who are better at maths than you do you think?

Mitchell: Yep.

Researcher: How do you know?

Mitchell: Because they're doing it right and I got some of them wrong.

Researcher: How do you know you've got them wrong?

Mitchell: There's 'exes' [Xs] by them. (Late Year 4)

Researcher: Are there any things that you don't really like?

Mitchell: Maths.

Researcher: Why is that Mitchell?

Mitchell: I'm supposed to do my times tables and I don't know them.

Researcher: How does that make you feel?

Mitchell: Sad. (Early Year 5)

Researcher: Do you get different work from the other kids?

Mitchell: Yep.

Researcher: Why do you get different work do you think?

Mitchell: Because I'm not very good at it. (Late Year 5)

Persistence on the part of his teachers in Years 4 and 5 saw Mitchell included in the mathematical doings of the rest of the class. By the middle of Year 5, Mitchell was exhibiting less disruptive behaviour. The regular use of concrete materials for mathematics in Miss Palliser's class had had a discernible positive effect on his learning but the introduction of formalised textbook work in Year 5 class created further barriers. His self-subjectifying statement, "I'm not very good at it", could be seen to have been synthesised in a multitude of signals from teachers and peers.

Mitchell's case illustrates the problems that arise in schooling systems where all children are expected to be exhibiting recognisable learning behaviours by a certain age (McDonald 1993) and to engage with mathematics in identical ways. The teachers' options appeared to be limited when confronted with a child who did not readily fit existing age-stratified structures and classroom practices. They were torn between the perceived social benefits of inclusion with the peer cohort and the perceived cognitive benefits of individual remediation or keeping the child back.

Mitchell was observed in a number of situations to approach mathematical tasks in insightful ways including devising for himself an effective finger-based system for subtraction involving bridging through tens that enabled him to produce the answers to simple two-digit subtraction "sums". Mitchell's skills in other areas, such as his ability to memorise the spelling of quite difficult words, his love of dancing, his enjoyment of construction and working with shapes and, in Years 4 and 5, his accomplished drawing of Pokemon and other television characters, indicated a strong sense of patterning, spatial awareness and making mathematical connections. Using the hundreds board in Miss Palliser's class helped him develop recognition of patterns found when counting from 1 to 100. It seemed that rather than learning mathematics through the predominant pedagogical practices of whole class chanting, individual writing and basic facts speed activities, Mitchell's use of materials supplemented with discussion from a range of supportive peers and adults was more beneficial. Reliance on ready-made activities and texts was also a problem, since these materials presumed a specific linguistic competence and a particular range of life experiences.

Mitchell's mother was aware of her son's apparent learning difficulties and his troubles at school caused her considerable anguish. By comparing her son with a niece who was a year younger than Mitchell, she had concluded that he was about a year behind children of his own age. During the 3 years of contact, Mitchell's apparent difficulties were never satisfactorily explained. The separation of his parents, problems with his hearing as a younger child and solo parenting on reduced family means were suggested as causal factors in Mitchell's "case". But other explanations could be considered. The "fact" of Mitchell's difference was constructed only in the naturalisation of learning as something predictable and controllable.

Mitchell provides a compelling example of a child for whom the demands of the primary school mathematics classroom were often overwhelming. His teachers and classmates had trouble incorporating him into the everyday doings of the mathematics classroom since he failed to fit the bounds of a discursively circumscribed normality. The ways in which others came to recognise, interpret and accommodate Mitchell's mathematical perceptions and ways of operating in the classroom positioned him for the most part as a struggling student, an odd student, a failing student and a student who would never succeed. Thus classified, Mitchell experienced profound negative subjectivity as a marginalised child.

Equity for all students, including those who, like Mitchell, experience difficulties in learning school mathematics, has become a strong component of recent curriculum statements on mathematics. *Mathematics in the New Zealand Curriculum* (Ministry of Education 1992) says:

> It is a principle of the *New Zealand Curriculum Framework* that all students should be enabled to achieve personal standards of excellence and that all students have a right to achieve to the maximum of their potential. It is axiomatic in this curriculum statement that mathematics is for all students, regardless of ability, background, gender or ethnicity. (p. 12)

The National Numeracy Strategy (Department for Education and Employment 1999) dedicates a section of its introduction to catering for pupils with special educational needs which notes:

> All teachers will have in their class some children whose progress warrants special consideration. Their difficulties may have physical, sensory, behavioural, emotional or neurological causes…but as a general guide, you should aim to include all these pupils fully in your daily mathematics lesson. … (p. 23)

The National Council of Teachers of Mathematics *Principles and Standards for School Mathematics* (2000) states:

> Equity does not mean that every student should receive identical instruction; instead, it demands that reasonable and appropriate accommodations be made as needed to promote access and attainment for all students… The vision of equity in mathematics education challenges a pervasive societal belief in North America that only some students are capable of learning mathematics. … Low expectations are especially problematic because students who live in poverty, students who are not native speakers of English, students with disabilities, females and non-white students have traditionally been far more likely than their counterparts in other demographic groups to be victims of low expectations. Expectations must be raised – mathematics can and must be learned by *all* students. (pp. 12–13)

Schooling systems that base teaching and learning on levels and stages and compare and rank children's achievement as assessed through a narrow range of methods produce children's "underachievement" as deficit. In systems where the mathematical child is constructed through book work, speed activities, competition and replication of facts and procedures, children such as Mitchell are pronounced pathological, requiring remediation to treat and repair their deficiencies. In writing of children with learning difficulties in mathematics, Cross and Hynes (1994) urged that teachers use only those assessment methods that enable children to show what they can do, and how they do it. Goldman and Hasselbring (1997) found that embedding mathematics in meaningful contexts based on authentic tasks was of benefit to children such as Mitchell, suggesting that this approach helped all children to make sense of mathematical activity in personally meaningful and fulfilling ways. Seen in this way, it was not Mitchell who failed to learn mathematics, rather it was the discourse of the mathematics classroom and beyond that failed to embrace Mitchell’s ways of mathematical learning.

Jessica: “Average” or “A Middle Kid”

Jessica began to experience ability grouping in Year 3, when Mr Loch, who grouped students primarily by year level, also used the results of pre-testing:

> Mr Loch: I do a little bit of readiness beforehand usually just a simple sort of test which I give to them so I can group the kids, you know, I try to have two or three groups operating at a time and she, for some reason, fractions was something she obviously felt confident in and she ended up being on the top group, whereas the rest of the time she has always been in that second group. (Late Year 3)

When explaining her self-rating on the scale that was used for the children to indicate how good they thought they were at mathematics, Jessica provided some interesting insights into the ways in which she made sense of the classroom practices of grouping and ranking in mathematics. In Year 3, this had already begun to contribute to her developing mathematical identity.

> Researcher: So why do you think you’re here (*pointing to 4 on the self-rating scale for mathematical ability*) and not here? (*pointing to 8, 9 and 10*)
>
> Jessica:’Cause I’m kind of in between I think.
>
> Researcher: OK. How do you know who’s good at maths in this class and who isn’t so good?
>
> Jessica:’Cause sometimes Mr Loch, he gets us to show our work to the class. So we know. (Early Year 3)
>
> Researcher: Where do you think you’d fit on there? [on the self-rating scale]
>
> Jessica: Number one.
>
> Researcher: Why do you think that?
>
> Jessica: Well, because I’m not really in his band, [development band group] so I don’t know any … (*pauses*)
>
> Researcher: How do you know you’re not very good at it?
>
> Jessica: Well sometimes I get everything wrong and stuff like that.
>
> Researcher: (*Later*) Are you in a maths group?
>
> Jessica: Yes. Group 1.
>
> Researcher: Is that the best group?

Jessica: Group 2's the best group.

Researcher: How many groups are there?

Jessica: Two.

Researcher: How do you get into Group 2?

Jessica: Well, you kind of like get everything right.

Jessica: (*Later*) I told them [her parents] I'm hopeless at it [maths]. (Late Year 3)

By the end of Year 3, she rated herself at 1 on the scale. At the beginning of Year 4 Jessica was transferred to another school. She found herself placed in the middle group of the class. She reported feeling "hopeless" at mathematics.

Researcher: Do you know some people who are better than that? (*Jessica nods. She has just rated herself 3 on the self-rating scale for mathematical ability*) How do you know they're better?

Jessica:'Cause, although they're a lot smaller [younger] than me, they're a lot better at maths. They're smarter than me.

Researcher: How do you know they're better?

Jessica:'Cause they've always got their brains on. When the teacher tells us to get something out, they're the first to get them out.

Researcher: (*Later*) So you're in Group 2? How do you think [teacher] came to put you in Group 2?

Jessica: She just puts you in a level. It think it's'cause we had these mathematics tests and that's how she found out.

Researcher: OK. Is Group 2 the top group, the bottom group or the middle group?

Jessica: The middle group, and there's an A and a B because the group's so big.

Researcher: Right. Are you in the A or the B?

Jessica: The A.

Researcher: So which is the top group then out of 1, 2 and 3?

Jessica: Group 3.

Researcher: Does Group 3 get harder work?

Jessica: Sometimes Group 3s and Group 1s get different sheets from us. (Early Year 4)

In Year 5, all the children in the syndicate were cross-grouped[2] by ability for each mathematics topic throughout the year. At the beginning of each mathematics session, Jessica would take her book and pencil to another classroom for mathematics.

Researcher: What makes a person good at maths do you think?

Jessica: If you practise quite a lot. And the little girl Marnie with the curly hair and glasses, she's really good at maths, she got a hundred out of a hundred this time [basic facts speed

[2] "Cross-grouping" is the term used in New Zealand primary schools for grouping by ability within a syndicate of several classrooms. It is the equivalent of the terms "setting", "tracking" or "banding" used in other countries.

test]'cause she's really smart, but I don't think it's, like she practises or anything, well she probably does, but I don't think it's really that reason, I think it's because she was just born like that. And some people are born differently than others. (Early Year 5)

Researcher: What makes you think you're a 5? [on the self-rating scale for mathematical ability]

Jessica:'Cause I don't think I'm perfect or anything like that, but I don't think I'm bad either. So I'm kind of about there.

Researcher: Would there be some people who would be 1s and 2s?

Jessica: Mm.

Researcher: So how can you tell that?

Jessica:'Cause when we do this numeracy skills mastery programme, some people are doing a different sheet, because they're not as up to the others.

Researcher: (*Later*) How do you think they've grouped you?

Jessica: Because we do tests and the different marks - they just put you into groups.

Researcher: So you were in Ms Tyde's last time weren't you?

Jessica: Right, yeah, I've been in Miss Moana's and Ms Tyde's.

Researcher: So it changes each time you do a test?

Jessica: Not every time but just sometimes:

Researcher: The ones that went to Ms Mere's class, were they the ones that did best or OK or worst at the test?

Jessica: The worst.

Researcher: Did [the teachers] say that?

Jessica: No, but…

Researcher: How did you figure that out?

Jessica: Well, because of all the other groups. My class teacher, she's got the highest group…and I don't know about Miss Moana and Ms Tyde, but…

Researcher: You know that Ms Mere's got the worst group?

Jessica: Mm.

Researcher: How did it make you feel when you were in Ms Mere's group?

Jessica: I felt pretty annoyed with myself, how I did, but when I got in there I thought it wasn't so bad, it's just work to me, no big deal, and we're just a little bit slower than everyone else. (Mid Year 5)

Jessica: At the moment I'm not really happy with myself. I was in the top group [second to top, according to the teachers] for this topic, I think it's called geometry, with all the shapes and everything and like, you know, those equilateral kind of things…I was with Ms Mere, I'm pretty sure Ms Maine's the lowest, Ms Mere's the highest and there's Mrs Tyde and Miss Moana, and I've no idea which is the highest of those.

Researcher: So you're not feeling happy with yourself?

Jessica: No, because I went down one or two groups.

Researcher: How come you went down? What made that happen?

Jessica: Well, you know how I said you have to be good at something to enjoy it, well I was really enjoying it in Ms Mere's group because I was good at that topic [geometry] But now…for measurement, I'm not that good at it.

Researcher: So where would you put yourself on the scale now, then? [Self-rating scale for enjoyment of maths].

Jessica: Probably between four and five.

Researcher: How did you feel when you were in Ms Mere's doing geometry?

Jessica: Well I didn't feel that great about it because, well most of the other people had been in Ms Mere's, well there's a girl who has been in Ms Mere's and no other group ever. Well Miss Maine used to be the highest and they swapped, and there's this boy he's been in the highest ever since we started rotating for maths. And there's one other girl from my class and we think she's also been in the highest.

Researcher: (*Later*) Why do you think you're here (*between 6 and 7 on the self-rating scale for mathematical ability*) and other people might be here? (*pointing to 8,9,10*)

Jessica: They just happen to be better than me at maths. I might happen to be better at, I don't know…it's a gift thing. (Late Year 5)

Jessica's self-rating seemed to correspond in part to her achievement in tests, basic facts tests, and also to the changes in her group placement: 0 when placed in a "lower" group, 5 or 6 when in a "higher" group. Many of the children, including Jessica, reported receiving little feedback from teachers about their achievement in mathematics. When asked where the teacher would place them on the scale, most of the children indicated the same place they had positioned themselves. This suggested that their self-rating was based in perceptions of their teacher's judgements of their competence. Dominic was a notable exception.

The teachers were asked about Jessica's progress in mathematics:

Mr Loch: I would place her, she's round about a middle kid. Before, [the fractions pre-test] I would have said she was probably a bit down on the average child in this class. (Late Year 3)

Ms Seager: She's at the top end of average (*Looking at the PAT*[3] *mathematics results*) *You* see I've got 12 children operating at that level in my class. It's a sort of bell-shaped curve really isn't it? (Early Year 4)

Ms Seager: She's doing really well apart from the basic facts tests. She's still using fingers, so they're not automatic yet. She's on the upper end of average I would say (Late Year 4)

Researcher: What group is Jessica in your grouping system?

Ms Tyde: The third group. I don't think she's as secure as the other children that are in here. You know, the top group has fifteen students, the bottom has fifteen, then Ms Moana and I

[3] PATs are Progress and Achievement Tests, standardised national multiple-choice tests for the core subjects, and administered by many schools in the 6th week of the school year to determine individual and cohort percentile rankings by age and by year group. Mathematics PATs begin at Year 4.

have got around twenty two, so I think she wasn't as secure, I think she may have been better one group down. [the second to bottom group]

Researcher: So you've got four groups, and she's in a middle one?

Ms Tyde: Yes, she's beyond the lowest group but she's not up with the top group.

Researcher: So you'd see her as…?

Ms Tyde: `Well, 'average' is a nasty word. She's basically working at, comfortably at the beginning of Level 3 objectives. That would be my estimate of her. I don't know whether her number pre-test showed that, but that's where I see her.

Researcher: And that's where you would expect to see her at this age?

Ms Tyde: Well, for a Year 5 that's absolutely fine. There are a lot of children who are working in the bottom group and that's not a nice word either, but the children who need extra assistance often are working on Level 2. And even the next group up is consolidating Level 2 and then moving up. Whereas my group's pretty much solidly working in 3 without any extension into 4. (Early Year 5)

Ms Mere: My group is the 'challenged' you might say *(laughs)*. Jessica is pretty good but there are a few from that class who were down low to begin with. [Jessica has only recently been placed in this group] I don't think maths would be her first love…She's a bit slapdash, untidy, but it might be her general way. (Mid Year 5)

Ms Tyde: She was in the second group for geometry, now she's in the third group – for measurement. From the pre-test, yes, it goes according to numbers. [Results of the test] (Late Year 5)

Jessica's mother talked about the school's grouping system and the difficulties she and Jessica had had in recognising where Jessica was sitting in relation to her peers, and whether such grouping was likely to be effective.

Jessica's mother: Jessica was confused about the maths grouping. They worked out the highest group from the one that this girl Gemma was in…Changing the groups has made a big difference to Jessica. It's school policy, you know, working on the children's strengths…But I think Jessica might be more of a left-brainer. (Later Year 5)

As with the other children, Jessica's self-rating of her mathematical ability was almost identical to that of the teachers. Through her experiences of mathematics assessment and grouping at school, Jessica's subjectivity as a mathematical learner emerged in the normalising judgements of testing and grouping, reinforced by interactions such as those with peers and the views of her mother. By the end of Year 5, Jessica accepted that she did not have the gift for mathematics and linked fluctuations in enjoyment to her variable success. In their review of literature on ability grouping, Sukhnandan and Lee (1998) noted the research indicating that pupils' self-esteem, school involvement, and friendship patterns were tied to ability grouping. It can be seen from Jessica's comments that she had experienced at least some of these subjectifying effects.

Jessica: I always say you have to be good at something to enjoy it.

Researcher: When you get to High School do you think you're going to enjoy maths?

Jessica: Probably not. (Late Year 5)

Rochelle: A "Super Smarty Pants"

Rochelle consistently reported that she enjoyed mathematics and found it fun. She was seen as a conscientious learner in all subject areas at school, her teachers commenting on the way she "got on with her work". Her determined effort to learn the basic mathematics facts, her pleasure in knowing them and being able to get most of her maths work right provided Rochelle a sense of satisfaction and accomplishment. Rochelle was placed in either the middle or top groups for mathematics for Years 3, 4 and 5, based mostly, it seemed, on her overall diligence and her accuracy in recalling of basic number facts and computational tasks, as the following extracts reveal.

> Researcher: Were you satisfied with Rochelle's level of prior knowledge on arrival in your class?
>
> Mrs Joiner: I had her last year, so…basic facts good. She needs to consolidate tens and ones. She doesn't get it instantly, always. She could go up to the top group but the children in that group get it quickly and they are a big group already. (Early Year 3)
>
> Mother: Well, Rochelle will come home and tell me what happened in the day, and they've just had a test and like yesterday she brought home a certificate to say she'd done excellent with her basic facts, so I mean that was really, really good. (Early Year 3)
>
> Mother: I was speaking to the teacher the other day, and she tells me Rochelle's gone up a maths group. She's very accurate in Level 1. Every time the home book comes, she gets more and more of her basic facts right, yeah, she's bettering herself each time, but she doesn't do the whole hundred yet. But the teacher said she deserves to go up because she's working really hard. (Late Year 3)
>
> Mrs Joiner: I've put Rochelle into the Squares group now, on her last assessment, she got 19 and a half out of thirty. (*Looking at the class results*) She's a way behind the top five – look, they're on twenty-nine, twenty-eight, but ahead of these others, so I thought she should go up. (Late Year 3)
>
> Researcher: Why do you think you're pretty good at maths, Rochelle?
>
> Rochelle: 'Cause in the *Daily Twenty* I can get nearly all the questions right.
>
> Researcher: (*Later*) What maths group are you in, Rochelle?
>
> Rochelle: I'm in the middle group.
>
> Researcher: How come you're in the middle group do you think? *(No reply)* Who put you in the middle group?
>
> Rochelle: Mrs Ponting.
>
> Researcher: Is that where you would put yourself?
>
> Rochelle: Yes. (Mid Year 4)
>
> Rochelle: I'm in the middle group – that's Circles.
>
> Researcher: Yes? How do you think Mrs Ponting put you in Circles?
>
> Rochelle: Um,'cause we done a test and she just saw where we were at. (Late Year 4)
>
> Mrs Ponting: Rochelle appears to enjoy maths, she's coming out of herself but she's a quiet little mouse…She works better sitting away from her little friends…Rochelle is in the

middle of my three groups. She’s got it in her but lets others do the thinking for her…She’s very conscientious at schoolwork. (Mid Year 4)

Researcher: What tells you that you’ve got better?

Rochelle: I’ve got more ticks in my maths book than last year.

Researcher: (*Later, after Rochelle places herself at 8 on the self-rating scale for mathematics ability*) What makes you think you’re an 8, Rochelle?

Rochelle: Because I have ticks and crosses.

Researcher: Are there some people who would be 9 or 10?

Rochelle: Some people would be 9s.

Researcher: How can you tell?

Rochelle: There’s a Standard 2 [boy] that’s a 9. Because when we done this sheet, he got a hundred out of a hundred.

Rochelle: (Later) Ms L. has a working group, and that’s the people who aren’t so good at maths, but I’m not in that, and they work with blocks and all that. (Early Year 5)

Ms Linkwater: Her recall is really good [basic facts]…And some like Rochelle’s group, and I’ve got a couple of Year 4s in that because they’re really, really good at it, I call them the Super Smarty Pants now and again…SSPs I put on the board and they could work it out (*laughs*). But it’s a really nice way of saying those kids who really work hard with a good attitude, good setting out, yeah it’s just that positive attitude and cope with the work. The reason I call them that is they have got the concepts, they work independently, and to work independently you have to be Super Smarties. (Early Year 5)

At the end of the first term of Year 5, Rochelle’s syndicate of classrooms was reorganised into a cross-grouping system for mathematics. Rochelle was placed in the group with Mrs Ponting (Rochelle’s teacher in Year 4) for mathematics.

Researcher: How come you got to go to Mrs Ponting do you think?

Rochelle: People who done really well in the test got to go with her.

Researcher: Are you in a maths group?

Rochelle: Mm.

Researcher: What’s your group called?

Rochelle: The Pentagons, which is the highest group.

Researcher: Why are you in the Pentagons group?

Rochelle: Don’t know.

Researcher: You’re not sure how she put you into groups?

Rochelle: I don’t know about the Triangles and Circles, but Rectangles, they’re in Room 3, and Pentagons, they’re much better than Room 3.

Researcher: Are you the only one from Room 3 in the Pentagons group?

Rochelle: I think there’s two others.

Rochelle: (*Later, after placing herself at 6 on the self-rating scale for mathematics ability and being asked why*) You take your work to Mrs Ponting.

Researcher: Does she say anything?

Rochelle: No. She marks your work.

Researcher: So you've decided you're a six. What things do you think you could do better?

Rochelle: Learn to do the three steps [written multiplication algorithm] (Mid Year 5)

Mrs Ponting explained Rochelle's progress.

Mrs Ponting: Rochelle is great at basic facts and computation. She gets them all right.

Researcher: Where would she sit compared with the other children?

Mrs Ponting: I'd put her right up there. She's a very hard worker, never talks or complains, and just gets on and does it. (Late Year 5)

During a number of classroom observations, Rochelle appeared to be a mathematical student who was able to follow rules and memorise facts in mathematics, but experienced difficulties on those occasions when tasks were open-ended or called for skills such as lateral thinking, logic, spotting patterns or explaining and justifying methods. Because little of her mathematics time was spent on such learning experiences during Years 3, 4 and 5, Rochelle did not appear to be daunted by this. Her teacher's opinions of her mathematical ability, and her placement in the middle or top group, continued to be based almost exclusively on her performance in routine basic facts and computation tasks and on her hard work. There were indications that Rochelle was aware of maths becoming harder and was expressing apprehension about her future achievement in mathematics.

Researcher: How do the other kids in the class feel about maths?

Rochelle: They don't like it.

Researcher: Would that be most of the others?

Rochelle: Yes.

Researcher: Why is that do you think?

Rochelle: I don't know. They say, 'Can we please not have maths today?'

Researcher: Can you see yourself enjoying maths when you get to high school?

Rochelle: No.

Researcher: Why is that?

Rochelle: It'll get harder.

Researcher: OK, what about intermediate?

Rochelle: No. My sister has really hard work.

Researcher: Do you think you're going to be good at maths at high school?

Rochelle: Um…I don't know.

Boaler (1997c) has noted the pressure experienced by children when placed in higher groups. Peers might also have contributed to Rochelle's feelings about the subject.

Sorting Children

Mitchell, Jessica and Rochelle provide examples of how children are recognised, classified, separated and treated differently as judged by their teachers' perceptions of mathematical "ability" in accordance with normalising continua of achievement. The grouping procedures they experienced were by no means unusual, as Table 6.1 shows. Arrows indicate promotion or demotion during the year.

Classroom environments often reinforced mathematics ability grouping in visible ways. These sometimes took the form of a chart or list on the wall with names of the children who belonged in each group, such as the one in Georgina's Year 3 room. Basic facts achievement charts (Fleur's Year 4 room) or graphs (Jessica and Rochelle's Year 4 rooms) were another means by which children compared achievement. On the board, or a chart, teachers frequently displayed the day's timetable including activities for each of the mathematics ability groups (Dominic's Year 5 Room, Rochelle's Year 4 and 5 Rooms and Georgina's Year 5 Room). In Year 5, Jessica's syndicate teachers produced typed lists of ability groups for each topic studied. In Mid Year 5, the children were observed crowding around the new list which the teacher had just posted on the classroom wall, to find out where they had been placed. Stickers, stamps and ticks were other signs used by teachers to reinforce achievement in mathematics. The children used such signs to assist them in a process of social "ability mapping" – identifying where they fitted in relation to the others.

Table 6.1 Groupings experienced by the children during Years 3, 4 and 5

	Year 3	Year 4	Year 5
Whole class teaching - occasional groups	Fleur	Rochelle, Jared Peter	Fleur, Toby
In-class ability groups			
Top	Rochelle	Liam ↓↑	Liam ↓
Middle	Liam, Rochelle ↑	Toby, Jessica, Liam	Liam
Bottom	Georgina, Jessica	Georgina	Georgina
Inter-class ability groups			
Top			Rochelle, Jessica
Middle		Dominic	Dominic, Jessica ↑↓
Bottom	Dominic	Fleur for one unit	Jared
In-class mixed ability groups	Toby		
Extension	Peter – (weekly)		Peter (later – weekly)
Special needs	Mitchell to younger class Jared Term 4 to special numeracy class	Mitchell with class some individual work	Mitchell with class – individual programme

As Table 6.1 shows, in most classrooms the children were grouped by ability in some form for mathematics. In almost every case, the grouping decisions were based on the results of timed pencil-and-paper tests. Syndicate cross-grouping for mathematics was an everyday occurrence in four of the ten schools. Teachers explained and justified grouping the children in this way.

> Researcher: So in this school you change around for maths. How was that decision made?
>
> Ms Torrance: Well actually I instigated it in this subject and the thing is that we were already doing that [in the senior part of the school]. I just thought it was so wonderful not to have a whole thread, [a variety of different groups to teach] and I actually think the standard is quite high at this school, so I thought it worked really well, and it certainly works well from a teaching point of view…I've just been to a course on educating the gifted and talented. We were having this big debate about whether you should enrich them or withdraw them or just…they [course tutors] don't think that streaming is a great plan. (Late Year 3)
>
> Miss Awatere: (*Explaining syndicate cross-grouping and why Dominic was put in the middle group*) I think it's just the logistics of accommodating children in a comfort zone to maintain their confidence in a school environment. (Late Year 3)
>
> Mrs Ponting: We changed to the cross-grouping – it was on staff recommendations. We wanted to change groups because that way they are a more manageable size, and, you know, it's less workload for us. (Mid Year 5)
>
> Researcher: Do you have a group system?
>
> Mrs Wai: I don't usually have groups, no. Because my special needs child goes out of the classroom and if I find I have anyone to cope with, we have within the school, we have facilities for them to go to. So if I had, say, three children who were away…not mixing in with the others, I would send them to another teacher and they would be able to cope with them. (Early Year 4)
>
> Researcher: You've told me how you regroup for maths [across the syndicate]. Do you do that for any other subjects?
>
> Mr Waters: No, that's the only one we do, but we'd have the arts, they get into syndicate groups, and for syndicate sport but that's the only [other] time we do it, it's got nothing to do with ability. Math's the only one.
>
> Researcher: So how many classes are involved with the swap?
>
> Mr Waters: Three. Next door is Alan, he's got [Years] 5 and 6, and Sue's 7 and 8, so I've got people going [from his Year 5 and 6 class] into Alan's and my Year 6, my more capable ones going right up to Sue's. Oh, in actual fact there's four,'cause Mark takes the extension classes.
>
> Researcher: Right, that's interesting, so did you use the PATs to decide who went where, or just looking at them [the children]?
>
> Mr Waters: Basically looking at ability, the PATs were done afterwards…it is just a consolidation basically, to keep them with their peers, basically, and then get them going, just to consolidate, understand where they're going, so they won't be completely lost. (Early Year 5)
>
> Researcher: So how did you decide who went where?
>
> Mr Ford: Just on their last year's achievement, across the board, in testing, in observational stuff, in their book work, PATs, you know, just looking at the whole thing and

> saying really where they fall in terms of where they're at in maths. And so we can give them the idea that we can give them the kind of support as a whole group, that they're all at. (Early Year 5)

Teachers who grouped children within their classrooms, usually created three ability groups – top, middle and bottom, explained as follows.

> Ms Torrance: I've got them in three groups and I'll just teach one group at a time, but I think particularly with number they need more intensive one-on-one thing.
>
> Researcher: Are they ability groups or random or…?
>
> Ms Torrance: They are ability groups…I don't regroup them for every strand so it's pretty stupid really. They are probably number groups, ability and number groups. (Early Year 3)
>
> Researcher: How did you form the groups?
>
> Mr Solomon: That's a pre-test for each unit.
>
> Researcher: So the groups would vary?
>
> Mr Solomon: Yes, they do.
>
> Researcher: Much?
>
> Mr Solomon: Mostly the same. Almost the same all the time in each group but yeah, they do vary slightly…That top group are mostly Year 4s…and there are some of the brighter Year 3s that are working with them there, then there's a middle group which are closer to that lower group, so there's a huge gap between that top group and the middle group I've got.
>
> Researcher: And the middle group would be a mixture of Year 3s and 4s?
>
> Mr Solomon: Yes, and then there's that smaller group [Georgina's] which have never really seen the sort of strands before, or don't relate to them in terms of the more structured maths that we're doing, so that's the group that I'm using lots of resources, you know, hands on resources with. (Early Year 3)
>
> Mrs Cayo: I would quickly go over one objective and do it together so they understand, then send that group, those who understand properly, set them work while I work with the children who are not…who didn't understand well, who are below average and then make them understand and then send the second lot away. I've got my maths groups but I haven't used them as much. Eventually they will blend into their ability groups and work at their own level. (Early Year 4)

Ability grouping *across* classes was rarely found in any other subject area and appeared to be a recent innovation for instruction in mathematics. Four of the fourteen schools were using this system consistently and had recently converted to this form of organisation. Another used it occasionally. A trend towards increased ability grouping across classes in the primary school was also noted at this time by Harlen and Malcolm (1997) and Boaler et al. (2000a) who stated that, "concerns with educational equity have been eclipsed by discourses of 'academic success', particularly for the most able, which has meant that large numbers of schools have returned to the practices of ability-grouping" (p. 631).

Ability grouping *within* classes was common practice for the teaching of mathematics and also appeared to be widespread in English instruction, particularly for reading. For other subjects, however, ability grouping was far less common.

This suggested that teachers viewed instruction in mathematics and English as more important than in other subjects believing children's learning to be enhanced by grouping according to perceived academic need. Teachers' also appeared to feel more comfortable working with children in homogenous groups. Mrs Ponting pointed out the reduced workload and greater manageability of the cross-grouping system. The few teachers who, like Mrs Cayo, said that they taught the whole class together, had built in flexible systems for catering for diverse and changing learning needs.

Extension groups for mathematics were found in several of the schools. While teachers may have been hesitant to use the term "bottom group" to name the children who were deemed to be at a less-developed stage of learning compared with the others, they used the more complimentary terms "top" or "extension" group unhesitatingly. Extension was not necessarily welcomed by the children placed in such groups, however, as the following comments showed. Peter's experience of the Year 3 extension group was viewed positively by his teacher, but not by Peter himself.

> Researcher: How do you think Peter feels about being in the extension group?
>
> Ms Summers: I think he's really enjoyed it. He hasn't communicated to anyone – just picking up. His smile. But it's amazing that you put a kid in that situation who perhaps wouldn't feel very confident about maths and suddenly that pupil rises. (Early Year 3)
>
> Researcher: Do you like the extension group better [than maths with own class] or not so much?
>
> Peter: Not so much.
>
> Researcher: Why don't you like it so much?
>
> Peter: Don't know. (Late Year 3)

An observation of the Year 3 extension group confirmed Peter's discomfort. He did not interact with the others, he laboured over tasks that the others seemed to complete with ease and he did not appear to be enjoying himself.

In spite of a growing body of evidence over recent decades suggesting that ability grouping in mathematics has a negligible positive effect on students in the higher ability groups, and appears to inhibit the learning of students in the lower groups (Slavin 1990; Hoffer 1992; Hallam and Toutounji 1996; Boaler 1997a; Linchevski and Kutscher 1998; Ireson and Hallam 1999), most of the teachers in this study appeared to uncritically accept that ability grouping was not only beneficial, but also the *only* way that they could successfully cater for what they viewed as the widely differing *needs* of the children. Zevenbergen (2002) suggested that it may be the dominant epistemological view of mathematics as a sequentially arranged body of truths that leads to what she sees as a pervasive and entrenched belief that ability grouping in mathematics benefits learning. In explaining how this may be justified she postulated, "if it is believed there is a hierarchy in the complexity and demands of the discipline, then it would be logical that students be mapped against this hierarchy" (p. 514).

Teachers Talk About Children

Through their descriptions of the children's progress in mathematics, the teachers revealed much about the ways they viewed children's mathematical ability, their beliefs about the reasons for success or lack of it and the terms they used to classify and name children of differing achievement.

Fleur

> Mrs Field: She's not up there, you know, way up the top. She's down a fair bit but she's quite enthusiastic about what she's doing. (Early Year 3)
>
> Ms Fell: She was in the lower group. (Mid Year 4)
>
> Mrs Meadows: She's middle of the range, you know. She'll never be top notch. I don't know what the parents' expectations are - is she expected to be higher at home, I wonder? (Mid Year 5)

Georgina

> Mr Solomon: I would have expected her to know more. There were four or five of them that that I thought might have been of a higher level. Simple number problems she can do but again it's the very slow adding on the fingers and going right back from the start to add all the fingers we've held up…She actually enjoyed and did really well on geometry, shapes and things like that so maybe she's a, um, spatial type person. (Early Year 3)
>
> Mr Solomon: Her negative attitude is not just to maths, it's right across the board. She's definitely capable but there's a blockage. (Late Year 3)
>
> Mrs Cayo: Yeah, she's not too bad, I think she can fit into…I could even make a Year 4 group and put her into the lower group. Some kids are very, very smart, got high ability and perhaps she can come to the next group. (Early Year 4)
>
> Mrs Isles: She's really not competent even with the 2 times table and by this stage she should be able to do the twos, fives, tens, so, no, um, and generally with maths tests and things, I mean we have pre-tests and mastery tests and there you can see she's struggling. (Early Year 5)

Dominic

> Ms Torrance: He's in the middle to up the top of my class. He's coming out with very good assessments – he's got double ticks in just about everything. (Mid Year 3)
>
> Miss Awatere: He's top of the pile in terms of ability, I mean not *the* top, but in the top, you know, twenty percent. He would be in the top eight children and he probably knows that because he knows the answers pretty much. (Late Year 3)

Mr Swift: *(Describing Dominic's group in the syndicate cross-grouping system)* Towards the bottom end. The two middle classes do a lot of similar stuff so we're towards the bottom end. He's a boy that's been exposed to level 2 so he can, for some of the subject areas, some of the strands, go up to level 3. (Mid Year 4)

Mr Ford: He's in the middle bunch. He's average for his age.

Researcher: What was his P.A.T. score for maths?

Mr Ford: About 65% I think. *[A later check shows that Dominic scored in the 86th percentile for his age. He is one of the youngest children in his class.] (Early Year 5)*

Jared

Ms Flower: I would say he would be a bit below average, but not…not being sort of fast anyway. (Mid Year 3)

Mrs Wai: I was quite surprised when his mother approached me at the [parent teacher evening] barbecue and she was worried about him academically. She said he was struggling. I see him sort of in the middle, within the normal band. (Early Year 4)

Mr Waters: He's right at the top end of the scale, basically, in this class ['lowest' of the syndicate cross-grouped mathematics classes]. (Early Year 5)

Liam

Miss Peake: He's in the Triangles group. Cycle 9 [the 'middle' of her three groups, based on the BSM system]. (Mid Year 3)

Ms Sierra: He's in the top maths group again – he went to the middle but now he's back. He's topped the *Quick Twenty* for 2 weeks now, so he's the class Maths Champ. (Late Year 4)

Mrs Matagi: I don't think he's, ah, brilliant at everything in the sense that he doesn't always get it first pop every time. I think he's quite comfortable on Level 3. (Mid Year 5)

Peter

Ms Summers: *(Talking of Peter's work with the extension group)* He's quiet in the group, and perhaps a few steps behind the other children. I always think he needs to be buddied up with someone who's an energetic thinker. (Late Year 3)

Mrs Waverley: I've no idea of his mathematical ability. If I'd [remembered] you were coming I would have got everything out [her assessment records] and had a good look…he would be one of those quite affable children whose hand would never go up and would never volunteer, and would sit very quietly, hopefully happily, and wait to escape. (Early Year 4)

Mrs Waverley: He's well behind other class members in basic facts – very variable results. (Mid Year 4)

Miss Sanderson: He's got a good grasp of where he should be now. Making steady progress.

Researcher: Will he be in the extension group?

Miss Sanderson: Yes. Oh. *(Checking his P.A.T. results in which he scored in the 71st percentile)* The benchmark is actually 75%, so no. (Early Year 5)

Toby

Ms Firth: I would say he's between middle and top, I would say between that sort of range. In general I've got quite a capable class when it comes to maths, so even with the majority of the Year 2 children, we have been working at early Level Two. Whereas I creamed some of those more capable Year 3 children and we've met them in the middle of Level 2 in the curriculum…yes, so I actually think Toby is quite capable because he's very quick to grasp concepts and that's because he has got such a good base knowledge. (Early Year 3)

Mrs Kyle: He's in the middle group, he's obviously not struggling. (Late Year 4)

Mr Cove: I just think he's an able student. (Mid Year 5)

Mathematical Ability as Discursive Construct

As these examples show, the most common metaphors used by the teachers in speaking of ability and achievement were those of velocity ("slower and faster") and altitude ("top, middle and bottom groups", "high and low" achievers). Given the emphasis on speed in classroom mathematics, this is not surprising. Altitude metaphors for achievement were by far the most frequently used: "high and low", "top, middle and bottom", "up and down" and "above or below" average. Scores and test results were similarly described as "high" and "low" by teachers and children. This spatial language, rooted in and productive of the discursive practices surrounding testing, grouping and differential teaching, positioned the children in relation to one another and constructed progress as a uni-directional movement along a hypothetical, developmentally ordered learning continuum. "Struggling" was a word that was used for those children whose progress from one stage to another was perceived to be "abnormally" slow and arduous.

Evidence for these views of mathematical learning as hierarchical can be found in the diagrams used in government documents in which mathematical learning stages are arranged vertically. *Mathematics in the New Zealand Curriculum* (1992, p. 17) shows levels of achievement rising in an ascending staircase. The *Numeracy Project* (Ministry of Education 2001b) depicted its strategy stages in a mountain diagram (Te Maunga Tau – The Number Mountain) with the highest stage at the narrow peak. This was later changed to a valley-shaped diagram. The children's common use of the concept of elevation (going up and down) in naming mathematical groupings and describing mathematical achievement suggested that the stratification of groups in classrooms produced children as subjects arranged in a ladder-like formation.

Other linguistic tags in common use to denote ability were “smarter” and “brighter”, “able”, “capable”, “competent”, “needy” and “struggling”. It was in the language of normalisation/abnormalisation that the children were recognised, compared and ranked as subjects, their capabilities measured by their success at performing tasks in the ways that their teachers *expected* and *accepted* and where ability was regarded as an immutable part of the child’s personal makeup. Labelling theory, developed by sociologists in the 1950s and 1960s (e.g. Lemert 1951; Becker 1963), has been used to explain the observed phenomenon, “that pupils tend to perform as well, or as badly, as their teachers expect. The teacher’s prediction of a pupil’s or group of pupils’ behaviour is held to be communicated to them, frequently in unintended ways; thus influencing the actual behaviour that follows” (Meighan and Saraj-Blatchford 1998, p. 309). This phenomenon has been demonstrated in grouping for mathematical learning where students of a similar “ability” are placed in different ability groups, and whose later differing achievement has been attributed to the grouping effect. It has also been suggested that it is the differing curricula delivered to students in their respective ability groups that produce the widening of gaps in such systems (Ruthven 1987; Boaler 1997a). A Foucaultian reading sees the children as subjects taking up the top-middle-bottom positions that the discourses of classroom, school and home create and maintain in practice, thus naturalising a structure that first establishes and then perpetuates inequality.

Lim and Ernest’s (2000) study of public images of mathematics showed that the vast majority of a sample of adults in UK (94%) believed that certain types of people are better at mathematics than others. Fifty percent of them regarded this mathematical ability as genetically derived, the quality of teaching was the next most quoted explanation, followed by effort and perseverance. The two most strongly held beliefs about mathematics that the sample revealed was that mathematics is difficult and that mathematics is only for the “clever ones”. This is consistent with the findings of Burton (1989), César (1995) and Vanyan et al. (1997). These findings suggest that the differentiating discourse of mathematics in schooling is based on and shared by the wider population.

The teachers’ systems for categorising, grouping and labelling appeared to be deeply entrenched. Where the children did not consistently and neatly fit, as in the case of Georgina who “got them all right” in geometry, but “struggled” with number, this presented competing signifiers for the teachers. Georgina was recognised as having geometric skills – “a spatial type person” – but this seemed somehow insufficiently convincing, as though spatial sense alone was not enough to signal “mathematical ability”. Even where there was apparent flexibility in grouping, for example regrouping for each topic, the groups remained relatively stable. Once categorised early in the school year, children were seldom re-classified. The greatest movement occurred with the “middle” children. The teachers’ views of the children remained remarkably consistent across the 3 years, indicating that “ability” in mathematics as defined by the schooling system is fixed from a fairly young age, contrary to syllabus directives that suggested that children learn mathematics at vastly varying rates and in many different ways. This would suggest that “mathematical ability” might be difficult to define and therefore even more difficult to “detect” or identify in a child. As it turned out, the teachers had little difficulty in ranking children according to mathematical ability.

Some teachers, Ms Tyde for instance, expressed discomfort about using terms of classification with “nasty” connotations such as *average* and *bottom*, referring to the hierarchical levelling system of the curriculum statement instead, but most teachers used such labels freely and in a manner that suggested that such classifications were a commonly understood, accepted and unchallengeable language of schooling.

Parents Talk About Their Children

Parents were greatly interested in their children’s progress in mathematics and talked about their children’s achievement in a variety of ways. Their comments included qualities such as confidence, “getting it” and “having it” or “being” smart, and took note of the positions in which they saw their children “sitting”. Their discursive construction of children’s mathematical abilities echoed that of the teachers indicating a shared acceptance that mathematical ability is part of an individual’s “essence” or personal makeup.

> Fleur’s mother: I think she’s somewhere at the top of the second group for maths. She tries her best but just doesn’t have the confidence. We had to help her a lot with the times tables. She would sit there saying, ‘I’ll never be able to do this’. Yeah, she’s more confident in other subjects. (Mid Year 4)

> Georgina’s father: I’m frustrated because Georgina doesn’t seem to be getting it (basic facts). I could do it easily – I’ve got a scientific mind. (Mid Year 5)

> Jessica’s mother: They’ve either got it or they haven’t, haven’t they? Genetics must play some part. (Early Year 3)

> Maths is just not her favourite subject. She loves writing and always has done. She’s in the bottom group for maths this year, apparently, but some of the children in that group are the brighter ones, so…hm, I don’t know. She often finds the maths they are doing easy but she’s scared to say – she’ll plead ignorance in case she gets harder work. (Mid Year 5)

> Rochelle’s mother: I feel she’s not pushed, that’s my main concern. I feel she should be pushed a bit more because she’s got the ability. She comes home and says maths is too easy, and she’s getting bored. (Mid Year 5)

> Dominic’s mother: His teachers for the last couple of years have worked out that he seems to have a bit of a gift for maths as opposed to reading and writing. (Early Year 3)

> Dominic’s father: He is aware now of where he sits in comparison to others, which he was blissfully unaware of before, which was really neat, so he is now…being in the last maths group. He’s aware now that the kids who go off to Ms Torrance for maths are the ones who are the lowest, whatever that means to him…When he talks about maths he sounds quite confident that he can do it. His only reservation is that the others think he’s thick or slow because he has to go to Room 5 to do it. (Late Year 3)

> Dominic's mother: With reading they just do a running record and work out how comfortable they are with a similar grouping, but with maths I don't know how they do it, whether they go by age or how they do it. (Late Year 3)

> Jared's mother: I thought he was taking a long time to get it, but it's starting to fall into place for him… I sometimes sort of get him to add, and he just guesses a number in the vicinity rather than actually knowing how to get to it, whereas Aaron [Jared's brother, younger by two years] will go forward and grab it and come up with the right answer. (Mid Year 3)

> Liam's mother: He's a little smarty. We'll say to Chantelle [Liam's sister, older by two years] 'What's such and such?' and he'll go like, (*clicks her fingers*) not a problem really. (Early Year 3)

> Liam's father: He'd probably be quicker, if anything he might be quicker than Chantelle. Yeah, but they're different people. He's not going to be a reader or story teller like Chantelle is. (Early Year 3)

> Mitchell's mother: It must be genetic, mustn't it? I'm not that great and nor is his Dad. (Late Year 5)

> Peter's mother: He's never been a kid who's really good at something, until he's mastered it. He said, 'I don't like maths,' and that's a sure sign that he feels just a little bit out of his depth… I was talking to his teacher and she was surprised when I told her that – as far as she's concerned, Peter's really good at maths. I was actually astonished that he was chosen for the maths extension group. (Early Year 3)

> Toby's mother: I think he's doing quite well – for his age… You do get some information but you don't like to ask how they compare with other kids. But yeah, he'd be around the top group. (Late Year 3)

Children Talk About Themselves

The children's talk showed how they had taken up the discourse of ability and used it as their own. In the cases of Mitchell, Jessica and Rochelle, assessment, categorisation and grouping according to teachers' systems of normalisation and judgement and ranking by peers or parents were powerfully implicated in their mathematical subjectivities. The following conversations reveal something of how the other children interpreted the ways in which others regarded their performance in mathematics.

> Fleur: I'm a bit of a slow learner. They're quick [other children]. I'm quite a bit slower. Because I struggle. They know a bit more and what they're doing. They get the point of it all. (Mid Year 4)

> Fleur: (*Having rated herself at 5.5 on the scale*) Well, I find it hard, so that kinda puts me back, so if I find it hard that means that I'm no good at it.

> Researcher: Are there some kids who find it easier do you think?

> Fleur: Definitely.

> Researcher: How do you know that?

> Fleur: They like maths, they enjoy it. (Mid Year 5)

By early Year 4, Fleur was developing an understanding of who was and was not "good" at maths, and this conversation shows some of her reasoning, including ideas from the television programmes she had been watching:

> Researcher: Is there someone you know about who is really good at maths like your family or friends?
>
> Fleur: Carly.
>
> Researcher: How did you find that out?
>
> Fleur: Because I sit next to her and she's usually, when I look at her work, it's like, so good.
>
> Researcher: (*Later*) What about in T.V. programmes or anything like that, that you think is good at maths? (*Pause*) What about Bart Simpson? Is he good at maths? (*Fleur has said earlier in the interview that she likes The Simpsons*)
>
> Fleur: (*Laughs*) Lisa is.
>
> Researcher: Is there anyone you know who's no good at maths?
>
> Fleur: Hm. Leanne.
>
> Researcher: How do you know that?
>
> Fleur: Because she's always in a group where she's trying to find out more things about the maths.
>
> Researcher: Anyone else you can think of who isn't very good at maths?
>
> Fleur: Hm. Mary-Kate and Ashley Olsen.
>
> Researcher: Are they in the same group as Leanne?
>
> Fleur: (*Laughing*) No, no, no! They're off, um, *It Takes Two*. Have you seen that programme? [Current television comedy for children]
>
> Researcher: No, I haven't. How do you know they're no good at maths?
>
> Fleur: Because, um, in the first one [episode] she said, 'You know in real life you can use a calculator?' They never do their homework. (Early Year 4)

Georgina did not feel happy about her positioning as student less able than most of her peers. The class grouping system reinforced her sense of failure through exclusion. Ruthven (1987) argued that ability grouping leads to differential treatment of children by teachers, and this may have been a factor in Georgina's unhappiness with her group placement.

> Researcher: How do you know Justin's really good at maths?
>
> Georgina: Because he's in the highest group and he's always getting everything right.
>
> Researcher: How do you know he's getting everything right?
>
> Georgina: Because he always, like, puts up his hand every time, 'cause he's really fast and goes 'Shp! Shp! Shp! (*Georgina acts out the way Justin puts up his hand quickly time after time*)
>
> Researcher: So he's in the highest group. What group are you in?

Georgina: Squares.

Researcher: How did you get into that group?

Georgina: It's the second to last group I think. I want Mrs Cayo to put me up because I'm actually meant to be higher'cause I get everything right,'cause I'm in a Year 3's group.

Researcher: And you're a Year 4.

Georgina: Yeah.'Cause there's only two Year 4s [in that group] and that's Erena and me.

(Mid Year 4)

Georgina: I don't like it when I have to stay on the mat [for extra work with the teacher] and the other kids can go off.

Researcher: Does that happen very often?

Georgina: Yeah. (Early Year 5)

Researcher: Why do you think you're around 5 at maths [on self-rating scale]?

Georgina: Well, when we were doing fractions it was really hard for me and I didn't get it and they [other children] were just going, 'Oh yeah, I know that one!' and they got it straight away and they were correct. (Mid Year 5)

Researcher: What makes you think you're a 5 [on self-rating scale].

Georgina: Some people would be about 8 or 9.

Researcher: How can you tell?

Georgina: I dunno.'Cause most tests they get them all right and in, like, two minutes, they get them all right. (Late Year 5)

Dominic believed that the teacher would rate him less favourably than he would rate himself. As described earlier, Dominic's Year 5 teacher considered him to be "average" despite his PAT score which indicated considerably greater mathematical competence than the "average" child of his age.

Dominic: Mr Swift would probably put me at about 9 [compared with his self-rating of 10]. Because he usually doesn't see things, but I always get it right, but the first time he saw it [all correct] he said, 'Gee Martin,' and he's [Martin] about 10. Now he doesn't even check me…I'm one of the best in the class.

Researcher: How do you know that?

Dominic:'Cause every basic facts test, I get eighty out of eighty.

Researcher: Would there be quite a lot of people that would be 10s in your class?

Dominic: No, only four, they are me, Eden, Whitney and Martin…We practice a lot and the other people don't practise much…I'm smarter than them… (Late Year 4)

Jared's mathematical subjectivity was seen to change when he was placed in the bottom group in the syndicate cross-grouping system. When comparing himself with others in that group, he now considered himself to be one of the best.

Jared: (*Rating himself 10 on ability scale*) There's one person in the class who's the same as me. We both know all the answers. (Mid Year 5)

This contrasted with his lowest rating of 6 during the previous 2 years. This phenomenon has been observed by Pollard et al. (2000) who found that for the lowest achieving children in their study, 50% said mathematics was their most-liked subject. They suggested that these children, “saw it as a refuge from more open-ended tasks like writing. They enjoyed the security its routines could provide and with differentiation they enjoyed a degree of success” (p. 101).

Liam had been placed in the top mathematics group for around a year and a half. He had come to regard himself as good at mathematics. However, an event occurred which shook that self-perception. Based on the results of one of his topic pre-tests, he was demoted from the highest group, with a concomitant adjustment in his self-rating from 8 to 6.

Liam: I’m not the best. They get higher scores than me. (Mid Year 5)

Peter and Toby also rated and ranked themselves according to their marks and scores by comparing themselves with peers.

Peter: (*Rating himself at 9 on the scale*) Because I can get most of it.

Researcher: Would anyone be a 10 do you think?

Peter: Yeah, because some people in the class always get top marks and stuff. (Mid Year 5)

Toby: (*Explaining why he rated himself 8*) Because there are people in my class who would be a 10 because they’re quite a lot better than me – Jasper Thompson who knows all of his times tables …(*Explaining his group*) Um, well, I think that, um, the Squares are the highest, the Circles might be the second highest and the Triangles might be the third highest but I don’t know if Mrs Kyle meant to put me in the Triangles because there are some people in the um, the Circles that I’m about as good as. (Late Year 4)

Social mechanisms of peer ranking for mathematics operated amongst the children as the following extracts reveal:

Researcher: (*To a group of boys in Rochelle’s class who have asked about the purpose of my visit*) How do you feel about maths?

Eli: Good. I’m the best in the class.

Brad: No you’re not.

Eli: Who is then?

Brad: Maria.

Tim: No, she doesn’t know four times nine.

Eli: It’s, um, thirty-six!

Josh: (*Sneeringly*) You think you’re better than *Corey* at maths! (*The debate continues in this manner for a little longer, with Eli becoming visibly upset*)

Eli: (*Finally, in a distressed voice*) Shut up! (*The teacher intervenes by asking the boys to get ready for maths*) (Late Year 5)

(*Georgina sits with a group of girls who are discussing those who are good at maths in the class*)

Charlotte: There's this boy in our class. He's really brainy, he knows his times tables and division and all that.

Hayley: What about Tara? She's good too. She's too brainy to be a Year 3. (Early Year 3)

Meighan and Siraj-Blatchford (1997) suggested that this manner of "pupils assessing pupils" is the most prevalent form of assessment in school settings, yet educators pay it the least attention. The children's statements reveal their positioning as self-rating subjects in measures of comparison with classmates, was deeply implicated in mathematical subjectivity. The primary indicators by which children gauged their own and others' mathematical abilities mathematics speed tests and games, mathematics test results, the difficulty of work they were assigned by the teacher, speed of task completion, feedback from the teacher including verbal feedback as well as stamps, stickers, and the proportions of ticks and crosses on the work in their mathematics exercise books and by group placement. It was through this system of peer-on-peer comparison that Dominic overrode the teacher's opinion of him and drew his own conclusion that he was one of the four best in the class.

Researcher: Do you ever talk about maths with your friends?

Dominic: Just probably after our basic facts tests, when we talk about our scores and stuff. (Late Year 4)

Where the structures of mathematics teaching encouraged peer assessment and ranking such as speed tests, games of *Around the World* and grouping based on pre-test results, there were winners and losers. Fleur, Georgina, Jessica, Jared, Mitchell and Peter had all experienced being losers. They had each developed unique coping strategies. Even the more confident children such as Rochelle, Dominic, Liam and Toby who generally regarded themselves as "winners", though positive about their mathematics achievement, had doubts about its lasting nature as the following extracts show:

Researcher: How do you feel when you do the tests?

Rochelle: Sometimes a little bit worried. Because I think they're going to be hard. (Mid Year 5)

Dominic: I feel quite nervous, well,'cause you don't know which group you will be in.

Researcher: You could change groups?

Dominic: Yeah…He changes the groups all the time but I've always been in the highest group. (Late Year 4)

Liam: Sometimes I get really nervous,'cause I might get a real bad score. I feel like my legs would shake…Kids might say, 'That sucks, you should've got higher than that.' (Mid Year 5)

Ability in the Archive

Mathematics in the New Zealand Curriculum (1992) was unique amongst New Zealand's current curriculum statements of the 1990s curriculum reform in providing a "development band" for children it perceived as "more able". It stated that:

> Some students develop *faster* in all aspects of mathematics than most of their peer group… The intention of the development band is to encourage teachers to offer broader, richer and more challenging mathematical experiences to *faster* students. Work from the development band should allow *better* students to investigate whole new topics which would not otherwise be studied and to work *at a higher conceptual level. Talented* students should have their interest in mathematical ideas stimulated. (p. 19) [Italics added for emphasis]

This differed from curriculum statements of other essential learning areas such as English in the New Zealand Curriculum (Ministry of Education 1994) which simply stated that "the aims and objectives in this curriculum statement provide goals and challenges for all, including *gifted and talented students*. Teachers should adapt learning contexts to stimulate and extend these students" (p. 15). [Italics added]

Mathematics in the New Zealand Curriculum (Ministry of Education 1992) also asserted that, "students of *lower ability* need to have the opportunity to experience a range of mathematics which is appropriate to their age level, interests, and capabilities" (p. 12) but made no special provision for these students. *English in the New Zealand Curriculum* (Ministry of Education 1994) on the other hand said, "there are a significant number of learners for whom the acquisition of skills in formal English is difficult. The English language programme must offer *students with communication difficulties and disabilities* every opportunity to develop their communication skills" (p. 15). [Italics added]

Development Band Mathematics (Ministry of Education 1996) was published as a guide to assist teachers in catering for the "*faster*" and "*better*" children. Throughout the handbook these children were variously named, "*with special mathematical abilities*" (p. 5), "*talented*", "*an exceptional few*" (p. 8), "*very able*" (p. 9), "*really able*" (p. 16), "*extremely able*" (p. 17) and "*very bright*" (p. 20). The authors were at pains to explain that they were "avoiding where possible" the terms "gifted" and "talented" in the handbook, "because of the implications and expectations the words carry for those who are given these labels" (p. 17). These classifiers *were* used, however (pp. 8, 18), presumably because complete avoidance was impossible. The handbook urged teachers to identify these children, and provided a range of diagnostic tools for this purpose.

The unique construction of *Mathematics in the New Zealand Curriculum* and its handbook, *Development Band Mathematics*, both reflected and reproduced dominant beliefs about the nature of mathematics and of mathematical ability. That the national mathematics curriculum included a special band for talented students and provided a guidebook for teachers to cater for such students when curricula for other subject areas did not indicated a pervasive faith in the idea that mathematical talent occurs naturally and demands a kind of special treatment not required for talent in other domains. Although a handbook was intended for the mathematically "needy" at the opposite end of a spectrum manufactured in measurements of achievement, this was never written.

The writers of *Development Band Mathematics* struggled to reconcile two seemingly incompatible beliefs (a) education should be inclusive and should provide equal opportunities for all students and (b) education should cater in special and exclusive ways for the individual needs of students, particularly the "very able". This conflict is illustrated in the authors' attempts to promote the normalising/

differentiating processes of identifying development band students, while espousing the principles of equity:

> The purpose of identifying students capable of development band work is to meet their individual needs. Since students' interests and apparent abilities change and develop, identification should be an ongoing process…It is especially important that equity is guaranteed in the identification process. Development band students will be both male and female and from all cultures… The identification of the majority of development band students is straightforward. They are the ones who do their work quickly and achieve good results in tests and assignments. (p. 16)

This contradicts the statement found in *Mathematics in the New Zealand Curriculum* (Ministry of Education 1992): "Traditional time-constrained pencil and paper tests have proved unreliable indicators of Māori achievement in the past" (p. 13). As tests such as TIMSS show, Māori (New Zealand indigenous) children are underrepresented in higher achievement stages and are therefore unlikely to be fairly represented in development band identification. A conundrum exists here, in the pervasive social compulsion to identify, rank and label. The teachers in the study showed how these same dilemmas drove them to seek ways to accommodate their paradoxical views of the nature and purpose of mathematical educating.

In *Development Band Mathematics* (Ministry of Education 1996), it is suggested that children's ability is fluid and mutable. While the impression is given that all students could and should at some time be included in development band activities, the handbook states: "At some time during their school years, about twenty-five percent will take part in a development band activity of some kind" (p. 8). In spite of the rhetoric of equity, it appears that the authors expected, as some kind of universal axiom, that only 25% of children would ever be included in the "higher cognitive levels", no matter how well they had been taught, and even then, not all of the time. Catering for Development Band students would appear to rest, therefore, on uncritical beliefs about a naturally occurring distribution of mathematical ability. The consequential denial of access to "higher" level mathematics for 75% of the student population is conversely a taken-for-granted.

Only one of the research schools appeared to make use of either the material for development band students in *Mathematics in the New Zealand Curriculum* or *Development Band Mathematics*. Apart from Lake School where Jessica said "I'm not in his band thing" (Late Year 4), the term *Development Band* was never heard. The schools preferred the terms *extension* or *enrichment*.

Boaler and Wiliam (2001) remarked that, "in the UK there is a long tradition of grouping students by ability, particularly in mathematics. This practice is founded on the widespread belief that ability grouping raises attainment" (p. 77). They provided evidence from extensive classroom observations and interviews with 11-year-old pupils that ability grouping was a negative experience not only for those in the lower sets, but also for those in the higher where children complained of excessive expectations and pressure to succeed (as Rochelle, Dominic and Liam also commented) and of more formal and faster paced lessons with less time for exploration and consolidation of new learning, and separation from friends whom they could ask for help. The study concluded that teachers teach children in the higher ability groups in quite a different manner to children in the middle or lower groups. Classroom environments of the top groups were characterised by faster pace, more procedural pedagogy and competition between students. The other key issues arising from their study of ability grouping were the lower expectations and more limited learning opportunities provided for the less able children, the apparent homogeneity of children in ability groups leading to inflexible placing of students (once children were placed, movement between groups was rare) inflexible pacing (all children in the group had to work at the same speed) and restricted pedagogy. Teachers in schools where children were grouped by ability were far more likely to rely upon a textbook approach to teaching of mathematics. Although the children of the present research were younger than the students discussed by Boaler and Wiliam, their experiences resonate with those the older students.

Inscribing the Mathematically Able Child

The discursive practices of schools construct a normality in which children as subjects are made and accepted as real. The child constituted in such systems can be viewed as "fiction operating as truth" (Cotton 2004), since the signifiers by which the child is produced are arbitrary and always open to change. In measuring, classifying and ordering children according to frameworks of normalisation such as levels, stages, benchmarks and standards, it becomes possible to differentiate, that is, to delimit, proscribe, admit passage or debar. As Gallagher (1992) argued:

> [Through its assessment procedures, education,] acts as a machine into which we put non-subjects…by which we produce *subjects* in every sense of that word. These procedures… objectify their subjects by making them visible in the light of certain measuring criteria… document their subjects bestowing upon them a certain history which captures and fixes them and…define each individual as a "case." (p. 298)

Parks (2007) took this further in remarking that:

> These technologies – the methods of measurement, the content being measured, and the way scores are (or are not) disaggregated – are not innocent, neutral or natural; they do not simply measure what is true; they produce it. Typically, scores are not reported by income-level, educational attainment of parents, hair colour or height. We choose which categories to make important. (p. 189)

In this view, schools act as disciplinary institutions in which the child is subjected to a normalising gaze according to the classification systems school creates, as Foucault described: "The perpetual penalty that traverses all points and supervises every instant…compares, differentiates, hierarchizes, homogenizes, excludes – in short, normalizes" (Foucault 1977, p. 183). In this view, schooling acts as a discursive domain productive of the mathematically able subject such as the "numerate child", created and maintained through a framework of practices of assessment. Dorfler and McLone (1986) commented that:

> Mathematics is one of many subjects but it nevertheless is in a unique position, because of its highly differentiating effect. There are the talented students and the underachievers, there is the necessity for remedial teaching, there are minimal competencies and many other features which demonstrate the quite peculiar position of the subject mathematics at school. (p. 71)

Metaphors found in everyday language (Lakoff and Johnson 1980) are commonly used to express and reinforce our beliefs about human differentiation and segregation, for example the biblical story about separating "sheep" from "goats"[4] or the saying "separating the wheat from the chaff"[5]. Recurrent use of such metaphors denotes a popular conviction that there are naturally occurring, distinct types of people, some better or worse than others, and that they can and should be identified, categorised, separated and treated differently. The discursive practices which produce differentiation shape perceptions of mathematical achievement and ability, reinforced through the metaphorical language and everyday practices of the classroom.

Postman (1996) argued that ability or smartness is not something people have but something they do in a particular place at a particular time:

> In schools, for instance, we find that tests are given to determine how smart someone is or, more precisely, how much smartness someone has…Smartness, so it seems to me, is a specific performance, done in a particular set of circumstances. It is not something you are or have in measurable quantities. In fact, the assumption that smartness is something you have has led to such nonsensical terms as over- and underachievers. (pp. 176–177)

Thus Mr Loch was surprised when Jessica *did* a smart thing – she scored well on the fractions pre-test. He had previously believed she *was* a "middle kid", even a bit below average. He tried to find explanations for this apparent aberration, while his view of her as a middle kid remained unchanged. Many of the other teachers talked of the children as though their ability was fixed - something they *were* or *had*.

Parents too sometimes held views that suggested they believed ability was something their children *had* for example Jessica's mother who believed Jessica *was* "a left-brainer", implying therefore that she was less likely to be able to *do* certain things.

Oakes et al (1997) viewed ability, as did Foucault, as a social construction built on an equally constructed view of knowledge. They used the work of Berger and Luckmann (1966) to explain the social construction of "realities" such as ability and intelligence, which teachers used to identify and group children. Dowling (1998) also challenged the notion of "ability" as fixed and saw schools as contriving to categorise and separate children, especially through the teaching of mathematics:

> Schooling comprises cultural institutions, practices and beliefs which are constituted by and are constitutive of the relations which characterize the social. Specifically, schooling in general, and school mathematics in particular, is organised on the basis of the distribution of pedagogic content and action in terms of student attributes. In the early stages of mass schooling the principles of this distribution were commonly explicitly stated in terms of social class and gender. More recently, the rhetoric has tended to background these social considerations in favour of categories such as ability, achievement and needs. Nevertheless,

[4] New Testament, St Matthew, 25:31–3.

[5] Psalms, 1:3–4.

> it seems that the differentiation of the curriculum remains more or less closely associated with the social stratification of the student population. In stark terms, my position is that there is no such thing as 'ability' or 'achievement' or 'needs' insofar as these are interpreted as substantive predicates of individual students. Rather, these are variables which are constituted in and by the practices of schooling. (pp. 68–69)

Berger and Keynes (1995) argued similarly that, "Separation creates an underclass which receives inferior treatment… Each year of schooling is a filtering process for students of mathematics. Only the top group is assumed to have passed through the filter". (pp. 90–91). Zevenbergen (2001) noted the close connections between social class and supposed mathematical "ability", and the results of differentiation by ability as translated into differentiated curricula for each of the identified groups.

In speaking of teachers of mathematics, Drew (1996) said, "our approach to teaching depends upon whether we assume that (1) virtually everyone can master the material and the challenge is to present it in a manner that allows them to do so, or (2) the material is tough and only a few of the best and the brightest will be able to learn it" (p. 9). He contended that tests designed to identify those with special mathematical aptitudes, "can be extremely destructive if they send a message – an incorrect message – to those who are not selected that they are incapable of learning the material" (p. 10).

For children such as Georgina who was never placed in a development band or extension group in spite of her apparent competence in geometry, subjectification through the differentiating practices in school mathematics is a disheartening experience. However, as Fleur showed below, when she discovered that there was something in mathematics that she could do better than most of her peers, being identified as "slow" does not necessarily have lasting or irreversible effects and that children can shake off such labels given even minimal encouragement or opportunities for success. However, "success" in the children's eyes was invariably equated with being better than others.

> Fleur: (*After learning to perform addition and subtraction calculations in written working form with renaming*) I love maths now. I'm one of the best in the class. (Late Year 4)

> Fleur: Seventy-nine was my highest score. One more point and I would've got into the top group, the ones that are at the top of the class. I bet a whole lot of people that I normally would never beat in that test. I just tried really hard. Tried my hardest. (Late Year 5)

In the schools' information pamphlets for parents, mention was frequently made of the importance of mathematics as a subject, and of the special provision made for top and bottom learners in this subject. Here are two examples:

> As part of the planning and assessment process all teachers regularly provide enrichment activities, particularly in the areas of language/reading and maths. (River School)

> This school offers: A comprehensive primary education with an emphasis on literacy and numeracy, with special help in reading, language and mathematics for children with difficulties. (Spring School)

Parks (2007) remarked that the range of categories now used to differentiate students was not seen in early research in mathematics education. She cited the examples of Thorndike (1922) who referred only to "the pupil" and Brownell (1938) who did not discuss differences amongst students, except in regard to ways that they had been taught (p. 190). This demonstrates the arbitrary and contingent nature of systems of categorisation in mathematics education that allow for the “succeeding” or “failing”, the “special needs” or “gifted” child to be *made*.

Much of what occurred in the everyday lives of the children was driven by processes of normalisation based on measurements of ability and every child was subjected to some form of ability grouping. Extension groups were provided in a number of instances for the children who were identified as talented, but little support were provided for those who were perceived as lagging behind. There appeared to be a widespread belief that effective teaching could not take place without some kind of differentiation by ability. Ability was usually determined by written tests, contrary to the clear directive of *Mathematics in the New Zealand Curriculum* (Ministry of Education 1992) that a variety of assessment techniques be used. As discussed in Chap. 4, regular speed activities were also used by the teachers and children as a major vehicle for sorting “tops”, “middles” and “bottoms”. Number skills were most often used as a determinant of mathematical ability, privileged over other kinds of mathematical facility.

The children’s subjectivities as mathematically able subjects were made in the testing and grouping practices of the classroom. For some, this manifested in feelings of anxiety, and exclusion; for others, pride and satisfaction. Furthermore, grouping practices denied a significant proportion of the children access to the broadened mathematical curriculum provided for others, resulting in expressions of alienation, marginalisation and impoverished learning. The children’s perceptions of mathematical ability were shaped and reinforced by the everyday classroom routines such speed games, tests, teachers’ marking of their work and grouping, since teachers provided minimal verbal feedback to the children about their mathematical strengths and needs. Such feedback might have provided them with more useful evidence of their mathematical learning development, than their readings of everyday events such as the easily comparable results of daily basic facts speed tests.

Blurred in the discourse surrounding teaching for needs, *ability* and *achievement* were accepted as quantifiable qualities of the child. As organising concepts in the classroom, they remained resistant to alternative perspectives even where the pedagogical and epistemological bases for such judgements about children’s learning of mathematics had been questioned. The examples of Georgina and Mitchell, whose mathematical understandings were recognised by their teachers only by means of a narrow range of criteria, illustrate how a pervasive reliance on traditional assessment methods such as timed written tests, allowed the kinds of categorisation, sorting, and differential treatment that captured these children in a cycle of mathematical subjectification from which they could not escape and in which they struggled to maintain positive subjectivities. For the other children in the study, fluctuation in mathematical subjectivity was tied to fluctuations in performance, and during Years 3, 4 and 5 of their primary schooling, their confidence ebbed and flowed with the various positions they came to occupy as mathematical subjects.

The following section of the book follows the children into their secondary school years where the discursive practices of subjectification that had been exercised from early in their primary schooling such as working alone at written tasks, racing and competing, striving for correct answers and being judged according to arbitrary measures of their ability, were reconfigured within regimes of formulaic lessons, standardised national testing and occupational choice.

Part 3

Subjects of Choice: The Secondary years

Chapter 7
Form and Formula

Every day it was the textbook … for the first like, 20 minutes you just write down notes and then you'd have 20 minutes of doing the work and then you do it at home …

Fleur, 16 years

When the second phase of this study began, the children had just completed 3 years of secondary schooling, their eleventh year at school, and their first major national mathematics examinations. As some of the children had anticipated in their interviews late in Year 5, moving to secondary school represented a major change in their learning of mathematics. They described how mathematics lessons at secondary school were organised into specific periods of the school day and taught by specialised mathematics teachers. New mathematical topics were introduced, new textbooks used and new techniques of assessment experienced, but many of the features of their learning of mathematics in the primary school years remained unaltered. Fleur's description of a typical lesson (aforementioned) demonstrated a universalised pedagogy of mathematics established as early as Year 3, in which teacher exposition was followed by exercises from the textbook with children working alone at desks, writing in their mathematics exercise books. As the page from Peter's books shows (Fig. 7.1), the use of the mathematics exercise book and its particular mode of setting out that the children's primary teachers had battled to instil in their students had been faithfully preserved into upper secondary school. Peter's teacher had stipulated its use in listing the equipment required for Year 13 Statistics.

> Requirements: You will need 2 x 1J5 exercise books, red and blue pens, pencils, an eraser, a ruler, a compass and protractor and graphical calculator. A graphical calculator is compulsory for this course.
>
> Year 13 Statistics, 2008.

In many of the mathematics classrooms in this study, the 1J5 exercise book anchored the regulatory practices that signalled and shaped students' "doing" of maths at secondary school. For Rochelle, daily subjection to working in her exercise book in the very specific way that her teachers demanded contributed to her growing disaffection as a learner of mathematics.

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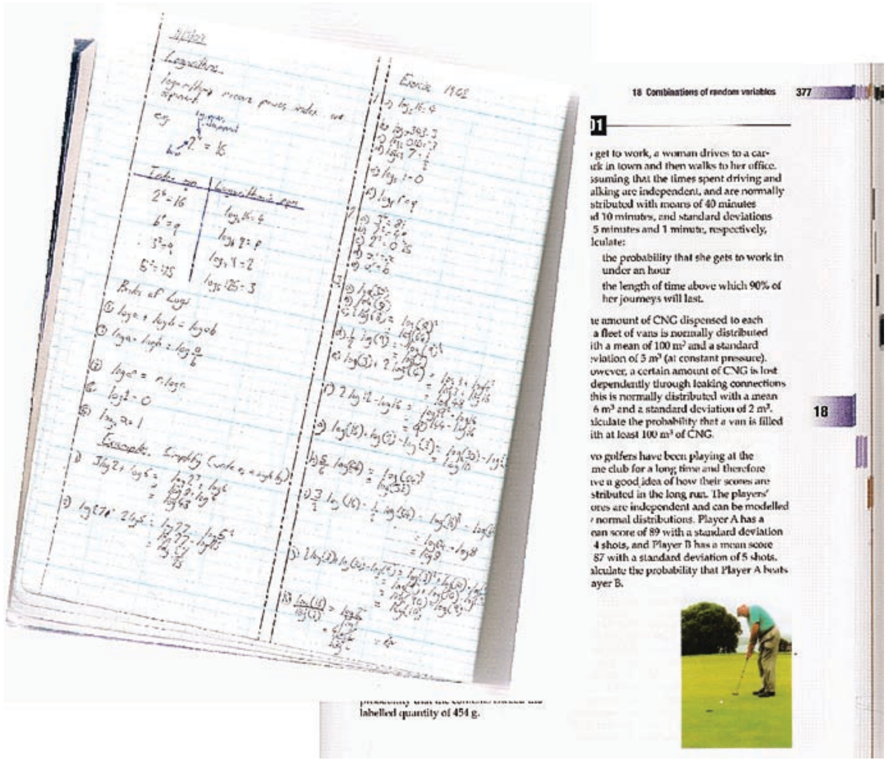

Fig. 7.1 Typical pages from Peter's mathematics exercise book and Sigma Mathematics NCEA Level 3 text book (Barton 2005, Auckland: Pearson) Dockside High, Mid Year 13

> Rochelle: We always had to rule our lines, one down the left-hand side and two lines in the middle, just real skinny ones, and then like write on one side of them. Red pen lines. I don't know why, I mean if we can read it, why? It's just to keep the book tidy I think. Silly things like that I just don't understand why we have to do it, like, you know, ruling up your book (*rolls her eyes*). (Mid Year 13)

Doing Maths: The Typical Mathematics Lesson Revisited

The children's descriptions of a typical mathematics lesson at secondary school showed how its unwavering routine not only defined the doing of mathematics but exerted its power over children whose everyday actions shaped in the mathematics classroom distinguished them as mathematical learners.

> Jessica: We have a *notes book* and an *exercise book* and we'll come into class and the teacher will be putting up the notes or we'll write up the notes and we'll copy down the notes … then you do a few exercises out of the book or whatever she's set us, there might

> be like a sheet instead of the exercise book, and then, depending on how difficult it is and stuff like that, we'll either keep doing it for the whole lesson and she'll just write up exercise after exercise and we'll have to do it, or we'll move on and have to write up more notes. And throughout the notes she'll sort of explain it to us and we'll sort of, kinda discuss it and that's where we'll do the questioning and that, discussing and all that and then we do the work … I've never really thought about it before but it seems like maths might be the one [subject] that's sort of, every lesson's the same, even though the work is different, every lesson's the same, and because it's like numbers it seems like it's always the same and when you look at English or Economics or Science you're always doing different topics, and to me maths, even though some of the topics are different, is quite repetitive … (Early Year 12)

> Toby: The teacher gives us notes … if it gets dragged on for a long time it just gets boring. (Early Year 12)

Jessica's description of the use of two exercise books – one for notes and the other for exercises – was common in other classrooms. Whereas teachers in primary school had explained new concepts to children, secondary teachers expected the children to take "notes" – an academic practice well established in universities and seen as one of the essential work habits that self-directed learners must develop. This became the primary method of transfer of new mathematical learning in secondary school. The textbook had also assumed a commanding position in the mathematics classroom

> Peter: We usually just do exercises and stuff and they tell us the formulas that we need to know and that doesn't change much throughout the year … we've got like, quite a big text book and it just has all the exercises that we do in it and some, like, exam questions and stuff … (Late Year 12)

> Fleur: Third and fourth form [Years 9 and 10] we did a bit more practical. Fifth form was real textbook and notes. (Early Year 12)

> Dominic: Um, well, we sort of learn a new kind of variation of what we were doing like say if we were doing linear equations another like step into it, like, adding brackets or that kind of thing, and then he'll allocate us some questions to you know, and it just gets slightly harder and harder and as soon as you get through and once you're done, usually that's it for the class because it takes us … he'll set about 10 or 15 questions, or so, it takes us the best part of half an hour. Yeah, out of a textbook usually, and whenever we come to a, you know, get stuck, Lars my teacher will go through it on the board and explain it and that kind of thing. (Early Year 12)

> Rochelle: When we walk into maths it's pretty much the work's on the board or the teacher just says, 'Right do this page and when you're finished bring it up or go onto the next page,' and stuff like that. (Early Year 12)

> Mitchell: We just like get a bit of paper, a sheet of paper and like just write the answers on the piece of paper. (Early Year 12)

> Georgina: I get bored having the same. It just gets so repetitive and boring, [I would like] going outside and something and diagrams not just notes all the time. (Early Year 12)

> Researcher: If you drew a picture of yourself doing maths now, what would it look like do you think?

> Jared: Um, me sleeping on my desk … we had heaps of textbooks and stuff like that … That was boring too. (Early Year 12)

> Liam: We'd just sit down and this year there'd be like a starter on the board just like, 10 questions, not on the same topic [as the one they are studying], just reminds us… mark those, go over any problems, if there's any problems with homework, just start on the work that we're doing that day and if it's like, a new thing the teacher would explain it on the board and that, if it's the same stuff just get the books out, the homework and work through them. (Early Year 12)

It was interesting that in Liam's class there was usually some kind of starter that was reminiscent of the Quick Ten of the primary school years.

In Year 12, Mitchell was placed in a vocational programme for children who had experienced difficulty with academic subjects such as mathematics. He described the structure of a typical mathematics lesson in this class:

> Mitchell: Straight away it's get a piece of paper, [then] questions and stuff, sometimes, then like a game puzzle thing, like, 'four times four' or whatever and you get a number from a grid and you get, we would always have that in the mornings, yeah, then, like stuff on the board, yeah, heaps of stuff, yeah, heaps of new stuff, like, 'five fives,' and stuff. When he was doing stuff, he'd write stuff on the board to explain, instead of talking so you can find out what you need to do, and [he would] leave it there … Then we'd just get on with our work really. We had a folder thing that we had. We'd open the book and that, and get out folders in the morning, and just done our work … (Mid Year 13)

Where other students talked of learning formulas and procedures, Mitchell spoke of a strong emphasis in his class on teaching children the basic number facts using daily repetition. Apart from the difference in difficulty of content, the overall shape of Mitchell's lessons – the teacher starting with a game and then explaining an idea on the board and having the students complete exercises – echoed the descriptions of lessons of students in the academic classes. This suggests that those pedagogical techniques that are regarded as peculiar to and defining of the mathematics lesson take little account of the learners for whom they are intended. Content is adapted while the form of the lesson is preserved.

There was little change in the descriptions of the typical mathematics lesson from the three boys who continued to take the subject in their final year of schooling.

> Dominic: Basically it's kind of just, 'Open up your textbook,' and you work from the start of a chapter to the end of it, and so each lesson you'd go onto a new exercise. It's really, it's just kind of fairly one thing after the other and you just progress. It's identical, every lesson's identical. Maybe you'll learn about something new, then you open the book and you do the questions and that's the way everyone does it. (Mid Year 12)

> Liam: You go in and there's usually like Flying in Five, in five minutes, well this year it's not five questions, it might be just like one or two, 'cause they're longer now, to refresh us from like, the last lesson, written on the board, like a starter, one or two questions. We do that, and then like, our teacher will explain to us and look at our answers and stuff like that, and then she'll usually write up notes on what we are learning today, she'll stand there writing up notes and we are copying them down. She doesn't usually like, talk much during that, that sort of takes like ten or fifteen minutes, they are not real short, they take up the whole board, and it'll be examples in there as well, like she'll do some writing and an example of that and we write that down then she'll give us examples of what to do like, out of the textbook, then she will go and sit down for ten minutes and we'll try and do that and then she'll come back up and do them on the board for us. (Mid Year 13)

> Toby: Yeah, um, basically this year what we do is, we take notes for about, 'cause it's 50 minutes long so I guess we'd take notes for about 20 minutes [to] half an hour, she'd

> explain them, explain what we have to do, and then the rest of it would just be doing exercises. And talking when she doesn't want us to (*smiles*) … I think the most helpful thing about [the textbook] is its convenience, it's not really convenient, it's huge, but it's convenient so you can take it around and you can study at home from the textbook and you can practice with the textbook. It just gives you lots of exercises you can practice on. All the information is together; you could study out of the textbook. (Mid Year 13)

Fleur found that mathematics in Sweden followed a familiar pattern.

> Fleur: Well in Sweden it's students sitting in class, teacher at the board, working from a textbook, usually with a ten minute break in the middle of the class. (Mid Year 13)

In these accounts the textbook secured mathematics as a specific corpus of knowledge to be absorbed by its user – the student. The children looked upon the textbook as the face of the curriculum. Speaking with the authority of the initiated, the textbook provided a schedule of graduated tasks (exercises) that, if performed as prescribed, would both enable and demonstrate students' attainment of the mathematical knowledge captured in its pages.

Seating arrangements were another notable feature of the mathematics classroom reinforcing the role of teacher as lecturer and the expectation that children work alone and limiting the kinds of discussion that could occur. Unsurprisingly, the children usually chose to sit next to friends.

> Peter: We always sit in the same place usually. I sit next to my friends and stuff. (Mid Year 13)

> Liam: We just sit wherever we want. There's only fourteen people in our class. Everyone usually sits in the same place. About six of us sit over there (*indicates the right side of the room*), there's no one in the middle and the rest of them sit on the other side. There's like me and my boy mate and there's three or four girls and my class, we don't hard-out talk, like in PE and stuff we've got more to talk about, it's not that you can talk about maths … (Mid Year 13)

> Georgina: There's rows of desks, all facing the blackboard. Two on that side, three in the middle and two on that side. I sat in the middle with my two friends and then here was another two rows behind me with three girls in each desk. It was pretty much silent. If we talked too much our teacher would be like, 'What are you doing? Shut up.' (Early Year 12)

> Rochelle: The girls sort of sat at the back and the boys were sort of at the front. (Mid Year 13)

> Jessica: Usually I work better when I don't talk. I get more done and I focus more, but I find it hard not to talk. I find it hard to just sit down and work solidly for an hour or whatever. (Mid Year 12)

> Dominic: I feel comfortable [sitting] with everyone in the class. There's no grouping, I would say.

> Mitchell: We can sit wherever but the girls prefer to sit on that side with the other girls. (Mid Year 13)

Like the pictures they had drawn as Year 3 and 4 students (see Chap. 3) the children's verbal pictures as secondary students continued to place them almost exclusively seated at desks and engaged in individual written tasks such as taking notes, doing exercises from the textbook and answering and marking questions. In these accounts, the teacher was positioned as the more knowledgeable other *setting work*, *explaining* rules, formulas and procedures and *helping* students when they become stuck. Little class or group discussion of the mathematical principles underlying the formulas that the students were so diligently memorising and applying appeared to take place. As Liam's statement showed, he had come to believe that there was nothing to talk about in maths. Mendick (2002) found that the secondary students she interviewed in England similarly believed that discussion was unnecessary in learning mathematics. As one student in her study stated, "Well, you do the discussion but if you know the answer, you know the answer and then there's nothing to discuss" (p. 383). She pointed to epistemological reasons for this view. The dominant approach to mathematics, she argued, holds that mathematics is an external body of knowledge and answers are therefore more important than processes. She suggested that, "it is only by moving to an understanding of maths as a social practice that discussion becomes an integral part of doing maths. Oral contributions are not judged whether they are right or wrong, but in terms of their value in furthering the collaborative social activity of doing maths" (p. 383).

Understanding Mathematics

Difficulties in understanding mathematics were widely reported by the children and featured strongly in their mathematical subjectivity. Jessica talked of the stress she experienced when mathematics was presented as a collection of seemingly incomprehensible formulas to be committed to memory.

> Jessica: My friend was about to go into a maths internal [NCEA examination], and she said, 'n to the power of something,' like, you know, something she obviously had to remember, and I was like, 'Oh my God, like, thank God I don't have to think about that any more.' So when someone says 'maths' I feel so good, I feel this relief washes over me. I used to get so stressed out, about like all that stuff and it's so much remembering… all that 'n to the power of blah blah', formulas and that sort of stuff. Although it never appealed to me, it was still one of those things that, you know [we had to do]. With another subject you can push past it and do it anyway. [Maths] was one of those things I really didn't want to do, and so I just think relief, and I'm so glad I didn't do it this year, that I didn't have another year of it, kind of thing. (Mid Year 13)

In this vivid recreation of an exchange between two school friends, Jessica described the strong aversion she had developed to a subject that had produced her as a non-fluent speaker of what seemed to her to be an indecipherable mathematical code. Georgina felt equally excluded, and elaborated on this theme when she talked about the way mathematical formulas were taught as disconnected from real contexts, noting that the mathematics she was using in physics (part of her Year 11 science subject) was more accessible for its contextualisation of mathematics.

Georgina: When [teachers are] going, 'Blah blah blah,' and then putting, just like a little symbols, I'd be like 'Eh?' but when they'd be, like, 'Oh so and so was riding his bike, and he travelled from this distance and this distance in this time, what was his speed?' and I'd be like, 'Oh it's acceleration' and then I'd be like, 'I have to use that symbol times that.' It's like A over V or something. No it's like A and the V, that's acceleration, and speed, A times C or whatever that's acceleration. That was like two months ago [we learned that] … if [teachers] started with the real-life situations first and then get into the formula, instead of formula first and then the situations [it would be better]. That's how it's always been in school and it really never made sense to me, cause it would be formula this and this and this, and I'd be like, 'Hm what does that actually mean?' and then they'd be like 'Oh, this is like the situation, how it is [used].' [Putting the real situation first] would make sense, cause you're explaining what you're going to teach first rather than, 'This is how it is,' and then explaining [its application] … yeah because like if you think with physics, you know, it's in everyday life, you're riding your bike, you're walking down the road, you're driving in the car, you're in the bus, you're in the train, and like, you're going this distance and it takes you this time and you're like, 'Well I'm actually travelling then I must be going somewhere,' kind of thing, so, you know, and then if they figured out the formula, you know that would make sense. (Early Year 12)

In itself formulaic, the teaching of mathematical formulas failed to create sufficient connections with the children's lives. Georgina's suggestion that greater sense would have been created for her if teachers were to start by using mathematics in a meaningful situation and *then* homing in on the relevant mathematical formula that could be used in similar situations, is important. It was algebraic formulae that Rochelle and Liam also found off-putting.

> Rochelle: Trigonometry I liked that. I hated algebra, I hated it so much, it was just so confusing, the little equations, but then it got to big huge ones about this long (*indicates a distance of about 10 cm with her hands*) you know, I hated it. (Mid Year 13)

> Liam: Yeah, heaps of formulas, like trying to remember them all, it's not only remembering them but knowing when to like, use which one … When I know what it will be useful for, then I find it more interesting but when I think it's just like, a lot of formulas and stuff it seems like it's pointless sometimes … she [the teacher] doesn't really tell us what we'll use it for in the future … like what job or part of the job you'd use it in. (Mid Year 13)

> Jessica: Algebra, because it was so massive, and stuff like sequences, it was supposed to be the really easy one but it really confused me, 'cause I sorta didn't know when to use which sort of formula. That confused me, and so did Calculus with the formulas.

Fleur noted that completion of the mathematics work as dictated by the level of difficulty of the mathematical content made the difference between satisfaction and frustration.

> Fleur: If the maths isn't difficult then I feel good, there is a nice sense of achievement when you complete something, something you didn't think you could do. But if you don't complete it and you are unsure why I find it very frustrating. (Early Year 12)

According to the children, learning mathematics required different approaches to study than did other subjects. There was a strong emphasis on memorisation. "Study habits" and "applying" oneself were terms teachers used that suggested that learning mathematics was something that was done alone and was expected to involve considerable effort. The main reason for studying mathematics seemed to be in preparation for tests and examinations.

> Mother: The teacher Dominic had last year … basically was saying that Dominic would need to develop some study habits where he might have to … she said she didn't doubt that

> you could do it but you would have to apply yourself consistently over time to get it, and so you had a choice to make about whether you wanted to do that do you remember?
>
> Dominic: Mm, Year 10 was a bit of a cruise year, and it is for everyone really I mean it's just the sort of calm before the storm I guess, 'cause in Year 11, in VCE[1] they've got your balls in a vice really, it's … in Year 10 everybody just sort of chills, and that. (Early Year 11)

Because mathematics was taught as a progressive sequence of rules within discrete units, missing lessons became problematic. Liam had been selected for a regional representative sports team and when he was participating in tournaments or training camps, he would sometimes miss mathematics classes or internal examinations. He noted the significant difference between missing a day of mathematics and missing a day of other subjects.

> Liam: Difficult this year. (*Laughs*) I don't know, for me it's not a subject like, well for this year there's heaps of like, we don't spend that much time on one thing but there will be a couple of days we'll spend on it and then we'll move on, so if I'm not there for one day I've missed a lot, like with other subjects like if I miss a couple of days I can just go back and just catch up pretty quickly, but with maths I find it's real hard to. (Mid Year 13)

Rochelle made a similar observation.

> Rochelle: I found it pretty hard, yep, 'cause I'd have days off school and then I'd go back to school and I'd be, like, 'Oh, I don't understand this.' (Late Year 12)

Moving on rather than consolidating ideas over a period of time indicated pedagogies in which mathematics was delivered to children as a compendium of rules, procedures and formulas rather than generic ways of thinking and working. This created barriers for all of the children. Mathematics increasingly became a subject that could not be easily understood without constant teacher guidance. Being "left behind" was thus perceived as a real danger, since catching up was very difficult.

The Nature and Purpose of Mathematics Continued …

In *The New Zealand Curriculum* (Ministry of Education 2007) a Māori proverb translated as "Cling to the main vine, not the loose one," was used to capture the essence of the Mathematics learning area: The sense of this proverb as a metaphor for learning mathematics is not immediately obvious but the "main vine" was perhaps intended to represent the core and substance of mathematical truth, strong and reliable. In an accompanying statement describing and justifying the study of mathematics, the following claims were made:

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[1] Victoria Certificate of Education.

> Mathematics is the exploration and use of patterns and relationships in quantities, space, and time. Statistics is the exploration and use of patterns and relationships in data. These two disciplines are related but different ways of thinking and of solving problems. Both equip students with effective means for investigating, interpreting, explaining, and making sense of the world in which they live. (Ministry of Education 2007, p. 26)

This description is significant for its division of mathematics and statistics into separate disciplines presented as requiring different thinking, and for its suggestion that these disciplines *equip* students with effective ways of exploring, representing and comprehending their world. In none of the children's statements could any implication of this sense-making purpose for learning mathematics be discerned. The curriculum's use of the metaphor "equip" to describe mathematical and statistical know-how positions students as acquirers and mathematics as a kind of must-have tool without which they would be deficient or ill-prepared. The word *equip* is also used for the skills gained in the English and languages learning areas, but not for skills, understandings and knowledge in other curriculum areas. The view that mathematical knowledge equips in ways that other kinds of knowledge do not positions mathematics as a subject essential to children's future survival, unlike health, social sciences or the arts. This view was reflected in the children's beliefs that English and mathematics were the most important of their school subjects. The children were far from convinced, however, that the mathematics they were learning at school was indeed equipping them in the ways that they felt they needed. Where they could see any practical purpose at all in learning mathematics, the children viewed the subject as comprising a set of procedures and facts useful for performing certain essential everyday tasks, as their comments illustrate.

> Jessica: The things that you learn in maths like the formulas and stuff, when are you going to see that? Like on the street, you know? You see addition, numbers are in the world but the maths stuff [we learn] isn't. (Mid Year 13)

> Liam: I don't understand why we learn that stuff, like, if you know what I mean, those long formulas and that like sometimes I wonder what jobs you'd get that in, stuff like that. Sometimes we are like, sort of sarcastic, we'll go (*in a whining voice as if to the teacher*), 'What are we going to use this for, this formula, what are we going to use this for in our lives?' so [the teacher] says, 'Oh you need this, you just need it, blah, blah, blah.' He doesn't really explain what we need it for, like, [he'll say]'You need this to pass your Level 3,' [but] he doesn't really elaborate on it. (Mid Year 13)

> Rochelle: I don't think you really need it all, I mean, where are you going to use algebra? I did ask my teacher and she just said, 'Because you have to,' but maths … I understand why English is [compulsory] but not maths. (Mid Year 13)

As schooled subjects, the children came to regard themselves as acquirers, possessors and deployers – rather than generators and disseminators – of mathematical knowledge. The children's experiences of how mathematics was taught and learned accorded with the findings of Hipkins and Neill (2003) whose study of teachers' perceptions of changes in their pedagogy with the introduction of the NCEA assessment system found that mathematics teachers reported using fewer open-ended investigations and fewer higher-order thinking tasks in their programmes than previously.

In Dominic's final year of schooling, Australia was in the process of reviewing its educational goals with the aim of creating one national curriculum rather than the state-by-state curricula of the past. A discussion paper presaging the national curriculum (National Curriculum Board 2008) described the goals and purposes of mathematics education as follows:

> … a fundamental goal is that the curriculum should emphasize educating students to be informed thinking citizens, interpreting the world mathematically, appreciating the elegance and power of mathematical thinking, experiencing mathematics as an enjoyable experience, and using mathematics to inform predictions and decisions about personal and financial priorities. Further, as appropriate in a democratic society, many substantial community social and scientific issues are informed by public opinion, so there is also a need for broadly based capacity of citizens to interpret quantitative aspects of those issues. A further goal is for Australia's future citizens to be sufficiently well educated mathematically to ensure international competitiveness. This has two aspects. The first is the need not only for adequate numbers of mathematics specialists operating at best international levels, capable of generating the next level of knowledge and invention, but also for mathematically expert professionals such as engineers, economists, scientists, social scientists, and planners. The second aspect is to produce an educated technical workforce contributing productively in an ever changing global economy, with rapid revolutions in technology and both global and local social challenges. Clearly, an economy competing globally requires substantial numbers of mathematically literate workers able to learn, adapt and create. (p. 5)

The mathematical subject is pictured in this statement as a "literate" citizen whose learning of mathematics enhances his or her capacity to engage not only as an informed, thinking, fiscally functional and active member of a democratic society, or as someone who appreciates the elegance and power of mathematics, but more importantly – since this takes up most of the paragraph – as a potential specialist or technician in careers where advanced mathematical expertise is required to "ensure international competitiveness." Both expertise (knowledge) and invention in mathematics are mentioned in this statement, suggesting that mere absorption of mathematical facts and procedures is no longer sufficient.

This vision of mathematics as personally empowering, as engaging thought and invention and as occupationally applicable was not generally shared by the children. Dominic recalled having seen a poster on the mathematics classroom wall showing where mathematics was needed for further study in a range of occupations, but only Toby could instance a teacher having made the occupational purpose of mathematics explicit.

> Toby: [My teacher] showed us examples of how it was applied in real life. Before it's been like you learn something and then you don't really know how it matters in life, but he actually showed us examples like architecture and … (*thinks*). It was much more interesting to learn about it. (Late Year 12)

Overwhelmingly, their accounts emphasised the boredom and disengagement created by unrelenting textbook-based written work. As mathematical subjects, they were constituted in the teaching/learning relationships they described, as those in cadetship, their roles in a system of training to take on, memorise and replicate methods and manipulations emanating from, and symbolic of, an unseen but powerful source. Teacher and textbook acted as the benevolent yet demanding conduits of its privileging expertise. Like the sphinx, the riddles of mathematics operated as a watchful and exacting gatekeeper, screening for those who were worthy of passage into the heady realms of mathematics beyond.

Subjected Subjects

In the primary years, doing mathematics had been constructed for the children as a way of working to a narrow brief and in a particular mode. At secondary school, these same work habits continued to frame teachers' judgements of their students' mathematical progress, as the following excerpts from Peter's and Toby's reports illustrated.

> Peter is a sincere and motivated student who is working well. He must keep in mind that theoretical work covered in the remainder of the course is more demanding … with continuing good efforts and revision he should be well-prepared for he tests at the end of the term. (School report, Mid Year 13)

> Toby … is making a satisfactory effort. It was pleasing to see his Excellence results in the second term. (School report, Mid Year 13)

In these typical statements, teachers valued the self-motivated, self-disciplined and independent worker whose effort could be seen in "pleasing" test results. There is no mention of the children's abilities to communicate, conjecture, test or justify, let alone invent mathematics. The children had formed opinions about themselves as mathematical learners that were similarly focused on their ability to study, that is, the effort they put into their memorisation and application of mathematical rules.

> Jessica: Internals you learn it, apply it right then and there, but externals, if I've learned it months ago I have to re-dig it up. Everything will be gone and I'll have to look at my notes and study again and I'm not a studier. I'm a bit hopeless in that area. (Late Year 12)

> Toby: It comes from listening in class and studying a bit and practising the exercises. (Mid Year 13)

> Peter: I have to pay attention to make sure I really understand the stuff. If I don't really pay much attention, I sort of can't really do any of the examples. (Mid Year 13)

These children had come to believe that success in mathematics required them to take up a particular mathematical subjectivity, dictated in the discourse of mathematics as played out in the classroom: that of the conscientious and diligent student who pays attention (to the teacher) listens, concentrates, absorbs, practices, studies, exercises and faithfully replicates mathematics' complex eternal laws.

Chapter 8
Measures of Success

Some of us are just naturally good at doing things like maths, or putting maybe a bit more work into it, and doing all the homework and doing all the exercises and stuff.

Peter, 17 years

Being good, bad or average at mathematics began to matter in new ways at secondary school. Peter's mathematical subjectivity, expressed in his explanation of success as part natural and part hard work, was wrought in systems of concentrated study, examination, grading and sorting. The children had come to view their mathematical capabilities through the lens of measured performance. Caught up in the machinery of testing and grading that now not only ranked them alongside their classmates but against students across the state or country, the children's mathematical subjectivities were confirmed, challenged, shaken and remade.

This was particularly noticeable for Mitchell whose learning of primary school mathematics had already produced/identified him as a marginalised student. The programmes of learning in which Mitchell was subjected throughout his schooling reflected versions of a mathematically "able" child expressed in the subtext of national mathematics curriculum and supported by developmental learning frameworks that produced a class of children euphemistically termed "special needs." By the time he came to sit the NCEA internal examinations in Year 11, Mitchell had experienced such a deep sense of inadequacy that making an effort seemed futile. He achieved only two of his NCEA Level 1 mathematics unit standards. The topics Mitchell and his fellow "special needs" students had studied that year included "Using networks to find optimal solutions in geometry," "Using trigonometric methods to solve problems involving lengths and angles" and "Using Pythagoras's Theorem to find unknowns in right angle triangles." Little of this appeared to make sense to Mitchell.

Researcher: Can you remember what Pythagoras's Theorem is all about?

Mitchell: Not really.

Researcher: Did it make sense?

Mitchell: Not to me at all.

F. Walls, *Mathematical Subjects*: *Children Talk About Their Mathematical Lives*,
DOI 10.1007/978-1-4419-0597-0_8,

As Mitchell made clear to be immersed in learning that was incomprehensible presented him with a choice – either he tried and failed repeatedly, or he gave up altogether. For Mitchell, NCEA assessment became a stigmatising process in which he was exposed and made as deficient. Encouragement and attempts to motivate him during his secondary years were largely unsuccessful because by this time Mitchell had little faith in his capabilities, exacerbated by the disjuncture between NCEA mathematics and Mitchell's life including his personal, intuitive ways of thinking and working mathematically.

Mitchell was not alone as a subject alienated by school mathematics. Mathematics was unpopular for the majority of the children in this study. Disaffected by the content and presentation of mathematical ideas in their classrooms, their self-confidence was contingent on external factors such as examination results, teachers' opinions and comparisons with classmates. Over their secondary years, sorting and differentiation became much more sharply defined through the apparatuses of inclusion and exclusion based on their mathematical achievement. Mathematical success and failure had become a "fact" of their lives.

Standardising the Mathematical Subject

Tests and examinations became the driving feature of the children's learning of mathematics at secondary school. As will be explained in more detail in Chap. 9, some children experienced screening tests to either gain entry into their secondary schools of choice (Dominic), or for placement into ability-based streams (Peter). From Year 11 onwards (the equivalent of Year 10 for Dominic) with their first taste of the external examination system (see "Introduction" for explanation of these systems) the children talked about their learning of mathematics as increasingly geared towards these assessments. Inducted into these systems, the children came to read them as mechanisms that were not only indicators of mathematical capability, but also as filters, determining who would be admitted to the more difficult mathematics subject options in upper secondary school and fashioning overall career choice, as Dominic explained.

> Dominic: Yeah you get an ENTER Score which sort of decides which university you can get into. Monash [University] you've got to get an ENTER Score of above 90. Like for all the really good ones you've gotta get … the highest you can get is 99.5. Yeah that's really, really hard.
>
> Researcher: So what do you think you're going to get?
>
> Dominic: Oh, I don't know, depends really because it takes, it's unusual like I think it does um ….
>
> Father: They publish the scores over 60.
>
> Mother: There are different thresholds, for each, the different [university] faculties.
>
> Researcher: (*To Dominic*) So how is this making you feel?

> Dominic: Oh it's a bit scary but I think you've just gotta do your best and try and keep up with it like, you get what you get, there's no second chances for it, so … (Mid Year 12)

Georgina had passed most of her Mathematics Numeracy NCEA unit standards examinations during the year, contrary to some of her teachers' predictions. In this subject, all her NCEA exams were internal.

> Georgina: NCEA is like you either pass or you fail, or you achieve credits. You have to get so many credits to get a pass, but if you pass it then you've passed it, you don't need to get higher, you don't get any lower, so everyone's pretty much the same if you pass. So that's what counts.

For some children the NCEA system was viewed as too lenient particularly with the introduction of internal assessment for some credits. They were somewhat mistrustful of the truth it told about their capabilities as mathematical learners.

> Toby: [The teacher] gets frustrated by the NCEA system, yeah, … with the fact that it's a lot easier than the old School C, so … she always talks about it 'cause there's um, different standards, and she always talks about how some of them are like, really easy to pass, and how some of them are like, to get Achieved you only have to write one line and to get Excellence there's not a lot more and, I don't know, she thinks marks should just be added up into a final score instead of, you know, grading like that.

> Researcher: Interesting. And what do you think of the NCEA system, Toby?

> Toby: I think it's really easy to pass, um, not so good, 'cause in some subjects you can, um, it just develops into subjects where the standards are really easy, so, um, you can pass really easy, like in Computer Studies at my school there's three credits or something for sending an e-mail, and that's … in some ways NCEA's ridiculously easy, but then it's good in the way that it, um, helps you know how close you are to passing, or how far away you are from passing and all that. Gives you targets.

The children described their experiences of sitting the NCEA external examinations, a stressful process for some, particularly for its capacity to confirm or demolish their existing visions of their mathematical expertise, as Fleur's comment showed.

> Fleur: It was kind of nerve-wracking 'cause you could leave when you wanted to … I left quite early … Almost made me feel worse about my ability. I do not like NCEA exams, internals I don't mind, but I do not like the externals at all. (Early Year 12)

> Rochelle: It was nerve-wracking when you went to school knowing you had a test or something that day. If it was an exam, it would be really, you know, you'd be, yeah, 'cause I wasn't the type of person to study. I hated study, so I would never study, but I would try sometimes because I knew I had to. When we had our Year 11 exams I was really nervous and I went in there but I knew that I only had to get some of the answers, like the easy ones, 'cause you know what questions were the Achieved questions the ones that were Merit, so I just kinda went through all my [examination] booklets and just did the easy questions, because you only get three hours, and then I went back, 'cause I knew at least I'd get Achieved … my lowest grade would probably have been Achieved. Maybe on the odd paper I might have been close [to failing]. I think every test in maths I passed, my highest grades, it was either Achieved or Merit which was good. (Mid Year 13)

> Liam: I always get worried before exams, nervous. I might study for a certain paper and not so much on other ones, so it makes me feel, like, bad. It's hard to study for all six papers kind of thing. (Mid Year 13)

> Jessica: I didn't care [about the NCEA maths exams]. I did study, but I was like, 'I don't really care about them.' I didn't get stressed or worried at all, I just thought, 'Whatever,' because I'd lost that like, interest in maths. (Mid Year 13)

In their expressions of nervousness, the children's subjectivities were brought into play through the visibilising capacity of the test to make them as subjects – succeeding or failing. The children's preparation for the NCEA and VCE examinations could be perceived as an act of what Foucault termed *cultivation of the self* (Foucault 1984). In this case, studying hard and denying themselves more pleasurable activities was driven by the degree to which the children regarded their success in mathematics as a necessity in their lives as they strove for desirable subject positions. Where success or failure did not exert such pressure, the children were less anxious. Jessica said she no longer "cared" about her results in mathematics, thus distancing herself from the orbit of mathematics' control. By the end of Year 12, mathematics examinations had ceased to play any part in the future she imagined for herself.

Mathematical Subjectivity Through the "Ability" Lens

From her primary years, Fleur had expressed uncertainty about her mathematical capabilities. She was surprised by her Year 11 NCEA examination results, but even the exceeding of her own expectations could not offset her self-view – that she was not one of those people whose brains are able to be "trained to think in the right way."

> Fleur: [I went] better than I thought. It wasn't good but it was better than I thought. I don't know, 'cause my mocks I didn't do very well, I passed like three papers and failed like two … I'm not very good at maths … I don't know what happened – why I did better for the exams. There was also a paper, I didn't do it, because I knew I'd fail it, so it got like a 'Not Assessed', instead of a 'Not Achieved'… I think my abilities are OK, I think they might be better than I think they are but I still am not happy with it … my teachers always tell me and my parents, 'Could do better, has the ability, needs to put in more effort, needs more confidence'… This will sound stupid, I think some people's brains are trained to think in the right way. (Early Year 12)

Comments from teachers over the years had fuelled her self-doubt. If she had untapped mathematical ability as they suggested, why was she not able to consistently rely upon it? Her struggles to explain herself were resolved in the attribution of her mathematical difficulties to something neurological. It did not occur to her to question whether the teachers, tests and examinations were capable of telling her a believable truth about herself.

Jessica's reflections were similarly concerned with unravelling the ability knot. Her positioning by ability had changed over her schooling career, and Jessica perceived herself metaphorically as having "dropped" from a position near the "top."

> Jessica: Yeah I had five papers. I think it went all right. I hope to have Achieved in a few, I think. I don't think I would get much past Achieved but I did feel sometimes, because I was a bit overwhelmed with all the work that we'd been taught in the year and to go back

> to study, there was just so much stuff and I didn’t know what to study and that was the problem, and so I got to the exams and I was kinda like, ‘Oh, I saw this but I didn’t think to study it,’ or whatever. There were some things I did look at but yeah, brushed over others and yeah, I probably needed a bit more structure with my studying to help me achieve in the exams but yeah, I don’t know. (Late Year 12)

> I used to feel, like when I was in Year 7 and 8, I was in like the top class, I wasn’t necessarily top of the top, I was never bottom of the top class, but I still used to feel, ‘I’m OK at maths,’ but when I got older, I felt I dropped a little bit and I don’t know whether that’s my abilities or other people getting better, or maybe I lost interest. I think my ability was still there but I lost interest in maths as a subject. (Mid Year 13)

With examination results her only reliable guide in determining her mathematical abilities, Jessica was not sure whether to explain her falling achievement in mathematics as lack of structure in her study, being overwhelmed, other children overtaking her or simply having lost interest. In the end she suspected she had retained her ability, but was no longer certain about whether she was really “OK at maths” or not.

Dominic was also in some doubt about his ability, as the following self-reflection showed. He tried to establish whether the fact the he took longer to do mathematics than other children but reached the same end result was an indication of his “ability” in mathematics or something else. As with Jessica, Dominic used examination results as the measure of his success.

> Dominic: Well I seem to get the same end result [as other children] as they do, it’s just, they seem to do it twice as quickly and much more neater so … my sort of average mark last year was about 75–80% so … Like I’m good at geometry and trigonometry where I can sort of, I sort of, yeah, I get the visual diagrams like where … I was always very good at, well last year I was very good at trigonometry and geometry. I enjoyed doing the angles and stuff ‘cause I could calculate it, but it’s sort of the variables with the algebra which … x could mean absolutely anything in the world, which, (*laughs*) and I never got that, it could be a bloody elephant for God’s sake, x number of elephants, and ooooh! (*makes a sound to show great frustration*) it’s just so annoying! (Early Year 12)

Dominic noted the areas where he achieved the best such as trigonometry and geometry and considered that for him, perhaps it was the impenetrability and seeming illogic of the mathematical content, rather than some generalised mathematical ability, which determined his success or failure.

Liam was puzzled by what appeared to him to be a change in his mathematical ability indicated by his falling grades. He wondered whether his former “strength” in the subject was not something he had lost, but rather something that had lost him – like Jessica, he was no longer so interested in it.

> Liam: I can’t have changed, like how I used to think I was really strong [at maths] and now I still think I can do it but I’m not that strong how I used to be. I wish I could still be strong, like, I could still probably do it if I put more time into it … your interests sort of change sometimes as you get older. (Mid Year 13)

The children’s reflections point to mathematical subjectivity as work in progress, as a process of disambiguation in which children remade themselves according to external indicators over their years of learning mathematics. Their inner reconciliation of competing subject discourses is the stuff of subjectivity and by implication, subjectification. Their desire to hold onto their subject positions as efficacious learners was challenged and confounded in the subjectifying practices of testing, classifying and grouping.

Sorting Mathematically "Able" Subjects

By the time they reached Year 11, the children were framing their abilities in mathematics almost exclusively through a judgemental lens of results of school and external assessments. Inter-class streaming or setting had become much more prevalent than in the primary years and by Year 13, the children were sorted by the selection of mathematics subjects into either the elite group that studied advanced mathematics including calculus, or the others who studied a more general kind of mathematics with a greater emphasis on statistics. Entry to the elite classes was determined by scores in external examinations, since these were seen to be the truest measure of a child's mathematical capabilities.

Table 8.1 shows how the children were grouped by ability over their secondary years.

Once the children reached the upper secondary grades, other systems of sorting came into play. In her reflections towards the end of her final year of mathematics in Year 12, Jessica spoke of the differences that were created in the NCEA system between children who were regarded – and regarded themselves – as *Excellence*, *Merit* or *Achieved* students.

> Jessica: (*Speaking of her mixed ability grouping*) Yeah, that was all right. I found it fine because we worked at a level that was all right for me but I suppose the people that really wouldn't have benefited were the Excellence people. Yeah, but I think they probably weren't extended as much as they could have been … sometimes my friend would say, she's like really intelligent, she'd say sort of, 'Are these like Excellence questions? Are we going to do some Excellence work?' and all that kind of stuff. Because if it was streamed, the highest class would only focus on Merits and Excellences, whereas the next class down would focus on the Achieveds and Merits. So for them it was kind of I suppose a little bit unfair on them, 'cause they didn't get that extra practice in maths … that was quite stressful when I realised like, 'Oh my God this is way too hard for me to even consider doing.' That was quite, yeah, I kind of stopped myself from getting too stressed about it like the idea in my head was like, 'It's just an exam at the end of the day, it's only like a grade, it's not the end of the world,' like, yeah it's kind of the attitude I tried to keep. I could see some others just studied insanely, I noticed that they were studying overboard … I wouldn't have been able to cope with that sort of study.

> Jessica: (*In speaking of her mathematics teacher's report*) Um, what did she say? She said as all teachers do, 'She's a lovely member of the class, a pleasure to teach, she joins in discussions when necessary, or appropriate,' or whatever, um, yeah, I don't know but I think it was quite good. There wasn't anything said about 'needing to focus more' or 'not performing well' or anything like that so I was quite pleased with what she said … I usually get like, 'Needs to focus in class' and 'talks too much' and stuff but I didn't get any of that this year which is really good.

Table 8.1 Ability grouping of the children in years 9–13

	Years 9/10	Year 11	Year 12	Year 13
Whole class teaching, mixed ability		Toby, Peter	Jessica, Fleur (5 months), Peter, Jared, Toby	Peter, Toby (mathematics with statistics) Dominic (further mathematics)
Inter-class ability groups				
Top	Liam, Rochelle, Peter (Year 10) stream based on all subjects	Liam, Rochelle, Fleur	Rochelle (4 months), Liam	Liam (mathematics with statistics)
Middle	Peter (Year 9) ↑ Jessica, Fleur, Jared, Dominic Toby (2nd highest maths Year 9), Toby - 2nd highest stream based on all subjects (Year 10)	Jared, Dominic, Jessica		
Bottom	Georgina	Georgina (mathematics numeracy)		
Distance learning				Jared – Year 12 numeracy
Special needs programme	Mitchell	Mitchell	Mitchell	Mitchell

> Jessica: (*In speaking of her NCEA results*) I did get like a Merit or Excellence or something like that … I'm not an Excellence student in maths and so I was really happy with that … I wasn't expecting to get that at all. I'm sorry I can't remember what it was, something like coordinate geometry maybe, like something I didn't expect to do well in at all and I got quite a good mark so I was really happy with it. (Late Year 12)

Jessica had come to define herself as a mathematical subject by the grading system of the NCEA. Even when she achieved with *excellence* in coordinate geometry, she remained certain she was not an "excellence" student in mathematics. Jared too was not convinced of his capabilities in mathematics.

> Jared: Yeah, there's easier classes for the dumber people.
>
> Researcher: I see. You're not one of those?
>
> Jared: No I'm average … Because I'm not very good at maths.
>
> Researcher: What makes it harder for you then do you think than other subjects?
>
> Jared: I choose not to listen (*laughs*) 'cause I don't like maths. (Early Year 12)

Choosing not to listen was one of the strategic options that Jared adopted in a classroom where he felt reasonably confident but did not enjoy mathematics. This was reinforced by the fact that his mates did not like mathematics either. Because he did not consider himself to be one of the "dumber" students he named himself in positional terms as "average" with reference to those who were worse. Jared had been placed in the lower to middle groups for mathematics through Years 9 and 10 at secondary school and found himself among students who were not keen to learn.

> Researcher: What about your mates, are they keen on maths?
>
> Jared: No.
>
> Researcher: Is there anything that school could do apart from making longer lunchtimes, with your learning of the subjects to make it something you'd actually want to do?
>
> Jared: Get younger teachers instead of old ones.
>
> Researcher: So the teachers put you off a fair bit do they?
>
> Jared: The older ones do because they're just so boring
>
> Researcher: Did you have an older teacher for maths?
>
> Jared: Yep.
>
> Researcher: So what did you think when you saw maths on your timetable and you thought "Oh I have to go to maths now"?
>
> Jared: I didn't really care 'cause it's not one of my worst subjects
>
> Researcher: Ok so you thought you could do it but you just weren't very interested.
>
> Jared: Yep. (Early Year 12)

Not unexpectedly, Mitchell was identified at secondary school as a child who needed special learning support and was placed in a group of similarly classified children where he received a modified curriculum and help in his earlier years at least, from a dedicated teacher aide. In Year 11, Mitchell took the Mathematics

Numeracy option and achieved six credits for the following NCEA unit standards, which were internally assessed: "Determine probabilities in practical situations," "Solve problems which require calculations with whole numbers" and "Read and interpret information presented in tables and graphs." He had failed a number of other mathematics unit standards. This pattern continued into Year 12 where he struggled to pass any unit standards. Mitchell's mathematics teacher had written on his school report:

> Despite numerous efforts to encourage and motivate Mitchell, there has been a minimal amount of work done. Mitchell needs to develop a sense of purpose and stop wasting his time. (Mid Year 12)

Mitchell expressed a deep-seated belief that he would fail no matter how hard he tried, that he would be so far behind the others that it would be impossible to catch up, and it was this that had created his loss of motivation. In the following description of his learning of mathematics, he suggested that there was little affordance for students who took longer to learn than the rest.

> Mitchell: I felt like I didn't even want to do it. I might not be as good at it [as other children]. I might not be able to do it anyway. [Other kids] rush and stuff and I think I just can't be bothered and I won't try because they'll be way ahead of me. (Mid Year 13)

In her explanation of the mathematics Mitchell had been learning and the difficulties he experienced with it shows, Mitchell's mother told how the question of whether his failure was a result of lack of effort or the inaccessible nature of the mathematics itself, remained unresolved. For Mitchell, the answer was clear – it was the difficulty of the mathematics.

> Mother: I think with the maths he was, on the more basics of it rather than, my understanding was there were two sorts [of options for mathematics], I'm not quite sure but I think he was doing the basics of maths rather than the more complicated things – still trying to get basics set … I think that Mitchell's enthusiasm to work hard's not there, and, well, I may be wrong, but I feel that because he's not prepared to put the effort in, probably that communication [from the school] with me, and that pushing with me, is not there like it used to be because initially when he first started and struggled, I, you know, you'd hear about it all [from the school] and, um, know about it all, and you know, they encouraged and things like but that depends on the teacher too really, you know, some teachers would ring and say "He's not achieved this or done that or done this and needs to" and others didn't bother.
>
> Researcher: So is it hard for you to try, Mitch?
>
> Mitchell: I don't know, sometimes I just don't feel like trying, yeah.
>
> Researcher: Does it seem like there's not a point in trying or what?
>
> Mitchell: Sometimes I feel too tired, and can't be bothered doing anything. Yep.
>
> Mother: I'm not sure what goes through Mitchell's mind and why he has this, 'I can't be bothered' attitude really, I don't know. Have you thought about it Mitchell? Is it because it's too hard or …?
>
> Mitchell: Umm … I don't know, I find it hard and I can't be bothered doing it because it's too hard. (Early Year 12)

Mitchell's mother entertained the idea that perhaps Mitchell's failure was something that school had created in its inability to cater for Mitchell's ways of learning.

> Mother: I think the education system's been geared up for years for those that have the intelligence and it's only been over the years that I've discovered people have different ways of learning - some are visual, some you know … I didn't even think about all of that, but, you know …

Mitchell's case shows that within a schooling system designed to expect the expected, or as Foucault would argue, create the expected, the established descriptors of normality failed to recognise the "unexpected" child. The unexpected – Mitchell in this case – became the "other," an aberrant requiring separation and correction within the limits of his/her unpromising – as his teachers saw it – potential.

Mathematical Minds: Fiction or Truth?

As the children expressed their thoughts about mathematical ability, they seemed to believe for the most part that it was something a person either "has" or not, an innate quality, rather than something developed in practice.

> Jessica: (*Commenting on the "fairness" of mixed ability grouping for mathematics*) Sometimes my friend would say, she's like really intelligent, 'Are these Excellence questions, are we going to do some Excellence work?' and all that kind of stuff. If [the maths class] was streamed the highest class would only focus on Merits and Excellences, whereas the next class down could focus on Achieveds and Merits, so it was unfair on [the good students] because they didn't get that [higher level] practice in maths. (Late Year 12)

Because her experiences of learning mathematics had been so consistently attuned to achievement in mathematics rather than acquiring a substantive understanding of its principles and appreciation of it uses over time, Jessica accepted without question that mathematical "excellence" and "intelligence" were quantifiable qualities that went hand in hand. Dominic too seemed convinced that intelligence and facility at mathematics were somehow connected.

> Dominic: I'm friends with a very, very intelligent good mathematician and she could sort of just look at the board and read it and just finish an exercise of 10 questions in 20 seconds and I'm like spending another 30 minutes on it, and that kind of thing, but I think it sort of applies totally differently to other things. Like, for example my historical, my interest in history that also, I can quote totally irrelevant things like Roman war tactics and that kinda shit that doesn't really help me at all in maths tests but, um …

> Researcher: (*Later*) What makes you think you're there? (*Dominic having rated himself as "about seven, or a six and a half" on the scale for how good he thought he was at mathematics*)

> Dominic: Well I'm not, I don't naturally get it every time, I sort of need to be explained through it but I've got the sort of motivation to keep doing it. If I see like a gain in it, but um, I'm not a naturally good mathematician. No, like some of the other people, but you know, yeah I get there in the end.

> Researcher: What's a naturally good mathematician do you think?

> Dominic: Well, last year my friend Kelly, I don't know how she did it but she could just adapt to everything, she sort of just needs one explanation and then she'd crack off on it and I'd be sitting there waiting for somebody to explain … maybe she had a bit of prior knowledge. I wouldn't know but she sort of just seemed to click, it didn't do that for me.
>
> Researcher: What proportion of the class would be able to do it like Kelly?
>
> Dominic: Oh, pretty rare, not many people could do that, she's pretty much the only person in the class who could, but um, I'm kind of the average student anyway, yeah…
>
> Researcher: Is that what your teacher says do you think?
>
> Dominic: Yeah, I'm not doing Specialist Maths which my friend Kelly is, like she could do rocket science right about now and yeah, but yes different strengths for other people like, she can't play soccer as good as me so … (*laughs*) (Early Year 12)

This view was reinforced in a conversation the following year:

> Dominic: I'd say there is definitely differing abilities in the class, like there are better people and worse people at maths and some people who need more help and some people who need minimal help. The way you can kind of tell is the people who did Maths Methods last year, they just rocket through it and they are just fine whereas the others do kind of struggle a bit. Maths isn't their forte. They are still in there because they know they need it, but it's not, yeah, their strongest area and it's not their main focus, whereas other subjects might be. Kinda like me, actually. (Mid Year 13)

As did Jessica, Dominic recognised those who were good at mathematics in their classrooms as special kinds of people, distinguishable by the speed and ease with which they could do mathematics. The negative subjectivity produced in such recognition for Dominic – who said he took much longer to figure things out – was ameliorated in his appreciation of other kinds of skills such as his understanding of history in which he excelled, but which he downplayed since it did not apparently require the kind of particularly "intelligent" thinking needed to succeed in mathematics. A number of the other children expressed beliefs about mathematics requiring a particular kind of ability which they were convinced they did not possess, as shown in Toby's response when asked about how he would rate himself at mathematics.

> Researcher: How would you personally describe your abilities at maths and if you rated yourself on a scale of one to ten, where would you put yourself?
>
> Toby: Ah, I think it's pretty good. Um, it's not natural to me, like it doesn't just come to me like it does for some other people, but, ah, generally I can do most stuff that she asks us to do, so I'd say, in terms of the subject I'm doing this year, it would probably be seven or eight.
>
> Researcher: OK. So the people who can do it naturally would get a nine or a ten?
>
> Toby: Yeah, there's some good mathematicians at our school.
>
> Researcher: Are there some of those in your class?
>
> Toby: No because, um, well we just got chucked together randomly, there is one scholarship Stats class and then everyone else just got into random classes.
>
> Researcher: Do you think she [the teacher] has noticed you, and that over the years the teachers have noticed you?
>
> Toby: More so this year, but in most years it's just been I'm part of the class really, I've never been one of the star students, so yeah … I'm happy to be where I am because, but

> um, it would have been good to get better grades all the way through school … it might have been put down to me not working as hard as I could, I probably didn't try my very, very best to get everything, to understand everything.
>
> Researcher: Do you think that goes for everybody? Everyone could do it if they put it in the effort?
>
> Toby: Yeah, for some people more than others, and some people less than others, 'cause some people are just naturally good at maths, like they can, they just see what they have to do once and then they can do it, but then some people are just hopeless with maths, so, they've got to work really hard at it to pass and all that so … yeah. (Mid Year 13)

Toby's description of himself as "not a star student" was double-edged; on the one hand, he believed that mathematics did not come naturally to him, and on the other, he felt his grades were the result of a lack of doing his very best. Both of these explanations were constructed within schooling systems that positioned and presented mathematics as a particularly demanding subject, accessible only to naturally smart learners – those to whom both Dominic and Toby referred as "mathematicians" – or those who are prepared to work extremely hard to overcome their natural deficiencies.

Jessica likewise viewed herself as capable of achieving better results had she worked harder, but had decided she was not a "natural" at mathematics.

> Jessica: I wouldn't rate myself too high [for maths], but like not too low, I would totally have been able to go further if I had studied. I feel that more of the people I know that are good at maths are good at quite a few other subjects; they are generally the really intelligent ones. I think it's the natural smarts, like they just naturally click with things quickly. You can decide yourself if you're not natural [whether] you can push yourself to understand.

Her observation that students decide for themselves who they "are" in mathematics, that is, whether they will need to work hard or not depending upon their "natural smarts," demonstrated how the children unquestioningly took up the positions that schooling allowed them, accepting as true the classifications of themselves created in everyday classroom interactions, tests and examinations. Like Dominic, Toby noted that mathematics became "annoying" at the same time that it became hard and confusing, a response to regimes of testing and classifying that presented difficulties for him and many of his classmates.

> Toby: We only talk about [maths], um, you know, um, internals, you know, tests and things, how hard they were, other than that maths is just like, 'Go away!' because no one really likes it once you get to college or high school because then it starts to get a bit annoying and hard and confusing, yeah. (Mid Year 13)

Waiting for the judgement of the Year 12 end-of-year external VCE examination results was an anxious time for Dominic. His description of this event in his life on the morning the official results were released on the VCE website provides a compelling illustration of the "unnecessary domination effects," as Foucault called them, of the widespread standardised systems of measurement uncritically accepted as necessary to the practice of education.

> Dominic: I had a horrible night's sleep the night before. I only had about two hours' sleep. I just kept waking up and looking at my watch and it was 2:00 in the morning and then 4:00.

> [By the time 7:00am came] It took us about 30 minutes to get onto it because the website was under massive stress, so it was a pretty anxious wait … I was a bit disappointed with it, but life goes on I guess … I got a 30 [out of fifty] in maths which was quite impressive. I didn't really think I'd do that well. I've gone through a sort of rebirth I guess. It's all right. It's not too bad. What I was sort of aiming for … My uni [university] aspirations have taken a hit because I can't do Commerce, I'll have to do Business Management. And maybe I could work my way up to Commerce either postgrad or if I do really well I could maybe transfer, I've still got enough [marks] for La Trobe and Deakin. (Late Year12)

Dominic's mother also spoke about the event.

> Mother: He was pretty distressed this morning. He didn't do nearly as well as he thought he would [in The VCE examinations]. It's probably a good lesson actually. In maths he got a B. He pulled himself up from a C with his tutor's help. It gave him a big boost. His overall [Enter] score was 72.8 I think. So that cut him out of quite a few of the [university] courses that he wanted to do. Commerce and Arts. It's a reality check. What's rocked him is the subjects he loved and was good at he didn't do as well [as expected]. We had a long talk this morning about resilience and what are you going to do now kind of thing?

Dominic's telling description of his VCE grades as his "university aspirations taking a hit" captured the instant in his life when everything changed. For Dominic, the truth had been told. This was echoed by his mothers' use of the term "reality check." One of the truths told in the VCE examination results was Dominic's improvement in mathematics from a C to B grade which he admitted was quite impressive and described as "a sort of rebirth." He had been worried that he had missed an entire section in the examination because he had spent too long producing the answer to one particular question using a process of iterative calculations rather than a short-cut method by formula. This seemed not to have affected his overall grade in mathematics too severely. But this was offset by his falling short of his own expectations in the subjects he had considered to be his strongest.

By contrast, Georgina was pleasantly surprised by her NCEA results by the end of Year 11. She had outperformed her own and others' expectations and "proved them all wrong" as her mother put it.

> Researcher: Were [the Year 11 NCEA results] better than you expected?
>
> Georgina: Yeah definitely
>
> Researcher: Better than your teachers you think would have expected?
>
> Father: No her report was pretty good … that she was working hard and achieving … during the year.
>
> Georgina: My principal didn't have that much faith in me though.
>
> Mother: I think she got you mixed up with someone else … when they talk about her, they don't describe the same person, it's like [someone else] … well she's proved them all wrong, hasn't she? (Early Year 12)

Georgina noted the mathematics questions where she had done particularly well. As observed in her primary years, it was those contexts with an element of tangibility that brought mathematical concepts to life for her, as something she could conceptualise and work with. She had drawn on her knowledge of cars and their fuel capacity for one particular question. This gave her confidence in her facilities to reason and make sense of mathematics.

> Georgina: I was like really good at one assessment [task] and it was like, litres, I was quite good at that 'cause we actually got measurements and we had to fill up, measure it, write it down, and I can remember that 'cause when you're driving your car, I need 30L in my car and that equals like $60. (Early Year 12)

Over the NCEA years, Peter had performed better on the internal examinations than the external. He felt confident that with focussed application he could understand mathematics.

> Peter: Hm, I think there's quite a lot of people, I mean I was in last year, I was in quite a good class so everyone got it pretty quickly, I think I did pretty well so it was not too bad.
>
> Mother: Were you in the Excellence class last year?
>
> Peter: Um just below that, in *A Class* or something. [For Year 11 NCEA results] I think I got one Excellence and Merits and I think I got quite a few Achieveds but, at least I didn't fail anything so that was pretty good. (Early Year 12)
>
> Mother: (*Later*) Yeah, Peter's done better on internal assessments than exams.
>
> Peter: Yeah I think internals [are] a lot better than externals because you actually get your best result when you do it at the end of your topic and they're still fresh in your mind.
>
> Mother: Other parents tell me that their teenage boys don't do homework and are slack and internal assessment works against them. But it doesn't work against my two boys.
>
> Researcher: So would you say you enjoy maths?
>
> Peter: Yep. I do if I'm doing well in it and I've got a good teacher I enjoy it.
>
> Researcher: Does it depend on the maths topic?
>
> Peter: Oh, a lot of it's pretty good. I enjoy it but I find graphs really difficult because you have to … you've got to use different formulas and you've got to work out the gradient and things like that, parabolas and stuff, it's really confusing sometimes. (Early Year 12)

Peter's choice of studying Statistics rather than Calculus had positioned him with those who were not the Excellence students at mathematics, but he viewed himself as not far below. He aimed not just to pass in mathematics, but to achieve as highly as he could. As it turned out, Peter did not do as well in the Year 12 external NCEA mathematics examinations as he had hoped and this had a bearing on his self perceptions as a mathematical subject

> Peter: (*Talking of self-rating on ability scale*) Yeah, a 7 or 8 maybe. I mean I understand all of it it's just a problem with external exams. You have to relearn a lot of stuff and remember a lot of stuff and I think that's why I didn't do as well as I did [on Year 12 NCEA mathematics external exams]. But with the internal stuff I got two Excellences for maths for one which was a Year 12 thing, um, and that was because we did it straight after we'd learned that topic so it was a lot easier. And that's like with a lot of other subjects 'cause I got three Excellences in internally assessed stuff and I didn't get any Excellences in the externally assessed stuff.

Peter told of how he also gauged his achievement in mathematics by "figuring things out," and the rewards that could be gained from this. This was expressed in his talking of doing mathematics as cracking a particularly challenging code; his mathematical subjectivity was thus linked to working things out as a measure of competence.

> Peter: Yeah, I suppose it's working things out and a bit more rewarding if you figure something that's very difficult out. Whereas in history you're just learning things, you don't really work anything out unless you're like researching something. Um … but yeah, I think you're just figuring things out and it's a bit more different and a bit more interesting sometimes than other subjects. (Mid Year 13)

For Dominic too, there was enjoyment in "accomplishing a question." He noted that although working to the speed pressure of examinations reduced his enjoyment of mathematics, he appreciated this form of assessment for the way it could tell him how he was doing and where he *was*. He implied that this was something he would or could not know for certain by any other means.

> Dominic: Um, probably about 8 [self-rating for enjoyment]. Yeah, when I get it I enjoy doing it, I mean I enjoy accomplishing a question, and … just, I don't know, everybody gets there at different times, I don't really work well if I'm in a race. I enjoy doing tests because I enjoy testing myself, and enjoy getting a good mark and if I don't get a good mark I want to get a better one, like, and that kind of thing, and everybody gets all scared about exams and you know how they're going to fail and I actually love mine, I go into them enthusiastic, you know, I want to find out how I'm doing and where I am and that kind of thing. So yeah I guess I do enjoy it. (Mid Year 13)

The construction of mathematics as a subject governed by externally imposed questions for students to work out was established in early in primary school and firmly ingrained in the mathematics of secondary school. It was not surprising then that the children came to use their answering of questions as a measure of their mathematical capabilities.

Mathematical Subjectivity "Spun" in Family Stories

The children's mathematical subjectivities were located not only in their schooling, but also in their "familying" as family members conversed about their own experiences of mathematics and exchanged views about success and failure in the subject. Sociological research draws attention to family storying as a potent means by which children are made as social beings. Pratt and Fiese (2004) for example described family storying as a social act in which children become both *narrated* and *narrators*.

Within the social text of family talk the children in this study could be seen to be actively engaged in their shaping and reshaping as mathematical subjects. This is illustrated in the following family dialogue, in which family storying is mentioned by the participants.

> Mother: Dominic did the Baccalaureate for a while which was in the UK, we got there in time for him to do the last year in primary school and the way the system works there, we were living … the area where we lived a lot of the kids had had computers since the age of

7 and they were being tutored in how to pass exams and get into a good private secondary school … They were doing assessment centres so Dominic rocked up. (*laughing*)

Dominic: I failed every one of them.

Mother: The parents paid, I think it was a hundred pounds for each school and some kids were booked in for five or six schools, and they'd rock up for a day and it was a mini assessment centre so Dominic who had not had the benefit of a tutor rocked up to the first one, had to do a maths test … and we didn't realise kids had been practising these for years … so you were absolutely perfectly normal and not performing like a trained seal.

Father: That's because of the league tables, the schools want the best kids.

Mother: It really did limit [Dominic's choice of school] though, because these kids had been groomed within an inch of their life and because of the school league tables the emphasis on written work was just huge, and the national exams that you had to sit, so the choice of high schools was limited and we found an international school … it's a very expensive franchise, but yeah, no, the Baccalaureate curriculum's fantastic and that really, well certainly the way it was explained to us, the maths and English and social studies was very tangible.

Researcher: What about maths at the international school?

Dominic: Um, I don't know, maths was just sort of, it was sort of … it wasn't sort of in-depth stuff, it was everybody did the same stuff …

Dominic: (*Later)* My sort of average [maths] mark last year was about 75 – 80% so … That's why I'm liking Year 12 because the end mark, the [end of] year's test is what decides it really … Well I'm sort of going to try harder this year.

Father: I'm diametrically opposite – I didn't do … I couldn't pass exams but I got through secondary school by internal assessments, not the year end stuff.

Dominic: It's like that make-or-break thing, whether you'll drop out in the face of adversary [sic] or thrive on it.

Mother: 'Cause some of it may be family stories that aren't true … some people's thinking styles are to try and make, to chunk things down and make them simple quickly, whereas others do a big picture first and convolute it and then come down to the simple and I know I'm the second, and I think sometimes your thinking style's a bit like that too, Dominic. Whereas I think your's is different (*to Dominic's father*) you chunk down into the smaller bits first, yep …

Father: Hm, and Harry's [Dominic's younger brother] like that. The first thing I do is break it up and say, 'Right, that bit's someone else's problem,' and I don't worry about the things that I can't fix.

Mother: I look at the whole universe and I think you do too sometimes don't you (*to Dominic*)? I don't know, what do you think?

Dominic: What do you mean?

Mother: Well you know how when you were doing the problem solving when you're doing that stuff on learning styles and problem solving, and how you were talking about, and tell me if I've misunderstood this, one of the challenges for you was to break things down into doable steps.

Dominic: Yeah

Mother: Because you tend to look at the big picture.

> Dominic: Yeah, and ask stupid questions …
>
> Mother: Why do you say 'stupid'?
>
> Dominic: Oh, we were doing this thing in physics, they were doing energy waves and they were just talking about energy and how it travels in waves and the particle doesn't actually move, but the energy passes through it and I was wondering if energy has any friction, how does it stop? And there's no friction and stuff and energy can't be, you know, deleted or made and I was like, 'Well what happened to the Big Bang?' and they're [the teacher] like, 'Well I don't know actually.' (Mid Year 13)

In this complex family conversation, as the discourses of mathematics, learning and family history elided, the subjectivities of family members including mother, father, brother, aunt and Dominic were made in the telling. Typologies were suggested in which the "big picture thinker" and the "small chunks thinker," the student who performs better on either the end-of-year-exam or the one who prefers internal assessment, were positioned as binary opposites. Using personal histories as examples, family members were suggesting that mathematical thinkers are born; for the non-mathematical thinker, therefore, success could only be forged in extreme determination and personal sacrifice. Dominic's ("stupid") questions and wanting to know the reason for something cut across the commonsense view of mathematics as a decontextualised procedural subject requiring breaking things into small manageable steps and following the correct (predetermined) rules.

Mitchell was also explained in family storying. For Mitchell's mother, the struggles Mitchell experienced with schooling, his modes of communication and his apparent of lack of "motivation" continued to perplex and frustrate her. The following conversation showed how subjectification occurred in processes of examination and diagnosis which created the category "abnormal"; both mother and child were subjected in the stigma of negative classification, which strongly manifested in Mitchell's subjectivity.

> Mother: I don't know, I use the word normal for lack of having, I don't know what label to put on it, but I've always wanted him to be … I mean, what is normal? We went through an assessment process with Child, Adolescence and Family and they said he was borderline IHC,[1] (*whispering*) sorry I don't like him to hear, but I mean this was years and years and years ago and I've given that information to the school right throughout but I didn't want him to hear … as I said, this is where my understanding comes because some [people] say to me, 'No way!' [He is not IHC] and so you don't know. I mean any mother's initial reaction is, 'No way!' but there's some aspects where I think [he] could be. Mitchell came up to me seriously and said to me, 'Mum tell me the truth, am I IHC?' And I said, 'Where did you get that from?' (*from a younger brother through Mitchell's father)*… I don't even know. As a parent, you rely on experts to … you know what I mean … and I just thought, um, I don't want him to know that. There were two fears, one that it would drag him down, and two, it would give him an excuse to behave like that, like, 'Well they've said I'm this, so, why bother?' And I don't want that … he still says it now … when I say, 'Why are you behaving in this manner?' and he says, 'I'm IHC.' I say, 'No Mitchell, you're just different.' My family

[1] In New Zealand this acronym refers to the Society for Intellectually Handicapped Children.

> and my mum and dad and my sister and all that say, 'No way'… I don't blame the teachers [for Mitchell's failure at school]. I guess it's the whole education system really, there's not enough teachers and there's not enough of everything, but that happens in every aspect of damn life, do you know what I mean?'… You know, what do you do? (Early Year 12)

Within ongoing family dialogue that included Mitchell's mother, father, younger brother, grandparents and aunt, Mitchell narrated himself into an expository script. As discussed in Chap. 6, it is in the discourses of recognising, ordering and naming - that is classifying – that the *normal* and *abnormal*, *special* and the *different* child is produced and with it, the effects of which Mitchell's mother spoke – being dragged down, and/or adopting the "abnormal" position as a strategic self-justification. As we can see from her conflicted explanations of Mitchell's "difference," Mitchell's mother needed to know the truth about Mitchell in order to make sense of and respond appropriately to his difficulties at school, but the diagnosis that had positioned him as "borderline" was a truth that was not convincing to those who knew him well. Such classification and treatment of individuals who fail to fit a socially constructed recognised norm was examined by Foucault (1967) in his documentation of the ways in which difference became tagged to the binary opposition of reason/unreason. He argued that through the establishment of reason as a classifier, societies could exercise control over unreason through a tyranny of stigma and exclusion. Medicating or banishing those who were deemed to lack reason came to be seen as necessary not to protect reason from contamination or unreason from itself so much as to bring reason into existence. Throughout his schooling, Mitchell was pronounced by a number of his teachers to be 'suffering' some kind of "learning disability" as their expressions "behind the eight ball," "different" and "special" suggested. Evidence of reason in Mitchell's engagement with mathematical ideas did little to persuade most of his teachers that he would benefit from the same kinds of learning experiences as the "normal" children in his classes and that his difficulties with mathematics were mostly social – he could not easily decipher the linguistic codes by which mathematical ideas were presented, discussed, modelled and assessed in the schooling situation. Mitchell's teachers used various techniques of exclusion and confinement to manage and control his "difference" such as sending him to work with younger children for mathematics lessons, placing his desk beside the teacher's table rather than allowing him to work with other children and grouping him with the "special needs" children in a separate class at Edgecombe High School. At secondary school Mitchell responded to this social deracination by taking up one of the few subject positions available to him – that of hopelessness, of choosing not to try to do mathematics rather than falling short.

In the children's experiences of learning mathematics at school, the NCEA and VCE examinations created a normalising mechanism by which children could be judged, and judge themselves, as mathematical subjects, endorsed, explained and reconfigured in peer and family narration. The children's self-visioning as mathematically in/capable was most strongly influenced by the results they achieved in standardised tests, particularly the eternal examinations that were seen as a more exacting and therefore more reliable test of their "true" mathematical abilities.

The children's mathematical subjectivities had undergone significant change since primary school; in most cases, the children reported feeling less confident than they had when younger, and most had come to believe that they did not have an inbuilt ability in the subject. Their explanations for success or failure were tied to their views of the mathematically able subject as one who is naturally good at mathematics. In this view, some children considered that it was possible for those who were not endowed with the "natural smarts" to succeed at mathematics through hard work (Peter, Toby, Liam, Jessica, Rochelle, Dominic), but the others believed that their success would always be limited, no matter how hard they tried (Mitchell, Fleur, Georgina, Jared).

Chapter 9
Keeping Up

> *I find [maths] quite hard to understand. I didn't do any extra [study]…I think I needed extra study throughout the year like take stuff home that we'd been taught and go over it, but I didn't do that…*
>
> —Jessica, 17 years

Studying mathematics at secondary school became increasingly challenging for the children in this study for the inaccessibility and incomprehensibility of the new material they were expected to learn. *Struggling*, *getting help* and *keeping up* emerged as compelling themes in their accounts of engagement with secondary school mathematics. "Not getting it" was reported as frustrating and demoralising. As Jessica's comment (above) showed, she experienced mathematics in upper secondary school as a subject that was hard to understand.

> Jessica: I think I liked graphs the best because you get to put it into your calculator. It gives you the answer…[I disliked] algebra because it was so massive. And stuff like sequences, it was supposed to be the really easy one but it really confused me'cause I sorta didn't know when to use which sort of formula. That confused me and so did calculus with the formulas. (Late Year 12)

Jessica found that in order to keep up with her peers, her study of mathematics required considerably greater effort than in previous years. As their mathematical performances began to matter in new ways, particularly where streaming or grouping classes by ability was practised or minimum levels were required for entry into the more "advanced" mathematical subject options, the children became increasingly aware of their standing within their peer cohorts.

Needing and receiving help was not just a matter of gaining access or not to mathematical knowledge, but became a categorising sign, a production of a truth about the children as (un)worthy mathematical subjects. The children and their families were faced with choices about how to respond to schooling practices which framed children as successful/unsuccessful, or fluent/struggling mathematical subjects. In their accounts, positioning can be seen as a critical component of subjectivity not only in the children's views of themselves, but also in the actions they took to defend or improve their positions.

F. Walls, *Mathematical Subjects*: *Children Talk About Their Mathematical Lives*,
DOI 10.1007/978-1-4419-0597-0_9,

Teacher as Helper

Teachers were perceived by the children as critical to their learning of mathematics and because most of the children reported that they experienced difficulties in understanding what was expected, it was often teachers' availability or effectiveness in communicating that the children felt they needed most. For all of the children it was teachers' actions they attributed most to their success or failure in mathematics. For some, the issue appeared to be one of neglect – that the children did not get the attention they felt they needed from the teachers – and for others, teachers' help became their only access to mathematics. Thus the subject of mathematics was presented and mediated through the teacher as the key to their success, as the children's comments showed.

> Georgina: Miss Sandbar was cool, she helped me out a lot, she always paid attention to me. I got along really well with her and that helped. It always helps when you like your teacher. (Early Year 12)

> Peter: [Teachers] can talk you through and stuff, they know it better than you, and they can explain everything as best they can. With textbooks I mean you've got examples, but if you just read the notes that they have in the textbooks you can't really understand what to do, and stuff. (Mid Year 13)

> Liam She doesn't really check our answers this year, she just checks if we're doing the work, then she'll ask us if she thinks we're like struggling or something, she'll ask us when she's up there [at the board] to do the questions she knows we're rolled at…if she wants an answer quickly she just asks someone else, not me. (Mid Year 13)

> Dominic: [With large class sizes] you're sort of competing against the hordes for the attention of the teacher and from the teacher's point of view it's almost impossible to get round everyone as well, so, yeah, you could basically spend the whole lesson sitting there with your hand up and you'd never really get attended to, and that's one lesson gone where you've got nothing to do, sitting there waiting for help and it never arrives. (Mid Year 12)

Jared described the strategy he used in Year 11 to get help with mathematics. In this approach his survival in the classroom was created through dependence on the teacher.

> Jared: If you don't get it you just have to ask [the teachers] to help you and then they pretty much do it for you, so you just keep asking them to help you, putting your hand up and say, 'How do you do this question?' and they do it for you and then you say, 'How do you do the next question?'

> Researcher: Is that what other people do too?

> Jared: Yeah, or they just look at my work.

The children noticed that some students in the classroom appeared to receive more attention than others.

> Toby: I've noticed a lot more, well the ones who aren't so good at maths she seems to go over the, um, the Achieved notes and all those sort of easier notes really well and thoroughly, but for the ones that are good she actually, she lets them come back like after class, or at lunchtime or something to show them the Excellence stuff, like the really hard stuff…

> she seems to like them more, but I guess she teaches the other, the Achieved people more thoroughly. I think she just wants everyone to do well. (Mid Year 13)

> Jared: I don't think [the mathematics teacher] paid much attention to me. He paid more attention to the smarter kids, probably because they've got a future. (Mid Year 13)

Classmates as Helpers

Help from teachers was often insufficient. Engaging the assistance of friends and classmates was a strategy the children commonly reported. It seemed that children's helping one another became a significant feature of the secondary classroom as the difficulty of the mathematical content increased and the teacher could not attend to every student in need. The children's reflectiona suggested that classmates were not averse to becoming surrogate teachers, but that teachers did not always look favourably on students' helping of one another.

> Jared: Yeah,'cause they [the teachers] always have to move me for talking…Because we get in trouble, she just wants her to teach you, not other people. (Early Year 12)

> Peter: Sometimes when you're sitting next to someone who's really good at maths it helps, but sometimes it's not that good if they're distracting. (Mid Year 13)

> Toby: I just ask my classmates because especially before this year I was sitting next to some pretty good people at maths, always, so I just asked them. (Mid Year 13)

> Jessica: That whole classmates teaching, it's a different, you know, point of view, and from a younger person it's a good idea, you know, to have younger people trying to teach younger ones because they know what it's like. (Mid Year 13)

> Dominic: Towards the end of Year 12 the class gets pretty closely-knit and unlike different years, say middle school Year 9 that kind of thing where people just talk and cause trouble and avoid work, this is more, they go hand in hand to an extent, like, people, I'd say I get more help from a classmate than I would from the teacher, by asking them for help like someone who is a bit further advanced than me, just talk to them and ask them how they did it and then sort of try to copy that,'cause generally you're in line waiting for the teacher's help or you could just ask [your classmate] and they'll help you right away. (Late Year 12)

Attending Tutorials

In recognising the many problems children were experiencing with mathematics, a number of the schools provided auxiliary instruction in the form of clinics or tutorials. The need to attend these classes was regarded by the children as an indicator of mathematical deficiency.

> Fleur: I'm not very good at maths…I can't do it. People say the penny drops but it just doesn't. I don't like, get it…I went to a lot of lunchtime tutorials. It was kinda hard 'cause the whole class like, there were a lot of people in there asking for help. (Early Year 12)

> Jared: My Year 8 principal who was my [maths] teacher as well, got us all involved. Used to just sit us down on the mat and get a big whiteboard with him and draw pictures. He had an after school programme as well for those who were struggling…we'd go to the after school programme and do our homework there and things like that. (Mid Year 13)

> Jessica: I could have understood it better, like at school they have Maths Clinic, an hour and a half after school once a week. Sometimes they would have a specific [session] for a specific level and a specific topic but most of the time you could just go and there'd be a teacher there and they would just rotate it and you'd take your work and they'd work through it with you, sort of sit there and do it and I could have gone to that, but it clashed with netball, so I could have gone to that and developed my understanding of those extra things I didn't understand and that would probably have helped a lot. (Mid Year 13)

The children described these extra supports as helpful but noted the difficulty in attending extra-curricular sessions where there was conflict with other commitments. The use of the term "Maths Clinic" at Jessica's school is significant. In his investigation of the, "conditions of possibility of medical experience in modern times" (Foucault 1973, pp. xxii), Foucault saw the clinic as an instrument as much of exposure as it was of healing, its dispassionate gaze capturing the individual as both subject and object of its own knowledge, practised in the art of observing and treating diseases. Foucault noted the similarities in purpose between the medical clinic and the school – the recognition and treatment of undesired states of being in the human individual. Stripped bare in the acts of examination, diagnosis and classification, the human body can be declared healthy or not. The establishment of a Maths Clinic in school can be viewed as an identical process – one of examination and corrective response to children's failure to pass. In this instance, the clinic operates as a space where the deficient individual is self-admitted for appropriate treatment.

Engaging Private Tutors

During my conversations with parents early in the first year of the research, I asked whether they would consider enrolling their child in some out-of-school programme for tuition in mathematics. At that time, most thought this to be a good idea and many had already considered such an option.

> Peter's mother: I've thought about it already. I would have to be concerned that he was getting behind. I would have no hesitation. The only concern is the costs involved…

> Mitchell's mother: I would consider it if I thought it was necessary, yeah. (Mid Year 3)

> Toby's mother: I would. I don't know what would make me think of that. Maybe if I knew he was, especially, not to say gifted, but quite bright, then it would help him. I would.

> Liam's Mother: Only if I thought he was having a lot of trouble with his maths. I'd have more confidence in the school and the teachers sorting it out [than an out-of-school programme].

> Dominic's father: Yes. More for excelling in something rather than, sort of, making up, because if we're not going to go well in that [naturally, there would be no point]

> Dominic's mother: Either actually, either end of the spectrum, and probably, certainly for me, [so] I can understand what they're doing, so to compensate for that.

> Jessica's mother: I have considered it already. Henry (older brother) went to NumberWorks and I've thought about it for her. But it's the logistics of getting to Greenwood [several suburbs away] and back, but it's there in my mind.
>
> Fleur's father: Definitely.
>
> Fleur's mother: I think if [the recommendation] came from a teacher or somebody like that, if they thought it would be helpful, somebody more qualified than Richard or myself.
>
> Fleur's father: Also if I think she enjoys something particularly and wants to take it further then I'm keen for her to take it further, so if she really enjoys maths, I would say [to Fleur] "Would you like to get some extra tutoring for something a little bit harder?" If we can afford it. Hopefully we can, to encourage her. Anything that gives them confidence, that gives them an edge over their peers, then I'm all for that.
>
> Fleur's mother: I'm not one to push people. I've seen too many children pushed from an early age. (To Fleur's father) You're competitive.
>
> Fleur's father: It's very different [for me] though. My parents were farmers and we lived in the country…there wasn't the opportunity [for extra-curricula learning].
>
> Rochelle's mother: Oh yes. I have thought about it for [older sister] but I have no idea where to start looking.
>
> Georgina's mother: I've actually thought of that. I just see little advertisements in the paper in the tuition section for mathematics tuition and I've thought to myself, "I wonder if she'd like that?" I don't know if she's that hot on maths.

As these statements show, parents' concern for their children's achievement in mathematics was not limited to situations where the child might be falling behind, but included the possibility of extension and extra challenge if needed. Parents were generally prepared to take additional steps wherever necessary. Their decisions were linked to their own education histories, the affordability of tuition and a belief that the school could be relied upon to do what was best for their child. Three of the children did go on to take part in some kind of tutoring in later years. In the following conversation, Peter and his mother talked of what happened when Peter reached secondary school at the beginning of Year 9 and was reassessed as a mathematical learner.

> Mother: Peter's first years [at Dockside Boys'] when he was in what they called the Gold stream rather than the A stream were quite unhappy because he missed out on being in the A stream because he didn't have the building blocks for maths, which was shown on one of the tests, which we didn't realise at the time was the reason, we found out later, and found out that he was in a classroom of boys that were really disruptive in class. He hated it. I think you kept saying, 'They're just a pack of idiots, Mum.' So that's what motivated you and also from Beach school, a high percentage of Beach get into the *A Stream* so it meant that a lot of his friends were in the *A Stream,* so I don't think he had many friends in the [Year 9] class.
>
> Peter: Well I knew a few people but they weren't friends
>
> Mother: No they were the bad eggs from Beach. (Early Year 12)

To be assigned to the *Gold Stream* was, for Peter, to be separated from his friends, and to be classified by association as one of the "idiots" or "bad eggs". This came as an unpleasant surprise given that he had been selected to participate in extension group mathematics at primary school. Peter's unhappiness appeared to be as much about his subjectivity as a learner as it was about his learning of mathematics. Because it was seen as a comprehensive and objective measurement of Peter's mathematical capabilities, the entry test used by the teachers at Dockside High School to diagnose Peter's apparent deficiency told a truth about Peter that no one appeared to challenge, not even Peter himself. When I enquired about what the "building blocks" might be that were apparently missing, Peter's mother said that the teachers at the school had provided no further information. It was likely that all the students who scored poorly on the test were offered the same explanation: that the score indicated some vital steps that had been missed in their developmental progression of learning mathematics, which could be traced back to primary school. Peter's mother set about repairing this lack so that Peter might be readmitted to a class where he felt more comfortable. She first tried *Kip McGrath*. This worldwide private tutoring agency made the following claim in its Web site promotion:

> Every child, teenager and adult has the right to reach their full learning potential…Give your child the confidence to do their best at school by enrolling them in our private tutoring programmes. Study courses are motivating, fun and engaging! Identify the problem: Our educators can help you work out the best learning plan for you or your child based on individual ability. Find the best programme: Our programmes cover everything from maths tuition, to essay writing…Find one that suits you. Get ongoing support: Everyone's learning needs change as they move through their education.[1]

Children in this advertisement were produced through the discourse of learners as individuals possessing an identifiable, quantifiable quality known as "ability", as bound by "potential" and as diagnosable and fixable. Learning was presented as something one "moves through". Peter and his mother described their experience with this agency and with the tutor they subsequently found for Peter:

> Mother: We went through *Kip McGrath* and Peter didn't like the tutors.
>
> Peter: I only went once, like [they gave me] a pre-test …
>
> Mother: They didn't treat us very nicely though did they?
>
> Peter: No.
>
> Mother: And when I said to them, 'Oh we've got a private tutor,' they got very snarky with me saying, 'Oh you know they're not trained,' and, 'maths tutors are like hen's teeth you've probably picked a dud,' so I was made to feel bad about that, but when we met Nat [the tutor]…I mean he's young, he's articulate, he's interested…Nat was friendly and [Peter] liked him – and [Nat] liked and understood maths. (Early Year 12)

The agency's claim that tutors must have specific training to be effective was not supported by Peter's experience of tutoring. Nat the tutor was a young university student whom Peter's mother had found by word-of-mouth. Peter's experience of working with Nat proved to be extremely positive. Nat did not give Peter tests, rather he gave Peter the kind of learning support he found helpful, as Peter's following explanations showed. He noted in particular the benefits of working with one person compared with trying to gain the teacher's attention in class.

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[1] From http://www.kipmcgrath.co.nz/

> Peter: Nat and I could spend time on the things I didn't know and we didn't have to cover the things I did…he could explain things more than once if I didn't understand…it was easier, I could tell Nat what I didn't know. (Late Year 11 - from email communication)

> Peter: You can ask all the questions you need to know for learning different formulas and stuff…I think [Nat] just explained things a bit clearer…It's a lot easier that way…in class they get you to do lots of exercises and stuff like that…you get an hour but half the time it's just the teacher trying to control the rest of the class. Yes, there's a lot more other people, and usually when I put my hand up the teacher doesn't come over anyway 'cause there's already other people [asking for help]. (Early Year 12)

As his experiences of learning mathematics in primary school had shown, Peter was not a student who actively sought attention from the teacher and as a consequence he had sometimes missed out on the assistance provided to other children. The tutor-based approach to learning mathematics seemed particularly suitable for Peter and his performance improved. After a year of working with Nat, Peter was placed in the *A Stream*.

Georgina's parents had also sought help from an agency. Hoping to boost her mathematical skills, they enrolled Georgina in *NumberWorks* a learning programme whose advertising recognised children's mathematical subjectivities such as confidence and enjoyment, as critical to their success in the subject.

> NumberWorks … is unique, specialist after-school coaching company providing a pathway to maths confidence for your child: Confidence in learning, confidence in new skills, and confidence at school. Developed by expert educationalists, the NumberWorks'nWords program is based on current curriculum objectives and standards in each Country or State, but is completely focused on your child's needs. Individually focused tuition means your child gains thorough understanding at each level of attainment. Learning is fun and maths is made easy.[2]

On two separate occasions Georgina recalled her tutorials with *NumberWorks* as a significant breakthrough in her learning.

> Georgina: When I was struggling at Motu School with maths and I was always getting put in other classes [lower ability stream]. [My parents] helped, helped me quite a bit with maths by putting me into tutorials (*NumberWorks*) every Wednesday night for an hour, for two years. It helped me quite a bit at school at the time, It was like, 'Oh yeah, I did this at *NumberWorks*,' so I would have an idea of what we were doing so it helped me at school. So it was support. [Without this support] I would have just, like, I would have tried to do the work but it would have been all wrong, kind of thing. (Early Year 12)

> Georgina: From like Year 8, when I was 12, I remember hating school. I remember hating maths. I remember being really bad at it. I went to *NumberWorks* every Wednesday afternoon in Year 8 and it was really good for me, because it was different to the learning we did [at school]. We would have levels that we had to reach, and we'd do so many questions on the computer. It was a like a computer-based subject, like computer maths games and it was fun. You had to do so many equations like times tables, plus, subtraction, addition. I think I learn better from pictures, colours, visual, like real visual things, and if they could put that into maths then I'd be really good at it. (Mid Year 13)

[2] http://www.numberworks.co.nz/nwnw_maths.asp

The *NumberWorks* programme appeared to foster repetition of mathematical facts and procedures rather than development of children's concepts of the underlying mathematical ideas. Georgina's ability to cope with school mathematics improved with the supplementary lessons at NumberWorks, so much so that she reported that her teacher accused her of cheating when she performed unexpectedly well at school.

> Georgina: Parent teacher interviews, my parents were there and he [the teacher] goes like, 'I believe Georgina's cheating in her tests and exercises.'
>
> Father: She'd changed so much.
>
> Georgina: I was like, 'You're crazy, I go to NumberWorks, I'm trying my hardest, Mr Archipelago, give me a break.' I remember Mum went nuts at him. I remember it so well. It turns out that Taila, my mate who's sitting next to me is copying my work, that's how it turns out. I've never copied anyone else's work. Because she was a smartarse anyway, she was cheeky and rude to teachers, but it isn't that she's smarter than me. (Early Year 12)

It seemed that once teachers had recognised the incapability of their students, they were reluctant to accept a dramatic improvement in their performance as though lack of success was something about which nothing could be done. Children too were sometimes unwilling to accept their difficulties as something that could be changed. In Year 12, Dominic's mother engaged the help of a private mathematics tutor. Dominic explained how this came about, and described his initial hostility to the idea.

> Dominic: I was sitting there denying [my struggles with maths]. My teacher called my Mum and she suggested [tutoring] so, then my Mum went and got me one and I kind of dragged along, I really didn't want to go especially because my first session was cutting into my soccer training, so I was very, very hostile! But I kind've got a lot of work done in a two-hour period so I came back thinking this is actually a really, really good idea and I was going to keep up with it and try my hardest with it. It has really helped. There was always about four or five kids there. She'd kind of make her way around the table and just sort of stop and help us, 'Anyone who's got a problem, I'll show you how to solve the equations that are stopping you,' and then she'd just let you get on with it until you got to another roadblock and then she'd sort of untangle that for you. The first lesson we did was algebra because I'm crap at it generally, it was really this big problem for me and she just showed me some fairly simple ways of kind of untangling it so to speak, of dissecting it into blocks and stuff, so that really, really helped me. At school we were doing an algebra chapter [of the *Further Mathematics* textbook] and in the SAC mark which was the internal assessment I got like 93%, so that really helped…I didn't look at it as a great big unsolvable problem [any more]. What I'd do [before tutoring] because the chapters were generally structured around two or three easy questions at the start and then when it would start to get complicated I'd just sort of, give up. Put my head in my hands and wait for the bell to ring. So I was just totally avoiding it. You know the tutor really helped me to sort of take [difficult problems] on, and take them on confidently, and then when I started to haul in the better marks then I really thought it was worth it…I think I found a better way of doing it…I don't know what [results] I would have got if I hadn't had [tutoring], I reckon I would have got 10, 12 [out of 50] I really wasn't doing that well at all. And it was a real kind of enlightenment so to speak. [Before tutoring] I was generally doing so much work for the other [subjects] I tended to neglect the maths stuff. And so if I had essays to do I'd do them first. [Tutoring] was like doing homework, but better than doing it on your own. (Late Year 12)

Dominic reflected on the benefits of tutoring.

> Dominic: I'd say it's just a simple one-on-one time that tutors offer, but also the fact that I've been going to a tutor outside school, where I'm not being distracted by my classmates, where I don't know the other people who are there, because they go to different schools in different years and that kind of thing, I've got no distractions, I don't feel the desire to talk to them about other stuff, I'm totally isolated from all the distracting factors and the fact that I've got, you know, someone who I can ask any time like, 'How do I do this, can you show me how?' that kind of thing, I'm not distracted. It's just perfect for me. (Mid Year 12)

By the end of Year 12 Dominic was awarded the school prize for the most improved student in mathematics and scored 60% for the external VCE mathematics examination, a significant turnaround.

> Dominic: I think [tutoring] was mainly inspiring confidence in myself and also when I had someone, you know, on hand to sort of clarify particular problems, it meant that I was capable of doing it in the future, and all this kind of thing, I was sort of really eliminating the roadblocks, in the way, I was more confident, I was more interested in it, I was more motivated because I actually felt that I could do it and I wouldn't, as soon as I got to one which I couldn't do I wouldn't stop, whereas, you know after sort of help on algebra, and you know, the sort of more complicated areas of maths I was much more confident, yeah, I'd say it was just helpful because it definitely helped my study habits. I did much more work on maths rather than totally ignoring it. (Late Year 12)

Dominic's description noted increasing fluency with known mathematical procedures rather than a development of deeper understanding of mathematical principles. Jessica was also familiar with tutoring. She had used a tutor to help her with Economics, and considered, in hindsight, the possible benefits of tutor assistance in mathematics.

> Jessica: I actually regret not having a maths tutor. I know two friends who got maths tutors, yeah, but I don't know how it worked for them or anything, I didn't talk to them about it…I feel like I should've maybe got like a maths tutor from the start of the year and had it maybe once a week or something'cause it's such a big amount of work to get to study for exams I feel like I would have needed more time to do it. (Mid Year 13)

For most of the children in this study, the one-to-many model of delivery (one teacher for many students) that remains taken-for-granted in public schooling failed when the substance of the mathematics that was being presented to the children became too difficult for them to understand within the limited scope of transmission modes of classroom pedagogy. Studying from the board, the teachers' notes, study-guides or the textbook provided the children with a proxy one-on-one learning situation, but as Dominic observed (see Chap. 13), "the textbook can't talk back". The children's accounts suggested that it was in social interaction, particularly in one-on-one discussion, that their most powerful learning occurred. In many cases, classmates became a critical source of assistance, and while teachers appeared not to have built group discussion into their classroom pedagogy to capitalise on the power of social interaction for building shared understandings of the mathematical material they were teaching, the children were creating these support systems for themselves within the constraints of the power/knowledge structures of the classroom.

Teachers' attempts to intervene, to stop children from talking for example, were in many instances subverted. Subjectivities were built within these social systems where mates-as-teachers took over from the teachers themselves.

Parents' concerns about their children's progress in mathematics were linked as much to social positioning and opportunity as they were to learning. The subject position of struggling student was shown to be one that could be shaken off with effort. Tutoring intervened in the process of subjectification – it provided Georgina, Peter and Dominic with a degree of success they would otherwise have not achieved. While this did not necessarily alter their view of their mathematical abilities and reinforced many of the learning approaches that had created their "struggles" with mathematics in the first instance, the children were able to identify the factors that they believed had brought about their improvement such as active engagement in colourful computer-based learning of mathematical facts (Georgina), the safety of a one-on-one teacher where questions could be asked and answered (Peter) and the intense study group situation where distractions were reduced and individual assistance was on tap removal of roadblocks (Dominic).

The parents' hiring of private tutoring can be seen as a significant social response to what was perceived as the children's failure in their school learning environments, as other studies have shown (e.g. Kenny and Faunce 2004). Taking matters into their own hands was generally viewed by parents as a last-resort action to be taken only where children had been identified as falling outside of the expected achievement range. Through its application of measures of comparison and ranking, schooling identifies a proportion of children as "struggling", "getting behind" or "not keeping up". These arbitrary categories are naturalised in the discourses of school where the children are tested, classified and grouped according to frameworks that monitor learning as a form of progress in which children can be described and represented in positional terms. Such regimes of regulatory practice subjugate children, as they subjectify them. Parents are gathered into this managerial system of normalisation as they place their trust in the school's expertise in examining and "identifying" their children as mathematical subjects, and are prepared to intercede to improve, protect and defend their children's positioning and life chances. Children as mathematical subjects, caught in a double-bind of subjectification from school and home (and sometimes tutor program), attribute their improved achievement in mathematics to various qualities of the help they receive. Their changed performances can be seen as improvement only in the reconfiguring of their subjectivity against the same instruments of measurement that had earlier identified them as struggling or falling behind in the first instance.

Chapter 10
The Shape of Life

I'm just hoping the [maths] exam that I buggered up won't drag me down too far [for the VCE university ENTER score[1]]. The results come out on 15 December I think it is. So that'll tell me. I can log on [to results website] at like seven o'clock in the morning to find out, you know, sort of how the shape of my life will be.

Dominic, 17 years

For many of the children in this study, achievement in school mathematics turned out to be a significant determining factor in the *shape of their lives*, as Dominic so graphically expressed it. He was all too aware of the links between achievement in school mathematics, access to tertiary study, and occupation, and as we saw in Chap. 8, was aiming for an ENTER score of 80 or more to enable him to enrol in a Commerce degree at one of the more prestigious local universities.

The TIMSS Advanced Assessment 2008 framework designed to assess students in upper secondary school in 2009, looked closely at the connections between the mathematics that children study at school, tertiary mathematics, and careers, justifying its areas of research as follows:

> The first category, *algebra*, includes much of the algebra and functions content that provides the foundation for mathematics at the college or university level. Topics from these areas occupy a substantial amount of the time devoted to pre-university mathematics. Since calculus is a central tool in understanding the principles governing the physical world, it plays a major role in advanced mathematics curricula at this level and merits significant emphasis. Calculus is the principal point of entry to most mathematically-based scientific careers. (Garden et al. 2006, p. 12)

As this assessment brief recognised, choices about whether to study mathematics beyond the requirement to do so and what kinds of mathematics to select marked a significant point in the children's schooling. Until Year 10, the study of general mathematics was compulsory. From Year 11 onwards, the children's choices of mathematical courses of study in upper secondary school became tied to their

[1] Equivalent National Tertiary Entrance Rank.

F. Walls, *Mathematical Subjects*: *Children Talk About Their Mathematical Lives*,
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emerging visions of life beyond school, in many cases both determined by, and determining, the life chances that they perceived to be open to them.

Occupational Subjectivity

In this chapter I adopt the term *occupational subjectivity* to describe the children's views of self and their associated behaviours in making choices about subjects to study in upper secondary school, tertiary enrolment and paid employment. This term blends occupational studies with Foucault's concept of self as a recognised/recognising subject. It offers a useful framework for investigating the children's career choices and the part that mathematics played in this process. Recent occupational studies define *occupation* as more than the vocations, careers or jobs that we have or choose or the kinds of workers that we are. Kielhofner (2008) for example described occupation as all those activities in which an individual chooses to engage for both leisure and work and the choice seen as constitutive of her/his *occupational identity*. Occupation in this broad view takes into account not only the kinds of paid work that we do, but also the many activities we value and enjoy, which comprise our ways of living as occupied beings. As I have argued earlier, subjectivity is a concept that suggests mutability and ongoing process. Occupation too can be seen as the active practice of construction in which human subjects are made in continuously unfolding occupational narratives. These narratives include social interactions, schooling experiences and access (or not) to occupational opportunities. Occupational subjectivity, then, is a term that captures the self in ongoing occupational becoming. As this chapter will show, occupational subjectivity begins very early in life and becomes a volatile dynamic for students as they near the time to leave school.

Occupational choice is usually regarded as something we make once we leave school, but occupation and schooling can be regarded as inseparable. Pollard and Filer (1996) use the term "pupil career" to describe children's strategic engagement in the business of schooling, and as Dominic observed, schooling itself can be seen as occupation.

> Dominic: [School is] essentially a full-time profession when you're in it because it takes up six hours of the day five days a week. (Late Year 12)

Throughout their lives at school, the children in this study could be seen as engaged in strategic choice-making in their learning of mathematics, including the ways in which they exercised learner agency during lessons, as Jared's comments demonstrated.

> Jared: I choose not to listen (laughs) because I don't like maths. (Early Year 12)

> Jared: My friends were sitting right next to me. We'd distract each other all the time, flick paper, just like, mucked around quite a bit. We weren't really interested in the lesson so we just talked to each other the whole time. (Mid Year 13)

These choices were occupational in the sense that they were tied to the children's futures beyond school. In rejecting mathematics for its failure to interest them, Jared and his friends were counting themselves out of the opportunities that success in Year 12 mathematics afforded, such as entry into university. Their choices cannot be regarded as freely made, however. They were made within the constraints not only of the cognitive availability or personal appeal of the mathematics with which they were presented, but equally importantly, that which was socially sanctioned and endorsed in the complex of social interactions between friendship group, home, school and classroom. Jared and his similarly disaffected friends legitimised – for each other at least – the strategic action of disengagement.

Georgina talked of how she had pursued a line of active resistance to the kinds of pressures of social persuasion Jared had experienced.

> Georgina: Most people I talk to hate school and just go like, 'Ooh (*makes groaning sound*) I hate school!' and they're never there and always in trouble with the principal and always got detention and stuff and it's like, 'Well if you're going to be like that, you won't pass school.' My friends wanted to pass but they had a negative attitude so they didn't pass, but I wanted to pass and I mean, at the time I didn't like school but I still did it, and just got on with it and passed.
>
> Mother: We've instilled in her the knowledge that she needs to get a good education to get ahead in life. And you know, she understands that fact, that if she doesn't get qualifications she is not going to have a good job, and she doesn't want to be a cleaner (*laughs*). (Early Year 12)

Walkerdine (1997) alerted us to the ways in which our choices are not free, but heavily circumscribed. In the first conversations with the children's parents early in Year 3 they talked about the aspirations they held for their children's learning of mathematics including how long they anticipated the children would continue to study the subject. This was often linked to their thoughts about their children's educational futures in general.

> Fleur's mother: That's hard [to anticipate]. The world's changing so quickly.
>
> Fleur's father: Education is very important, obviously, so probably I would like to think that she'll go to university.
>
> Fleur's mother: That wasn't your opinion.
>
> Fleur's father: Of course it was. It's always been my opinion.
>
> Fleur's mother: I don't have great expectations. I don't know. I think Year 12, or whatever, somewhere around there.
>
> Georgina's mother: I have a scholarship so she won't leave a schooling institution until she's about twenty (*laughs*). Hopefully. I have high hopes for that girl. Hopefully she'll go to university and utilise her scholarship. I just want her to achieve something, be the best she can. She wants to be a teacher … She likes working with people, so, if she grows up to be happy and healthy and the best she can possibly be, I'm happy with her.
>
> Rochelle's mother: I'm hoping for them to go right through. Naturally, as a natural parent I'd like them to finish Year 13 and go on to their chosen, varsity or whatever, just go on to better things.
>
> Jessica's mother: I hope she takes it right through to secondary school. I hope it going to be one of her main subjects. It's often compulsory now anyway isn't it? I mean I don't know her … she may decide to become an accountant or whatever. It's hard to … She'll probably be an art student or (laughs) … I can imagine her doing something like that. I expect all of [the children] to go to university. I'm going to have very high expectations. It was never expected of us. My parents were refugees and they just knew no different really.

Dominic's mother: I think he'll take it right through. I don't think he'll have a choice personally, that they will have to have some kind of tertiary whether they want to or not, like Polytech or whatever, there wouldn't be an option for us I suppose. I hope he'll have a positive sense of self, so that he can have a belief that he can have a go, not necessarily that he's good or wonderful but that he will have a go … I hope he finds some things that he's good at, seeing things as they are. I hope he discovers what his talents are.

Jared's mother: Right through to Year 12 or 13. [His decision about what to do beyond school] depends on how they go through high school, to see each of their strengths. I've got a nineteen year-old who dropped out of school. He had all the brains.

Mitchell's mother: I guess I want them all [her children] to go as far as they can. Realistically it would be nice to see him do Year 11 at college or something.

Liam's mother: Until he leaves school. What age is that now? Fifteen?

Liam's father: He's not leaving school then. Go to varsity. They've got to. They don't have a choice. They need a career.

Peter's mother: My husband thinks maths is the most important subject at school. And when it comes to choice of careers, if you're good at maths, you've got a huge choice ahead of you … I hope he gets something with a job at the end.

Toby's mother: Academically I think probably maths would be where he's strongest. Yes. I would like to think he would carry on doing quite well in maths. Take it right through [secondary school]. That's what I can see at the moment.

Gottfredson (2005) argued that occupational choice is an individual's process of compromise between that which is *ideal* and that which is *possible* within socially circumscribed occupational space in which masculine/feminine and high/low social value form intersecting and opposing axes. This is explained more fully in Chap. 11. Mendick (2006) who studied students' subject choice in upper secondary school used the concept of *identity work* or *identification* (from Hall 1991) to capture the nuanced, mutable and lived nature of identity as situated, as in constant process, as both psychic and relational, and as represented/representable in narrative. In her analysis of students' subject choice, Mendick suggested that, "'identity work' positions our choices as producing us, rather than being produced by us" (p. 23). In this view children are psychically active and distinctive "selves" as well as socially interactive and connected beings in communities of practice; children choose to act in particular ways as learners not because of *who* they *are*, but in a continuous *process* of *becoming*.

When asked towards the end of Year 13 which subjects they believed were most important to study at school, most of the children continued to cite mathematics and English as the top two subjects, as they had done when asked the same question in primary school. The importance of mathematics in their view seemed to be related less to its practical use in everyday life than its role in creating occupational opportunity.

Toby: Um, I'd say maths is up there, maths is probably really important, just general maths, the specific stuff that we do isn't so relevant but maths itself is really important, ah … (Mid Year 13)

Liam: Definitely English. Probably maths as well, not so much now as being important generally unless I wanted to do something with maths in it, but up to like Year 11 I think

> it's pretty important for general use, yeah, probably those two. To get into uni you need credits in those two subjects at Level 2, so everything else they are basically saying is your option. (Mid Year 13)

> Rochelle: I think the most important would be maths and English, I don't know why, you do need to learn English and maths really, 'cause otherwise you know, you'd be dumb wouldn't you? Well not dumb, but … (Mid Year 13)

> Dominic: Maybe English, it's the cornerstone of Year 12 and kind of relates to all my other subjects.

> Mitchell: Probably Transition, teaching you about the world and stuff. Like money and jobs and stuff, like different jobs around the world. (Mid Year 13)

> Jessica: I think maths and English are the sort of subjects that are the more rounding off subjects, you know, it's good to have that in your Year 13, and it's good if they see that you've got that, that covers quite a wide spread I guess, but maths, like I can't see myself ever doing anything with maths. (Mid Year 13)

Choosing Mathematics

Planning for their occupational futures was the chief consideration in the children's choices about studying mathematics. This was determined to a large extent by their perceptions of their abilities in mathematics. Where mathematics was concerned, their choices were not simply confined to whether to continue their study of mathematics beyond the compulsory years, but which of the mathematics options to choose. Mathematics was the only secondary school subject that was split into two or more options in the final years of schooling. This was rationalised as catering for what was judged to be a much more significant gap between students' abilities than occurred in other subjects. Tables 10.1 and 10.2 show the options offered to students in New Zealand and in the State of Victoria, Australia, respectively.

The students who lived in New Zealand could choose between two options at Year 12 while Dominic in Victoria, Australia was presented with a wider choice (see Table 10.2). A students' interpretation of these divisions was found in a public blog in which high two school students from different states in Australia were discussing their study of Year 12 mathematics.

> Well… [In Victoria] There is Further Maths - which is super easy. Like baby maths. Maths Methods (CAS) – which is annoying, it's a harder maths. Specialist Maths – which is hardcore maths, although some find it easier then [sic] Methods. Then there is no maths.[2]

This student-to-student communication demonstrated how students perceived their options in mathematics as hierarchical and how the categories produced subject classifications that were cognitive and social at the same time – "super easy" maths was "baby" maths for example. Jessica explained further:

[2] http://forum.sportal.com.au/yaf_postst35365_VCE-MATHS-METHODS-34-NEED-HELP.aspx.

Table 10.1 Mathematics subjects offered in secondary school in New Zealand

		Year 11	Year 12	Year 13
Year 9	Year 10	NCEA Level 1	NCEA Level 2	NCEA Level 3
Mathematics*	Mathematics*	Mathematics*	Mathematics	Mathematics – calculus
		Mathematics – numeracy	Mathematics – numeracy	
			Mathematics – statistics	Mathematics – statistics

* – compulsory

Table 10.2 Mathematics subjects offered in secondary school in Victoria, Australia

			Year 11	Year 12
Year 8	Year 9	Year 10	VCE Units 1/2 *	VCE Units 13/4
Mathematics*	Mathematics*	Mathematics*	General mathematics	Further Mathematics
			Mathematical Methods/ Mathematical Methods (CAS)	Mathematical Methods/ Mathematical Methods (CAS)
			* (One of the above options)	Specialist mathematics

* – compulsory
CAS computer algebra system

> Jessica: I think maths is definitely one of the more academic subjects, there are the more academic subjects and what people call the 'bum' subjects, but the thing about drama and P.E. and say, computer studies that don't take like, the smarts, it's more about, um, it doesn't take the stuff like maths does, like the intelligence and the quick thinking and things, it's more about your creativeness, it's kinda like art and things, not that you'd call them bum subjects, but it's a different sort of learning, so it might be that they take those roads, it might be that they are more of a creative person than a logic person. (Mid Year 13)

Choosing mathematics (or not) was therefore an act of subjectivity, mathematics aligned with logic, intelligence and quick thinking, and other subjects with creativity. To choose or reject mathematics therefore, was to make a statement about the self. Table 10.3 shows the children's choice of mathematics subjects over the final 3 years of secondary schooling and/or into the workforce. In Mitchell's case the teachers had chosen for him, since no other options were considered to be available for such students.

By the final year of the study, none of the four girls was continuing to study advanced mathematics of any kind, and two (Georgina and Rochelle) were already in fulltime employment. Georgina, the first of the children to obtain tertiary qualifications, had undertaken a 20-week course at the local polytechnic college to gain a Certificate of Business Administration and Secretarial Studies. The table shows the gendered process of subject selection for upper secondary school and planning careers beyond school and the implications for the life chances of these ten children.

For all of the children, the choice about whether to continue studying mathematics, and what kinds of mathematics, was tied to their perceptions of the value of mathematics in their lives. The girls' explanations for their choices about studying mathematics were particularly revealing. Choice was seen as a socially shaped act.

> Fleur: I'm not doing [Year 12 mathematics], I'd rather do classics and history and geography … I wanna do psychology or sociology [at university].
>
> Researcher: What is it about [those subjects]?
>
> Fleur: I like the people [aspect] … and Miss Highly said that you need maths in bio [tertiary study in biology] but the others you don't have to. (Early Year 12)
>
> Mitchell: Some [of my mates] like [maths] and some of them don't; some will say it's good for them and some of them think it's boring.

Table 10.3 Participation in mathematics subjects in Years 11–13

	Year 11 (mathematics compulsory)	Year 12 (mathematics not compulsory)	Year 13 (mathematics not compulsory)
Fleur	*General mathematics*	No mathematics	Remained at school No mathematics
Georgina	*Mathematics numeracy*	No mathematics	No longer at school. Studied for Polytechnic – Computer skills certificate (20 weeks' study); employed fulltime call centre
Jessica	*General mathematics*	*General mathematics*	Remained at school No mathematics
Rochelle	*General mathematics*	*General mathematics* (first 3 months of year); Left school Term 2. Employed – supermarket sales assistant	No longer at school. Employed in temporary secretarial work in two government departments (6 months each)
Dominic	*General mathematics*	*General mathematics B*	Remained at school *Further mathematics*
Jared	*General mathematics*	*General mathematics*	Left school, unemployed (6 months); employed part time; studied Year 11mathematics by distance
Liam	*General mathematics*	*General mathematics*	Remained at school *Mathematics with statistics*
Mitchell	*Mathematics numeracy*	*Mathematics numeracy*	School/polytechnic transition to work programme – part-time work kitchen hand
Peter	*General mathematics*	*General mathematics*	Remained at school *Mathematics with statistics*
Toby	*General mathematics*	*General mathematics*	Remained at school *Mathematics with statistics*

For some of the children, a certain standard of mathematics was required for entry into other upper secondary school subjects.

> Dominic: Yeah, well for the start of this year I was really quite worried about Physics 'cause I thought I wouldn't survive it because, we do a little orientation class before the summer holidays, of each subjects, and that was when they gave me this maths test and I'm like 'Oh dear, I'm gonna fail this, I'm gonna really struggle,' but, um, I've had pretty much, had a pretty good pick of the teachers this year like I haven't got many bad ones and yeah my physics teacher sort of explains it to you, he doesn't rush it he doesn't, that kind of thing, make you really work through as fast as you can, but it's not the sort of slacker lifestyle either, he just makes you just sort of work and makes you understand it and does practical activities not just theory all the time and that kind of thing, keeps you motivated to do it – keep going. (Early Year 11)
>
> Researcher: Is it impossible to be a pilot without that [advanced] maths?
>
> Dominic: I think it's very hard to get back into it. [If you haven't it all the way through]
>
> Mother: Do you remember though you did look at the options, you could still …
>
> Dominic: Well I've done Physics which I've sort of kept as my back-up card 'cause they [pilot training school] required a Maths Methods and Physics and I guess I could probably go back afterwards and maybe do a Maths Methods course, you know, after school, and because I've still got Physics I can sort of keep that as a halfway point … and I can sort of use that for other things maybe if I wanted to go into engineering, or something.
>
> Mother: From memory what it did, was if you wanted to go, join the air force the maths criteria were less for that they were to go straight into an aviation degree. But for engineering which was the other thing you were thinking about at the time, after your work experience, you needed the other maths I think, the maths that you're not doing, and physics, isn't that right, so where you ended up going I remember was A Maths, 'cause you thought it was important to have some, and Physics, 'cause it's still, even though you weren't sure you would be able to do it, and you wondered a bit about Economics because that had – you remember you weren't sure about that initially? (Mid Year 13)

This conversation showed that subject choice was not just the child's; parents were part of the process, working strategically with their children to consider the best options. Dominic viewed physics as a back-up card to keep his options as open as possible, and the lack of *Maths Methods* could be made up at a later stage since he had already passed the physics requirement.

Georgina had opted to study "*Mathematics – Numeracy*" in Year 11 rather than "*Mathematics.*" She described the process of her choice as follows:

> Georgina: In Year 10 when we were writing out the options we wanted to do in Year 11, I said I wanted to do Maths Numeracy instead of normal maths, and then my Dean and my maths teachers in the department of Maths had to talk about it between all of them to confirm me, because apparently it's a lot easier than real maths, but for the kids that are actually in real maths it's just average, it's not hard and it's not easy.
>
> Researcher: How do you think you would have gone if you'd chosen normal maths?
>
> Georgina: I'd have failed it, because it was different teachers and bigger classes, and harder stuff like geometry and algebra and Pythagoras. (Early Year 12)

Georgina's differentiation between Maths Numeracy and Mathematics, in which she referred to the Mathematics option as "normal maths" and "real maths," positioned her in a group that was regarded as taking an easier option that was, by implication, not ‘normal’ or ‘real’ mathematics. Her choice was based on her self-predicted failure in “normal” maths.

As soon as she discovered that it was not necessary for any of the career paths she was likely to choose, Fleur dropped mathematics.

> Researcher: You didn’t take maths this year. Was that a good choice for you do you think?
>
> Fleur: Well for me it was, because last year I dreaded maths so much, like going to the class, so this year it was nice not to have to do it.
>
> Researcher: Did others decide not to take maths [in Year 12] as well?
>
> Fleur: There weren’t many of us. They didn’t realise that you could not take it and still get into university, so others were like, going, ‘How come you’re not taking it?’ and we’re like, ‘You don’t need it.’ They were quite gutted. (Late Year 12)

Peter’s choice of mathematics was tied to choices about science subjects, the calibre of the teachers and a general weighing up of where his strengths lay.

> Peter: I was thinking of maybe taking physics this year but I didn’t do very well in the exam this year so I’m not sure if I want to take it ’cause it’s apparently quite confusing and quite difficult and I didn’t really get good maths teachers and science teachers so I’m not sure how well I’d do in that, so I’m not sure, I might just stick to the same subjects that I’m doing at the moment which is graphics and history, and geography … (Early Year 12)

At Liam’s school, the choice to study mathematics was linked to perceptions of “braininess,” and only those who were considering tertiary study were likely to continue mathematics to Year 13.

> Liam: I think at our school everyone thinks it’s only brainy people [who] try and do it, especially at Year 13, it’s like calculus and stats, and calculus is the harder one, and when you look at the people in there and even the people in my class, it’s mostly prefects and people that are hard-out like, striving to go university. (Mid Year 13)

The choice about taking the more advanced mathematics was not necessarily “free”; at Toby’s school an advanced mathematics (scholarship) class was provided only for those students who had reached the required mark in the previous year’s examinations, as Toby explained.

> Toby: [To get into the scholarship Stats class] you had to get really good marks in the [NCEA] externals. You can still take scholarship Stats but you just won’t be in the [scholarship] class, and, ah, then there’s [the] Calculus [class] and most of the people in that are pretty good at maths, because to take Calculus you’ve got to be pretty good at maths.
>
> Researcher: And you didn’t want to take that?
>
> Toby: No it seemed like too much work. Too hard. I’m not very natural at maths, so …
>
> Researcher: So, you think your achievement then, it doesn’t come naturally but it’s more …
>
> Toby: No, um, well it comes from listening in class, and studying a bit, and practising the exercises, yeah, I don’t just know what to do. Yeah.

Toby and Peter showed that hearsay became a significant part of the process of choice for some.

> Toby: I sort of decided, I just thought, because I think, yeah I didn't really know what to replace it with, and then (*laughs*), I heard there was easy credits in Stats, from older, [students] from last year, and, ah, yeah, I just sort of decided, didn't really think about dropping it. (Mid Year 13)

> Peter: Some of the subjects that we did in Year 12 [maths], 'cause in year 12 we did all of the different maths topics, and I was just hearing from other people, people who had done calculus, they just say it's really difficult. (Mid Year 13)

Teachers also played a significant part in some children's choices.

> Fleur: The teacher said there was a really big jump between Year 11 and Year 12 maths.

> Jessica: Um, I kinda figured that I'm not going to be doing anything with maths. People say you need maths for everything but, in some situations I just don't think you do and I talked to my maths teacher about what I was doing and she actually said, 'I actually don't think you need maths like, it's not a '*must have*' sort of thing.' Especially because I've had Year 11 and 12 maths. (Late Year 12)

> Dominic: My maths teacher thought [Maths Methods] might be hard for me, 'cause I've never been, well you know, flash hot at algebra and that kind of thing, so yeah, she kind of advised me to do some maths which is the general kind of thing and to sort of go down the humanities path 'cause I'm much better at that … [she said] there's creative and there's analytical brains. And I don't have an analytical one. (Mid Year 12)

> Liam: I talked to my last year's maths teacher 'cause I got on with him real well. He said, like, if I put more time [into it] I should be able to do it, Level 3. (Mid Year 13)

Their choice of mathematics as a subject was rationalised by some of the children according to its percieved usefulness in everyday life:

> Jessica: They say you've got to take [maths] 'cause you, you don't know what you're going to be doing in the future and you may need maths or whatever, but now that I'm up to the point that I know that I don't need maths, I guess there's a certain feeling of like, 'Well that was a waste of time,' like, you know I should have been doing what I want to do in the future all through school. But I suppose you don't know what you're going to do until you get to this sort of age, then giving you maths is really quite good I think, because even though it's not like, 'I'm going to become a mathematician,' necessarily, they're still teaching you while you're trying to decide. Like you're still doing stuff while you're making up your mind about what you're gonna do, if that makes sense. They're still working your brain I guess rather than you just sitting there doing nothing trying to decide what you wanna do and everything. (Late Year 12)

> Toby: Um, so far I mean, obviously, the complex skills like the stuff that we do at school doesn't really apply to anything I do outside of school so just the basic adding, subtracting, multiplying, and dividing is used like, every day, simple maths is so useful, yeah. (Mid Year 13)

Parents seemed to support the children's freedom to make their own decisions about school subjects while continuing to take a close interest in their child's choices.

> Toby's mother: Yeah, he did talk about the course he was going to take, and there was always um, last year I think he took on extra subject, you only have to take five, he took six because he is interested in things, and there are things he knows he should take, he couldn't fit it all in so he had to take an extra one, history he's still doing that, obviously French, he's really good at that and he's continuing that, I think he basically decided [by himself] but he runs it by us. (Mid Year 13)

> Rochelle's mother: She was very undecided about what to do and basically, mainly she wanted the boyfriend and she didn't care about, you know, that horrible stage of not worrying

> about school and never mind about the future; it's all about now. So she left school in Year 12, and yeah, had a couple of jobs at MacDonald's and Pak'n Save, and then sort of tried something else, then hung around for a bit and didn't do anything for a short time, then registered with quite a few agencies and all of a sudden she got this, 'I wanna work,' thing and has been basically working ever since. (Mid Year 13)

Mitchell's mother had made efforts to help her son find work as part of the transition to work programme in which he had enrolled at school in Year 13 and was aware that his limited English and mathematics limited in turn, the work options that were available to him.

> Mitchell's mother: My ultimate dream and goal for him is to be able to get a job, but you know, um, he's got to have the enthusiasm for that. (Early Year 12)

> Mitchell's mother: I worried immensely about his future and where he was going … He went for interviews at the supermarket and he just does not interview very well, he has a real lack of self-confidence … I was just thinking if someone would give him an opportunity. I knew the kitchen manager [of the place where Mitchell works] and she said, 'Do you know of anybody?' and I thought of Mitchell and suggested that perhaps, you know, 'What about my son?' and so they got together and employed him and it's really progressed from there. (Mid Year 13)

Dominic discussed his choices with his parents. The following conversation showed Dominic's occupational positioning as shaped around a view of himself as someone who was not "naturally" able to do sciences and mathematics. He looked to other subjects as possible occupational strengths. Trade subjects were never in question.

> Dominic: Yeah, probably, probably do something around history, 'cause I really enjoy that …

> Mother: You're not planning on an apprenticeship or anything dear?

> Dominic: No, no, I'm not sure that bricklaying's my thing …

> Mother: The best thing's to have options, you don't have to make your mind up yet.

> Dominic: You sorta do now, because I've gotta choose my subjects.

> Mother: Yeah but they're broad enough that you're not pigeon-holing yourself into any one thing that you've got options, do what you love rather than what you think you have to do …

> Father: There's pressure for Years 11 and 12, this year, you have to get it right.

> Mother: Well the pressure really was an internal one Dominic, wasn't it, it was, tell me if I've understood correctly, it was around how hard did you want to work [at physics and mathematics], how important was the dream that you had had about being a pilot and then an engineer, and how important was that still to you, and then how hard were you prepared to work to do that?

> Dominic: If I was going to fight an uphill battle, you know, keep on the same tier as everybody else who can do it sort of naturally, that was what I wasn't really sure about, whether I could do something I'm good at and which I can get much better marks at, but I'm not really sure if I wanna do it, if you know what I mean … I'm not sure really what sort of future there is in a sort of history-orientated [career], I mean, basically become a lecturer and that's it. (*Laughs*) I don't know, maybe I'm wrong, maybe I'm wrong, but …

> Mother: It's a bit scary having all those options sometimes, but it's scarier not to have any, or only one … I think you've chosen well, you've got a good broad range of things and there's actually some themes that go through all of them aren't there …? Strategies. You were thinking of marketing. Psychology, you're actually good at analysing why people do things.

> Dominic: That's what the teacher Mr Burnside was saying about Economics – it's not about teaching you how to make money, it's about choices, which you make … (Mid Year 13)

Peter had attended the open day at the local university and this confirmed his decision to study Geography and History. After sitting his final Year NCEA external examinations he commented about his performance in mathematics as something that would give him personal satisfaction rather than occupational advantage.

> Peter: Yeah, pretty well, I'm pretty sure I passed everything, it's just whether I got Merits. It doesn't make any difference for university but it would be nice to get it, to get good marks. (Late Year 13)

Jessica and Liam noted strategic advantages that might be realised some time in the future in choosing to study mathematics:

> Jessica: Maths is a good thing to do even from the point you should do things sometimes that you don't want to do even if they are not enjoyable or whatever, 'cause they're character-building or whatever, and sometimes, one day that lesson might come back and you know, be beneficial. (Mid Year 13)

> Liam: At least I can say I've done [maths] to Level 3. Like in the future if I ever do come across any of that stuff at least I'll recognise that a little bit. I won't be totally like (*mimes looking very puzzled*) 'Um, um …?'

For Rochelle who left school early in Year 12, the decision was linked to her social life, her disaffection with school in general, and the difficulty of the subjects she had chosen, which she had regretted in retrospect.

> Rochelle: I'm not sure whether it was my age, my attitude, I just didn't want to be at school full stop. I had had enough of sitting down in the classroom listening to teachers, and I think friends is a big part of school. If you don't have friends, you know, you don't go as well do you? But I knew that if I left school I'd have to get a job. I knew that but I was scared of leaving school at that age, because I was, you know, basically just turned sixteen when I left school and it was actually scary knowing that I'd finished school. I wasn't into [school]. Plus the friends side of it, you know. I think I chose the wrong subjects … I should have taken easy ones like tourism then probably [I would have had more success] … (Mid Year 13)

It seemed that although Rochelle could no longer see herself as a pupil "sitting down in the classroom listening to teachers" launching herself into the workforce had been equally challenging and something she felt she had not managed as well as she might. Her choice of subjects including mathematics was part of this occupational dilemma.

The children's accounts illustrated that their choices about studying mathematics and staying at school were primarily occupational, that they were social since they were made with reference to or in collaboration with teachers, friends and family, and that they were multi-faceted and conflicted. For these children, enjoyment of mathematics was not a determining factor since all but Peter seemed to have lost interest in the subject. For Fleur, Georgina and Jessica whose aversion to mathematics had become severe by the end of Year 11, choices were modified by issues of mathematical subjectivity, which in turn were implicated in their occupational subjectification.

Part 4

Mathematical Futures: Life After School

Chapter 11
Girl Time and Boys' Clubs: Mathematical Genderfication

The boys, when there was a [mathematics] teacher, a female teacher, they would muck around a bit, whereas if there was a male teacher they wouldn't, and I don't know why that was.

Rochelle, 17 years

In Chap. 2 it was noted that successive rounds of international studies such as TIMSS and PISA reported sex differences in attitudes, achievement and participation in mathematics. The connection between gender, achievement and participation in mathematics is revisited in this chapter. Rochelle's aforementioned observation suggests that boys and girls engage in their learning of mathematics at school as distinctly gendered social beings and that the subject of mathematics is itself constructive of children as gendered subjects. Learning mathematics can thus be viewed as much more than the acquisition of a set of cognitive skills and processes we call "mathematical."

Mathematical Genderfication and Occupational Subjectivity

Many studies have examined recognised gender differences in mathematics education (e.g. Walkerdine 1998; Boaler 2002; Bartholomew 2005). Mendick's (2006) research involving upper secondary students of mathematics in the UK was compelling for its demonstration of the continuing alignment between mathematics and masculinity, which she viewed as a social power relationship rather than a genetically inevitable one. School subjects vested with high masculine status such as mathematics and physics were noted by Gilbert and Gilbert (1998) as productive of failure in boys who do not succeed within these male domains (p. 9). Studies such as these suggest that it is the power dimensions of the masculinity/mathematics connection that are most significant in children's participation in mathematics.

The children's stories revealed patterns of difference by gender in their experiences of life in general and their engagement in learning mathematics in particular. These differences in occupational subjectivity appeared early in the study and

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became more pronounced as the children began to choose subjects at upper secondary school, courses of study at tertiary level and paid employment. As discussed in Chap. 10, occupational subjectivity can be seen as a continuous constructive process in which the real and imaginary self produces, and is produced in, unfolding occupational narratives in response to social interactions, schooling experiences and access to opportunities.

As they made choices about continuing to learn mathematics into upper secondary school, enrolling in tertiary study after leaving school or joining the paid workforce, the children in this study were engaged in wider processes of occupational subjectivity seated in family patterns laid down in their early years. This was expressed and enacted in their selection of recreational pursuits, their participation in extracurricular activities, their interactions with classmates, friends and family and their conversations about learning mathematics, indicating their growing awareness of what constitutes "women's" and "men's" work and the valuing of occupations reflected in their evolving occupational aspirations. These were linked to the qualifications, occupations and educational aspirations of their parents, and parental experiences of learning mathematics, as outlined in the following section of this chapter.

Gendered Lives

Investigations of gender in education include studies of children's patterns of play (e.g. Wood et al. 2002). During the first 3 years of the study the children were asked to nominate their favourite toys. Their responses revealed distinctively gendered patterns of preference. The girls mentioned soft toys and dolls and the boys toy soldiers, remote controlled cars and sports equipment. There was some overlap in Pokemon toys and computer games. The differences between girls' and boys' toys of choice demonstrated an early appearance of a masculine/feminine divide in the children's occupational subjectivity. The boys' toys notably included models of masculine occupation in the form of soldiers and superheroes and scale models of real objects they might one day use such as cars and skateboards. The girls' toys presented views of females as less occupationally active or socially powerful. They were mostly non-mechanical and focussed on nurturing and adornment. Social positioning was thus gendered through the children's play from a very young age.

When asked about construction toys, Fleur's mother related the following story.

> Fleur's mother: There was a colouring in contest in the paper the other day that Fleur was going to do and then she realised that the prize was Lego; it turned her off. She stopped as soon as she realised, she stopped, so there's your answer. (*Laughs*) She's not interested in that, in building things. (Early Year 3)

Biological difference is popularly offered as an explanation for this gendered selection/rejection of toys including girls' apparent lack of interest in "building things." While it has been argued that the boys' greater involvement with toys such as Lego, transformers, computerised games and remote-controlled vehicles exposes them to the kinds of logical and spatial thinking that can be found in mathematics, Walkerdine (1998) warned that this justification for girls' lack of engagement in certain kinds of mathematics at school feeds deficit views of girls and women as inferior mathematical thinkers. She argued that typical girls' play offers just as great a range of opportunities for developing spatial sense as boys' play. A deeper examination of the social processes that construct men and women as mathematical/non-mathematical is required, she suggested. Her research noted that parents' and teachers gendered interactions with children, such as privileging boys' responses to questions, engaging children in competitive activities that aligned mathematics with the sports played by boys/men outside of school and responding differently to children's classroom behaviours – allowing boys to muck around more, for example, as Rochelle noted – and praising girls more for their diligence and neatness than for the rigour of their mathematical ideas.

Differences were also found in the out-of-school activities in which children were regularly occupied. The boys' involvement in competitive sports from an earlier age than girls' was particularly noticeable; the girls were more likely to take up less competitive activities such as dance, drama and music lessons. Georgina and Rochelle played netball – a distinctly female sport, and Jessica water polo. These were less popular than the male-oriented sports of soccer and rugby league played by four of the six boys. Classroom pedagogies of mathematics in this study were found to replicate recognised elements of sporting culture such as team games and timed individual performance. This was found to appeal particularly to those boys for whom this kind of competition was familiar. Rochelle was also keen on such games. Conversations with the children showed how classroom practice strengthened alignment between masculinity and mathematics, as shown in Dominic's reflection about whether boys or girls are better at maths:

> Dominic: I don't really know but we play this game called Maths Challenge … there's two boys standing up and two girls, and [the teacher] will choose someone, and they'll say, like, who they want to challenge and if the person who's standing up gets it wrong, then the person who called it will go up [to replace the person who got it wrong]. Out of all the games that we've played … we've [the boys] won seven and the girls have only got two. (Mid Year 4)

Structured as a contest between boys and girls, the game was productive of mathematical ability as gendered, since the teams were segregated by sex and boys won significantly more of these matches than girls.

The Gendered Construction of Occupational Aspiration

Table 11.1 shows the children's changing career aspirations over the 11 years of the study. The levels of mathematics required for these occupations are indicated.

The links between competitive sport and masculinity were performed in the imagined careers of those boys for whom sport played a major role in everyday life. The occupational aspirations of the children supported the model developed by

Table 11.1 The children's vocational aspirations and current jobs: ages 7–18 years

	7–8 Years	9–10 Years	15–16 Years	17–18 Years
Fleur	Florist	Florist	Psychology or sociology degree	Wants: Psychology degree
Georgina	Teacher, hairdresser, animal rescue (likes her pets) masseuse (parents say has gentle hands)	Doctor or vet (parents say she is good with people)	Teacher – Year 12 maths required	Wants: Own business Current job: Call centre
Jessica	Violin teacher, bus driver (aunt is a bus driver)	No idea	Commerce, film studies	Wants: No idea Current job: School sport coach
Rochelle	Dental nurse, teacher	Teacher	Nurse – Year 13 maths required	Wants: Policewoman – Year 12 maths required Current job: secretarial work, basic numeracy required
Dominic	Army, air force	Pilot	Pilot – advanced Year 13 maths with calculus required	Wants: Commerce degree
Jared	Judge – make people go to jail (father in prison); not a baker, too messy (mother a cook)	Cartoonist	Food technology or degree in Sports and Fitness	Wants: policeman – Year 12 maths required, builder Current job: shelving supermarket goods, builder's labourer
Liam	Policeman, helicopter pilot, builder, mechanic	Professional cricket player	Professional sportsman/personal trainer	Wants: Professional sportsman/ personal trainer/coach
Mitchell	Army	Fireman (like father)	Supermarket checkout	Current job: Kitchen hand Wants: Cook
Peter	No idea	No idea	Not sure	Wants: History or geography degree
Toby	Air force, professional sportsman	Professional soccer player	Economics or Commerce	Wants: Commerce degree

Gottfredson (2005) in which occupational choice was constructed as a compromise between the imagined *ideal* and the socially *possible* and that such choice is gendered and classed.

> Regardless of their own social origin … newborns will develop essentially the same view of occupations by adolescence. Like adults, they will distinguish occupations primarily along two dimensions – their masculinity-femininity and their overall social desirability (prestige level). They will also share common stereotypes about the personalities of different kinds of workers – accountants vs. artists, engineers vs. teachers, and so on. Despite their similar perceptions, their occupational aspirations will nonetheless reproduce most of the class and gender differences of the parent generation: girls will aspire mostly to 'women's' work, boys to 'men's' work, and lower class youngsters to lower level jobs than their higher social class peers. (p. 72).

Family Patterns in Occupational Subjectivity

Many studies including TIMSS and PISA have demonstrated the significant links between parental qualifications and occupation, and children's educational achievement and aspirations. Table 11.2 shows the qualifications, levels of school mathematics and careers of the children's parents and when compared with Table 11.1, links can be seen between the aspirations of girls and their mothers, and boys and their fathers.

In this study, mothers were less likely to have gained higher qualifications than their husbands, were engaged in different occupational fields to those of their husbands and for the most part earned less than their husbands.

The study revealed that familial patterns of interaction including the ways in which parents and siblings supported the children's mathematical learning, and parental explanations for the children's mathematical achievement, played a significant role in the children's learning of mathematics. Fathers in this group were considered by their families to be more mathematically capable than mothers, and mothers were more likely to report negative experiences of school mathematics and enlisting the help of their husbands to assist the children with mathematics, as shown in the following example:

> Fleur's mother: Maths was a real struggle for me all my life … Maths was always the subject that I hated because I couldn't get to grips with it … I have to say I'm dreading when I can't help Fleur. (*Turning to Fleur's father*) You're going to have to help her with maths. (Early Year 3)

The day when she could not help Fleur with her mathematics came the following year.

> Fleur's mother: When they did the power of ten. On the first day of that she came home with her homework and couldn't do it, and when I looked at it, I couldn't work out how they'd taught her. I got her father to look at it when he came home. He went through it with her patiently for three-quarters of an hour. (Late Year 4)

Table 11.2 Parental qualifications and occupations

	Mother's highest qualification	Father's highest qualification	Mother's occupation	Father's occupation
Fleur	No academic qualification – Year 10 mathematics	University entrance – Year 11 mathematics	Home maker/typist/ retail assistant	Credit manager large business
Georgina	No academic qualification – Year 10 mathematics	School certificate Year 11 mathematics	Small business employee	Manager, small business
Jessica	School Certificate – Year 11 mathematics	School certificate – Year 11 mathematics	Home maker/personal trainer	Self–employed small business
Rochelle	No academic qualification – Year 10 mathematics	No academic qualification	Personal assistant small business	Professional sportsman/tradesman
Dominic	Bed – Year 11 mathematics	MBA – Year 12 mathematics	Human resources large business	Systems manager large business
Jared	School certificate, Year 11 mathematics	Unknown (no contact with son)	Manager small business	Sales rep (stepfather)
Liam	No academic qualification – no mathematics	Higher school certificate	Retail assistant	Ordering clerk medium-sized business
Mitchell	No academic qualification – Year 11 mathematics	No academic qualification	Call centre, rest home administration manager	Fireman
Peter	BHSc Year 12 mathematics	PhD Science Year 13 mathematics	CEO small NGO	Policy adviser government department
Toby	University entrance Year 10 mathematics	B.Com. – Year 13 mathematics	Self-employed small business	Adviser government department

Although Fleur stayed at school longer than her mother and planned to go to university, like her mother, she dropped mathematics as soon as the subject became optional.

Jessica's mother did not see herself as good at mathematics, but not entirely incapable saying, "I wasn't, um, useless at it, I passed Year 11 School certificate." She had opted for shorthand typing instead of mathematics and left school in Year 12. When talking of Jessica as a 7-year-old, she saw her daughter as a particular "type" of girl:

> Jessica's mother: She wants to sing in the choir and she's going to be that sort of girl, you know, she may be more creative … I just get this feeling there's a lot of the creative side coming out of her. (Early Year 3)

While Jessica stayed at school longer than her mother and had continued to study Year 12 mathematics she failed her external examinations and like her mother, she chose subjects that did not demand mathematics and science – what the children referred to as "bum subjects" – such as drama, media studies and physical education.

Georgina's mother reported that she did not do well at school mathematics and it was her father who provided Georgina with assistance.

> Georgina's mother: I left [school] early in [Year 10] so I don't have any qualifications … I'm not very good at mathematics, her father shows her how to do it. (Early Year 3)

> Georgina: He [Dad] tells me what to do and then I write it down, and then I tell him what the answer is and he says if it's correct or not. (Early Year 4)

> Georgina: In my maths book the first week there was these really hard working forms and my dad's, like, taught me how to do the first one and then I got to do it and I got all of them right without anyone helping me. (Early Year 5)

> Georgina's father: I'm frustrated because Georgina doesn't seem to be getting it [basic facts]. I could do it easily – I've got a scientific mind. (Mid Year 5)

In these interactions between father, mother and daughter, masculinity was aligned with mathematical capability and in turn, scientific-mindedness. Observations of Georgina during mathematics lessons from a young age revealed that Georgina exhibited strong spatial awareness, was a logical thinker and, particularly where contexts were meaningful, made sense of mathematical situations. There appeared to be no significant cognitive barriers to her learning of mathematics, yet she was always placed in the bottom group, opted for numeracy (practical) mathematics in Year 11 rather than general mathematics like most of her peers and failed the numeracy test when she applied to gain entry into university after leaving school at the end of Year 12.

Four of the six boys in the study continued to study mathematics to Year 13 level, although none of them chose the more difficult options that included calculus. As discussed in Chap. 9, Peter had not felt confident or comfortable with mathematics early in his secondary schooling but when his parents engaged the help of a private tutor – a male university student – this made a significant difference to Peter's achievement. Peter's father was also very comfortable with mathematics. Although he considered that Peter's school mathematics might be challenging for him after so many years, he felt confident that he would be able to help Peter with it if necessary.

> Peter's father: He's doing Stats this year, that's one thing I did a lot at university and with my PhD and I've had a look at some of the Stats that he has been doing this year. I know if he came and asked me it wouldn't take me very long to get up to speed.

In statements like these, we can see mathematical challenge, confidence and masculinity in close association. Sibling comparisons also played a part in producing gendered mathematical subjectivities, as feminine and masculine occupational attributes were "recognised" by parents.

> Liam's mother: He's a little smarty. We'll say to Chantelle [Liam's sister, older by two years] 'What's such and such?' [a mathematical question] and he'll go like, (*clicks her fingers*) not a problem really. (Early Year 3)

> Liam's father: He'd probably be quicker, if anything he might be quicker than Chantelle. Yeah, but they're different people. He's not going to be a reader or story teller like Chantelle is. (Early Year 3)

> Toby's father: He's noticeably more serious about schoolwork than the girls, but I don't suppose that's uncommon is it? Girls, it's all about friends (*laughs*) social activities, that's the reason they go to school. (Mid Year 13)

Gendered Mathematical Subjects

As shown in previous chapters, differences were observed between the boys and girls in the ways in which the children responded to the pedagogical practices of their mathematics classrooms as shown in their reported feelings about doing mathematics.

In reflecting on how she had felt about learning mathematics during Year 12, Jessica described a female teacher who had mitigated her lack of enjoyment in the subject.

> Jessica: Um it's been OK (*unenthusiastically*). It actually went kind of well 'cause I had a really good teacher. She had like this incredible love of maths. Like she was hugely, she told us at the start of the year, 'I'm an absolute maths freak.' Like, she said, 'I'm a nerd absolutely 100%.' We thought she's really cute and stuff and she's really nice. The way talks to you and talks about maths it gets you kind of excited about it as well … it changed my attitude a little bit towards maths, like I was sort of a bit more keen to go to class and everything, um, yeah, and it kind of, it didn't make it easier but it made you want to do it more because you kinda wanted to do it for her, 'cause she put in so much effort you wanted to reciprocate and give something back, sort of. (Late Year 12)

This statement reflected widely-recognised stereotypical views: those who enjoy mathematics are nerds, and females even more so. The teacher's "cuteness" and "niceness" offset her "freakish" love of mathematics to some extent and in turn some of Jessica's aversions to the subject.

Early in primary school, Georgina was not quite sure about why mathematics was learned, but by Year 5 she had begun to make some links between mathematics and future occupation.

> Researcher: Why do you learn maths at school?

> Georgina: Um, that's a hard one. Because we need to learn maths.
>
> Researcher: Any ideas why?
>
> Georgina: No. (Late Year 4)
>
> Georgina: Well I really want to be a designer but that's got to do with lots of maths. But I'm really good at like, designing things, like how long it needs to be and stuff … I reckon I'll be a designer 'cause Mum and Dad think I'm a really good designer and drawer. (Late Year 5)

Georgina's recognition of the links between design and mathematics was conflicted because she saw herself as good at design but not at mathematics. By the end of Year 5, Georgina told me that she could not see herself enjoying maths at high school. She dropped mathematics once it became non-compulsory. On leaving school she took up business administration and secretarial studies, having failed the numeracy test to gain entry to university. She worked in a call centre and then enrolled in a beauty therapy course. When asked to reflect on who it was that succeeded at mathematics from her experiences of learning the subject Georgina responded:

> Georgina: I remember at [primary] school there were three of us girls that were really bad at maths, and we always got taken aside and shown how to do it step by step, and all the boys, there were about seven boys had no trouble whatsoever. I'm not too sure if I read it in the paper that boys are better than girls at maths … I think girls are just as good as guys. (17 years)

Later in the conversation she noted that in her polytechnic course, which required no mathematical qualifications or mathematics entry test, there were only two males.

> Georgina: You don't see many females working as mechanics and technicians and engineers and things like that, there are very few females that take that on so I'm thinking that possibly males have more mechanically minded brains and they have more, it's easier for them to figure out equations and things, but then there are some things that females are better at doing, it all equals out in the long run, everything has an opposite, so you give and take things. (17 years)

In this statement, male/female binaries were offered as an explanation for gendered mathematical difference and occupational choice. Throughout her schooling, Georgina had experienced being positioned in the tail of underachieving girls in mathematics and as a school leaver, genderfication by career choice. While she rejected the view that boys are better at mathematics, she wondered at the same time whether there might be natural differences when it comes to certain kinds of thinking. This suggested that Georgina was juggling competing discourses about male/female achievement for their differing subjectifying properties. Where construed as balanced (equal) opposites, such differences could be accepted for their inevitability.

Fleur opted out of mathematics after Year 11 but found that she had to attend mathematics classes in her final year of schooling in Sweden where mathematics was compulsory for the first 6 months of her stay, the equivalent of the second half of Year 12 in the New Zealand system. She noticed a division between the boys and girls in the way they approached their learning of mathematics, boys behaving as though mathematics was a subject they could learn without attending class.

> Fleur: The boys never came to the maths class 'cause they didn't like it, but I think they could do the work without the teacher. Quite often we were only in the class for twenty

> minutes where the teacher would give everyone the work and then any help they needed and then left it up so them to do the work. (Late Year 13)

By the time Rochelle had reached upper secondary school, mathematics had become something she did not enjoy. When she moved from an all-girls school to a co-educational school in Year 12, the presence of boys in the class made a difference to her level of comfort. She observed that a female mathematics teacher produced a change in boys' behaviour in class:

> Rochelle: The boys, when there was a [mathematics] teacher, a female teacher, they would muck around a bit, whereas if there was a male teacher they wouldn't, and I don't know why that was … (Late Year 12)

She also noted that outside the classroom, boys and girls differentiated between the kinds of time they spent with each other at school:

> Rochelle: Girls wouldn't hang out with boys unless, I mean, some would, but a majority of them wouldn't, yeah … I don't think boys want to, you know, play kicks or play basketball with girls, but you would see the odd girl playing basketball … but not very often, unless they were like, family, or like cousins or something like that.

> Researcher: I wonder why that is, why that happens?

> Rochelle: Maybe having their space from girls, like you know, you just need, if you're a girl, you need your girls'… you want your girl time, you know, and I think the same goes for boys, they wanna hang out with their boys, 'cause even my boyfriend you know wants to hang out with his boys like heaps of time without me, but not because he wants to get up to something, just because he misses his boy time.

The use of the terms "girl time" and "boy time" suggested that Rochelle and her friends viewed sex-segregated activities as part of everyday life. Her account of how girls and boys operated as distinctly male/female subjects at school demonstrated how boys' and girls' experiences of life are gendered, supporting theories that gender is produced in our everyday enactments of "self" as subject. This was also reflected in the following comments where girls and boys were seen to be leading different yet "equal" lives and any differences in achievement or participation in mathematics could be explained as social rather than genetic.

> Peter: Boys like doing more physical things and stuff, and girls are sort of the opposite, maybe not always. They probably talk a lot more than guys … I think girls are maybe a bit better at maths I think. I don't know. I don't think there's really a big difference. I think everyone's the same if you just put the work in, you'll be good at it. (Mid Year 13)

> Toby: It seems like at girls' schools there is a lot of different subjects offered, like home economics isn't offered at our school, and photography, so I guess maths would come second if you wanted to take photography.

Choice about continuing study of mathematics was tied to the children's perceptions of the value of mathematics in their lives beyond school. Their explanations were revealing.

> Fleur: I'm not doing it next year [Year 12 mathematics]. I'd rather do classics and history and geography … I wanna do psychology or sociology [at university], and Miss Highly said that you need maths in bio [tertiary study in biology] but the others you don't have to.

> Jessica: I was really considering dropping [maths] before last year … I am pleased, [I continued taking it] because it meant that by the time I got to the end of it I really knew I didn't want to do it any more, I was like I'd really had enough now, you know at the end of Year 11, I was like, 'I'm so over maths, I don't want to do it any more' at the end of Year 12. I was like, 'Hey I'm really done in maths.' I'm pleased I made that decision then rather than before. Now I'm like I'm totally sweet with the fact that it's gone … I found it quite easy to make the decision to drop it.
>
> Researcher: No one tried to persuade you to carry on?
>
> Jessica: No, my mum was kinda like, 'Oh, so no maths?' and I'm like 'No! I'm not doing it'. 'Ok then.' I think she would have loved it if I'd continued, but nevertheless she is not really that fussed, I don't think that it's really … I think it's more that she felt she had to encourage, because she doesn't really care a lot about maths that much, she's not doing anything with maths and I think it is more that she felt like it was one of those things that was expected … that everyone does maths, so she encouraged it for that reason, but I don't know that she really felt that strongly about me doing it or not. (Mid Year 13)

Jessica's decision to discontinue her study of mathematics can be seen as an intergenerational one when linked to comments made by her mother 10 years earlier. Choice was played out from mother to daughter, and feminine/masculine occupational subjectivity strongly preserved.

> Jessica's mother: [Mathematics is] really important, and more so for girls. Not because I'm being sexist, I just feel that, I know that the girls get to a certain level in college like we did, like I did, and it's almost expected that you should drop out, you know … and maybe it wasn't obvious, but it was like, you know, you don't *have* to do well at this, there are other things [for girls]. (Early Year 3)

Jessica did not regard mathematics as something that was likely to have benefits in the future, just as it had not for her mother. Like her mother, Jessica perceived the choice of studying mathematics as something dictated more by expectation than necessity, as something girls *can* do, but do not have to. Because mathematics was not seen to be central to the occupational subjectivity of girls, failure in the subject could be easily dismissed, as Georgina explained:

> Georgina: I was always really struggling with maths … [dropping mathematics] hasn't disadvantaged me in any way at all and I don't think [lack of mathematics] will ever stop me from doing anything.

The boys who had continued to study mathematics had done so more for its occupational value in keeping their options open, than in providing them with worthwhile occupational skills.

> Toby: It'll be a good thing to have [Year 13 mathematics credits] obviously some stuff we do isn't relevant but it'd be a good thing to have for later in life and all that, yeah, it might keep some doors open. (Mid Year 13)
>
> Peter: I wanted to keep my options open so I took Stats. (Mid Year 13)

Liam's choice was also tinged with occupational recognition of his father:

> Liam: (*Speaking of his choice to take Year 13 maths*). Good if I get it [Year 13 maths credits] but if I don't I'll be gutted. I should be able to like, scrape through, I should get enough credits to get where I want to go. My Dad was sort of good at maths, but it's changed for

> him … like [his generation] never used to have a calculator and I'll like say a formula and they say, 'We never done this when we were at school.' (Mid Year 13)

For Liam, continuing to study mathematics was difficult as many of his male friends had already dropped mathematics to take subjects that would lead to some kind of trade. For Toby and Peter the choice was much clearer since they were following in their father's occupational footsteps towards university study. Toby's following comment captured the decision to continue studying mathematics as a form of masculine circumscription inscribed in mateship that could be seen as flowing on into the study of other subjects and an accepted part of their occupational futures.

> Toby: Amongst my mates [maths has] been like the sort of thing that they maintain even if they might not like it a lot, but, yeah, it's considered one of the important subjects so they start it, like, when they start school, and even if they don't like it, they seem to just continue it, just 'cause it has that flow-on effect into other subjects, and you need it later in life. (Mid Year 13)

Genderfication and Mathematical Discourse

Mendick's contention that boys and girls are subjects made in mathematical discourse is supported by the children's stories. Irigaray (2002) suggested that all discourses are sexuated and that women are produced in dominant discourses such as the field of mathematics through an invisibility she described as *monosexuality* or *sexual indifference*. Bourdieu (2001) wrote of this as a pervasive masculine domination, which he termed the *androcentric unconscious* ways of thinking so much a part of everyday thought, word and action as to be barely perceptible. The rejection of mathematics by the girls in this study may be best explained then, as their perception – conscious or not – of mathematics as a masculine and masculinising domain in which they could not easily locate themselves as subjects.

Further support for this argument can be found in the children's responses when asked in the final year of the study where they thought mathematics comes from.

> Georgina: From the Romans isn't it? Wasn't there a guy called Archimedius [sic] or something? And like da Vinci, he had to figure out numbers and equations to figure out how to make something fly.

> Fleur: Ah, this might sound dumb, I'm not actually sure, but I think it's always been around, because maths is around us all the time even if we don't realise it … So I think it's been around forever.

> Jessica: I have no idea … I really don't think I've ever been told.

> Dominic: To look historically I'd say the Renaissance and you know, sort of the development of science and that kind of thing, moving away from religion into science like, logic … Just look at famous mathematicians like Fibonacci from the Renaissance. The sequence is not the man. I'd say that would be the only famous mathematician that I know; it's just a name that cropped up.

> Jared: People have been doing it for years, like, since the beginning of time.

> Liam: I don't know. Maybe Roman numerals or something, that's the only thing I can think of.

> Peter: We don't really do the history of it we just do it, they just give us, tell us what to do and we don't really ask questions.

These statements reveal an unquestioning acceptance of the male origins of mathematics and its place in our society as something about which children are not told and do not ask. The failure of mathematical discourses to substantiate female/feminine/woman/girl mathematical narratives and contributions to the discipline of mathematics as distinctly female – and not to be seen as singular or essential as Fuss (1990) cautioned – has rendered mathematics a masculine subject in which boys as mathematical subjects are more "naturally" made.

As the children's responses reflected, the mathematics adopted in contemporary curricula worldwide has a patriarchal genealogy. Wertheim's examination of the cultural/historical construction of Western mathematics (Wertheim 1996) showed that the intersecting discourses of mathematics, physics and an omniscient God can be viewed as a "gender war," which has consciously and explicitly constructed the feminine out of mathematics. Dominic noted how physics, which was chosen only by those who were also taking advanced mathematics, was produced as male territory at his school:

> Dominic: Last year in physics it was the Boys' Club really. There were two girls in this class of 20, yeah, and the teacher was a guy, which didn't help. He was a bit of a, I won't say chauvinist, but he did sort of support the Boys' Club atmosphere. (Mid Year 12)

This prevailing alignment of masculinity and the mathematical sciences is also discussed by Walkerdine (1998) whose research demonstrated how the feminine is subtracted from mathematics, as science, reason and the male mind are co-produced through socio-psychological discourses of education. This subtraction of the feminine is embedded in a wider discourse surrounding equity and rights, as Lynch (1999) observed:

> Our society is profoundly androcentric in the sense that male norms and values are persistently privileged over female norms and values; things named as 'feminine' are treated as inferior, unworthy and subordinate. These injustices of recognition have deeply inegalitarian implications for women (p. 138).

The children's experiences provide us with glimpses into the mechanisms by which androcentrism works, manifesting in their orientations to life, vocational aspirations and their learning of mathematics. By their final year at school all of the boys continued to study mathematics but none of the girls. The girls had chosen careers that they believed did not require high levels of mathematical attainment. The girls who became alienated from mathematics from a younger age were more likely to attribute their lack of success to the "hardness" of mathematics, their failure to understand the teachers, to their own (natural) lack of ability, than were the boys, who were more likely to blame their personal lack of effort, the teachers' failure to teach, or teachers simply failing to "see" their abilities. Parental beliefs about children mirrored these causal attribution patterns. Both groups commented on the irrelevance and boring nature of mathematics lessons but the girls exhibited a much earlier rejection of mathematics as unnecessary for their lives within and beyond school.

Mathematical Subjects as Gendered Subjects

Children live gendered lives, as this study shows. From their proclivities and aversions, social pursuits, recreational activities and choice of school subjects, to their friendship groups and roles within the family, children act out and become "boys" or "girls" based upon discursive practices that delineate and circumscribe the doable and sayable. The children's experiences of learning mathematics, which were not based solely in schooling but also in family, peer-group and wider social settings, were demonstrably both a gendered and genderfying process of mathematical self-production. Liam's reflections on boys, girls and doing mathematics in his secondary years point to the ways in which gendered practices worked to produce girls and boys as differentiated mathematical subjects. Competition featured strongly in his account.

> Liam: Naturally girls are going to be interested in other things than boys. They always want to do shopping or their homework … All the boys are into sport hard out, sports, partying, we're all into partying especially now everyone is older; people are starting to turn 18 and go to the pub … Everyone thinks everyone's [boys and girls] hard out competing and stuff like that. I don't find it like that in our school [co-educational]. Now we are pretty tight, I get along with like most people at our school, there's not much competition, people trying to outdo one another. Sometimes I think there was competition at Summit [his previous all-boys school], all the boys were trying to like jockey for top dog kind of thing … (*Later, when contemplating what would improve mathematics for him*) At Year 9 there used to be like a little game and competition to try and motivate, and I guess [teachers] kind of take that out when you choose maths, but I guess for me it would probably motivate me more to excel if I had a bit of competition or something like that. (Mid Year 13)

Mathematics, competition, sport and masculinity are linked in Liam's account, indicating potent discourses at work positioning boys and girls as subjects. Kaiser and Rogers (1995) argued that interventions in improving the status of girls and women in mathematics have failed because it is a change in mathematics itself that is required. They envisaged a mathematics that includes everyone – a mathematics reconstructed.

For Walkerdine (1998) the issue was more properly framed as one of social power. In mathematical discourses, she argued that the rational, reasoning mind is associated with masculinity in a dichotomy that positions women as naturally irrational. Women's success in mathematics is limited (by genetic capacity) to performing accurate calculations and attributed to conscientious and painstaking rule-following rather than understanding of the underlying mathematical concepts; masculinity/femininity is aligned with procedural/propositional mathematical thinking. Walkerdine saw girls' growing up as a struggle against discriminatory practices in which they are bound to feel always on the back foot simply because they are not male. She argued that, "higher status is accorded to calculations which require the production of the rational and logico-mathematical discourse in which statements have power because they can refer to anything … Here Mathematics becomes invested in reason's dream of a calculable universe: the control over time and space" (p. 165). In this dream of reason, a women's mathematics grounded in the labour of nurturing and catering can be dismissed for its lack of the arcane. Doing gender, then, can be seen as doing occupation at the same time.

This study showed the ways in which the girls as mathematical subjects inexorably counted themselves out of mathematics for its increasing alignment with masculinity enacted in social patterns including the pedagogies of the mathematics classroom. Thus, boys "muck around more" for female mathematics teachers; girls opt out of mathematics because they say they find it "hard" and "boring" and they "don't really need it," and boys continue to study a subject they too say seems "boring" and "irrelevant" but for them "keeps doors open." In their stories, the children and parents appealed to discourses of equity within practices of inequity. The actions of teachers, parents and peers to support decisions to drop or continue studying mathematics in upper secondary school endorsed differentiated and differentiating views. Mathematical genderfication was thus exercised through the deeply-embedded discursive alignment of mathematics and masculinity producing boys and girls as masculine/feminine mathematical subjects whose occupational subjectivities were shaped according to the subject positions such discourse allowed.

Chapter 12
Background or Foreground? Home, Social Class and Ethnicity

I don't think [the mathematics teacher] paid much attention to me. He paid more attention to the smarter kids, probably because they've got a future.

Jared, Mid Year 13

In Jared's statement, he did not count himself as one of the smarter students of mathematics and suggested that the attention he needed from the teacher was not forthcoming because he was not considered to have "a future" – in other words, he was not worth the teacher's attention. This statement illustrates the links that the children began to make between learning mathematics, career prospects and teacher/student interaction. The teacher's apparent indifference to Jared's failure in mathematics could be seen as an act of mutual positioning – Jared positioning himself as not as smart at mathematics as other children and attributing this to a forgone conclusion that he had no future, and the teacher seemingly feeding and reinforcing this positioning. This self-limiting subjectivity has been recognised by researchers such as Good et al. (2003) as *stereotype threat*, claiming that it is this that "disrupts academic performance because the stereotypes provide a pejorative explanation for struggle and difficulty. That is, they raise the possibility – at least in the mind of stereotyped individuals – that the academic difficulties they experience may be due to an internal fault or shortcoming, namely, that they lack the ability to succeed on the task" (p. 649). This view constructs limitation as a socially generated block located within the student.

When talking about mathematics in their lives outside of school, the children showed that there were many other mathematical facets of their experience that were not taken into account in the narrowly-prescribed examination-dominated approach to learning mathematics at secondary school.

> Toby: There was a lot of maths in building this deck. I helped build this deck. I'm so proud of it. (Mid Year 13)

> Jessica: In water polo we do timekeeping and stuff. Someone might get kicked out for 20 seconds and you have to, like, subtract 20 seconds off the clock and I'm always the one that does it. [The others] will be like, 'What is it?' and they'll be like, 'Er?' and I'll tell them. I always do, say the time might be 4:04 and they go, 'Oh my God, what is that time? I have no idea.' And so I always like subtract from 60, so it's 4:44, and they'll be like, 'OK, sweet.'

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> 'Cause I find it really hard to work out sometimes. You'll start doing it from 100 rather than 60, 'cause you forget. I've always done it that way, the whole 60 thing. (Mid Year 13)

> Georgina: I will only use maths when I go into a shop to buy things or like ratios of petrol like the revs in my car equates to such and such amount of petrol being taken every time I drive and the kilometres that I drive … (Mid Year 13)

The subjectivities that children carry with them to the classroom, that is, their experiences of childhood beyond the school gates including their relationships with family and friends, their out-of-school activities and their views of themselves as social beings, are often treated by educators and researchers as "background" to the core business of schooling. In this positioning, children must be prepared for life at school, rather than the school prepared to embrace the lives of children. This privileging – or foregrounding – of the schooling experience creates children, family and society in a power/knowledge relationship in which the discourse of schooling, and the subjectivities it creates, proclaims itself as the foremost authority on the child as her/his abilities, learning styles, grasp of concepts, progress, stages of development and overall "character" are captured in the diagnostic apparatuses of schooling. Indeed, parents can often be heard to describe their children in terms of reading ages, awards or grades they have gained at school as though these measures of achievement were the most "truthful" and reliable indicators of their child's make-up. As parents engage with the machinery of educational expertise, they are in turn subjectified; "good" parents are produced in the discourse of schooling as those who most actively submit to, aid and abet the schooling project.

This study showed that out-of-school existences were so vital and present for every child in the mathematics classroom that they would have been more properly considered as foreground. For the children, learning mathematics was set in personal history and fed into rather than out of the realities and immediacies of life outside school. Mathematical subjectivity was part of a wider subjectivity, created within, but also beyond, the visibilising practices of school. This is consistent with the findings of the UNICEF (2002) research report that examined educational disadvantage within rich nations:

> … it is clear that educational disadvantage is born not at school but in the home … Significant levels of educational disadvantage exist in all developed nations, and the gap between children of the same age can be the equivalent of many years schooling. Looking back, such disadvantage at school can be seen to be strongly linked to disadvantage at home. Looking forward, it may be predicted that the disadvantage is likely to perpetuate itself through educational under-achievement and a greater likelihood of economic marginalisation and social exclusion. (p. 3)

The UNICEF study found that New Zealand was one of the countries in which the greatest disadvantage gaps in mathematics had been shown in international studies.

Social class is one of the "background" factors that is often noted for its powerful bearing on children's learning outcomes in mathematics. Reponses to educational disparities by class usually focus around the expectation/achievement dualism. It is believed that in creating higher expectations for lower class children, achievement will automatically rise. While this may motivate some children to perform well at school, this approach fails to take account of the complex nature of *class*ification and its links to occupational subjectivity. Issues of gender have gained some foothold in everyday conversation and the discourses of popular culture and politics, but the concept of class is conspicuously absent from such discourse in New Zealand and Australia whose colonial pasts were founded in part at least, on an ideal of the "classless" society where every person, irrespective of their social origins, should be given a "fair go." Echoes of this past can be found in the curricula of these countries, which strenuously emphasise the principle of equal opportunities in learning. Discussion of class in this research is therefore not a straightforward matter, but so compelling and ongoing are the demonstrated connections between mathematical performance and the socio-economic status – as class is often construed – and by implication the educational qualifications of children's parents, that it would be a dereliction of scholarship if I were to attempt to present the mathematics lives of the children in this study without attending to issues of social positioning we call "class." In general, "class" is used to refer to levels of income and its associated advantage/disadvantage that locates individuals and groups within society. Class is played out most obviously in the places we live, the material goods we possess, the qualifications we have, the schools our children attend and the activities and occupations in which we engage. But class is a word that is also built into our education systems as a learning space and as the group of children that occupies that space. Traditionally, children were sorted by achievement in education, that is, *classed*, and separated spatially for appropriate instruction. "Class" then is a concept that is very much alive in everyday social grammar.

Children's differential achievement in mathematics by class and ethnicity has long been recognised, and attempts to address these disparities have sparked numerous studies attempting to isolate those variables in children's backgrounds, which might account for this success/failure and to document the processes of differentiation at play in the mathematics classroom. Various measures of (dis) advantage are used in these studies including parents' qualifications, income, the number of books in the home and the kinds of resources available to children, including computers. International studies such as TIMSS for example have gathered data over time to document the links between children's mathematics achievement and factors such as ethnicity, language spoken in the home, family income and material standard of living. The 2008 report for the New Zealand TIMSS results noted the strong correlation between family standard of living and achievement in mathematics.

> Students from higher socio-economic backgrounds tend to have higher mean mathematics achievement than those from lower backgrounds as evidenced by the proxy measures *books* in the home, *items in the home*, *household size* and *mobility*. In addition, the decile of the school they attend, indicative of the level of economic disadvantage in the community in which they live, was positively related to mathematics achievement. That is students in higher decile schools had higher mathematics achievement, on average, than those in lower deciles. (Caygill and Kirkham 2008, p. 45, italics in the original)

Wylie and Hogden's (2007) report analysed a longitudinal study of a sample of New Zealand children from early childhood to 16 years of age, which charted the development of children's "cognitive competencies" (literacy and numeracy skills) in the context of home, leisure and educational experiences that might account for differences in patterns of children's performance. Their report concluded that social factors played such a significant part in competency scores that sustained long-term intervention was recommended to offset educational disadvantages.

> Social characteristics continue to account for some of the variance in competency scores … Higher maternal qualification tends to be associated with higher competency scores for both the cognitive and attitudinal competencies. A similar trend was evident for family income for numeracy and literacy scores only, though there was little difference between the average scores for those who came from homes where the family income had been between $60–$80,000 when they were preschoolers and those where the family income had been more than $80,000. Young women had higher literacy and attitudinal competency scores than young men, and Pākehā//European or Asian 16-year-olds had higher numeracy and literacy scores and scores on the *thinking & learning* and *focused & responsible* competencies than Māori or Pacific 16-year-olds. (p. 12)

> As with previous reports from the Competent Children, Competent Learners project … we need to provide greater support for children from homes without the advantages of good levels of maternal qualification and reasonable levels of family income, and to continue to provide it, rather than limit it to one-off interventions. (p. 23)

Similarly, the PISA study (Caygill et al. 2008) showed strong connections between ethnicity, income and mathematical achievement.

> Pākehā/European and Asian students had higher mean mathematical literacy performance than their Pasifika and Māori counterparts … Both high and low performers were found in all ethnic groupings. A larger proportion of Asian students, and to a lesser extent Pākehā/European students, achieved high proficiency levels in mathematical literacy, while a larger proportion of Pasifika students, and to a lesser extent Māori students, performed at a low level of proficiency in mathematical literacy … Overall, the mathematical literacy performance of New Zealand 15-year-old students increased as their socio-economic status increased. A larger proportion of Māori and Pasifika students were in the lowest socio-economic status grouping compared to their proportions in the population. (pp. 6–7)

As this research demonstrates, ethnicity and socio-economic status were not guaranteed predictors of mathematical achievement, but these social characteristics clearly implicated students from particular "backgrounds" in processes that had a powerful bearing on their success in schooling. These findings reinforce those of other studies that link home factors with academic performance. Studies that look more specifically at background and achievement in mathematics include Walkerdine (1998) who noted "a huge class divide" in the English schooling system. While she found that class and ethnicity were not distinguishing factors between children's performance in mathematics early in their schooling, black and working-class children faced enormous problems in national competition. She found that girls from working-class backgrounds struggled to go on to higher education and their possibilities for attainment were, "nowhere near that of middle class girls" (p. 169). Cooper and Dunne (2000) looked at social class as a factor in children's performances when solving mathematical problems where real contexts were used. Their study showed that life-like contexts in which mathematics was supposedly meaningfully embedded were differentially interpreted by children from working-class and middle-class backgrounds. Explanations for disparities of achievement in mathematics by class have been generated in other studies, which include disjunction between home and school linguistic and grammatical codes (Hoadley 2007; Zevenbergen 2001, 2004).

Studies such as these show that children's social class can be determined in a number of ways including family ownership of material goods, the employment and levels of income of their parents, parents' qualifications and in New Zealand and their school decile ratings. Cooper and Dunne (2000) used a classification system of occupation based on that of Goldthorpe and Heath (1992), which positioned occupations on an eleven-point scale composed of service class (higher and lower grade professionals), intermediate class (non-manual employees, personal service workers, small proprietors with and without employees, farmers, foremen and technicians) and working class (skilled, semi-skilled and unskilled manual labourers). Using this scale, none of the children's families in this study of mathematical subjects would have been classified as working class although Mitchell's mother alluded to the difficulties she experienced as a solo mother supporting four children. As an unskilled builder's labourer and then a student of the plumbing trade, Jared had taken up a working class position like a number of his mates, but his mother, a caterer, cook and manager of a restaurant, noted that she had chosen her vocation from a number of possibilities rather than having been coerced into it through insufficient qualifications. Peter's and Toby's parents worked in occupations that could be described as service class and those of the other children's parents as intermediate class.

Another way of determining the children's class was by their school decile ratings. Research shows a strong correlation between school decile rating and children's achievement in standardised tests (e.g. Timperley and Alton-Lee 2008). Harvey (2007) reported in his analysis of achievement of students in two externally assessed NCEA mathematics achievement standards (*use straightforward algebraic methods and solve equations* and *solve straightforward number problems in context*) that, "there was a very strong relationship between the decile rating of the school and the performance of the candidates" (p. 19). Few students from low-decile secondary schools in New Zealand enrol in university courses and five times as many students with higher professional family backgrounds obtain school qualifications that permitted them entry to university (p. 88). Pursuing one's aspirations within the bounds of what is socially prescribed can be seen as one of authoring oneself; socio-economic status is deeply implicated in subjectivity, as class-based discourses work to produce and constrain who we may become. A strong correlation between socioeconomic status and achievement can also be seen in Victoria, Australia as shown in the study by Teese et al. (2004), which found that, "A third of all low achievers came from low to very low socioeconomic status backgrounds. Post-Year 12 students from high socioeconomic status backgrounds were more likely to continue to build on their Year 12 achievement through further education and training" (p. 2). Crossing the social boundaries reflected in school decile ratings is clearly difficult.

The family circumstances of the research children can be only roughly classified by their school decile ratings as summarised in Table 12.1.

Table 12.1 Children's schools by decile rating or estimated SES

	School decile ratings (indicated by numbers 1–10) or estimated SES			
	Year 3	Year 4	Year 5	Secondary years 9–13
Fleur	6	6	8	8
Georgina	6	10	10	10
Jessica	8	10	10	10
Rochelle	8	8	8	7, 9, 4
Dominic	7	7	7	Medium to high SES
Jared	5	5	5	9
Liam	5	5	5	5, 4
Mitchell	1	4	4	8
Peter	10	10	10	10
Toby	8	8	High SES	10

This table suggests a certain social mobility amongst these families as the children moved between schools of varying decile ratings but this was not necessarily the case. The children who attended primary schools with the highest decile ratings were Jessica, Dominic, Toby and Peter. Fleur's and Rochelle's schools were ranked only slightly less, with Georgina, Jared and Liam somewhere in the middle of the range. Mitchell's first primary school had the lowest decile rating, but his secondary school serving a large area serving a diversity of income groups was rated much more highly. Georgina moved to high-decile school from a medium-decile school, and Rochelle moved from two high-decile secondary schools to a low-decile school for Year 12. Jessica, Rochelle, Toby and Dominic all attended private schools at some stage of their schooling. Toby and Dominic attended international schools, which are generally only accessible to families who can afford the high fees. School attendance by decile rating provided only a suggestion of the economic circumstances of these families. A better indication of SES can be gained when this data is combined with parents' employment and qualifications, as seen in Table 11.2.

Mathematics, Occupational Subjectivity and Social Class in Process

There were indications from the children and their families of the was that social class worked to constrain or allow, create opportunity or delimit choice. Mitchell's mother for example reflected on why it was that Mitchell had struggled at school and recognised that it may have been the family situation – her solo parenting of four children on limited resources for example – that may have contributed to his failure to thrive.

> Mother: I can't entirely blame the school system [for Mitchell's achievement] because it's probably been also myself just trying to get through life, you know… but that's not, it's not the kid's fault, it's not anybody's fault, it's just part of the circumstances of our family really. (Early Year 12)

But class is as much about discourse, about social networks, patterns of activity, methods of accounting for life and ways of describing and recognising each other as it is about occupation, income and opportunity. At Liam's decile 4 school, the choice to study mathematics was linked to perceptions of braininess. Only the few who were "hard-out striving" to pursue tertiary study were likely to continue mathematics to Year 13. Others, including his mates, had dropped out.

> Liam: I think at our school everyone thinks it's only brainy people [who] try and do it, especially at Year 13. It's like calculus and stats, and calculus is the harder one, and when you look at the people in there and even the people in my class, it's mostly prefects and people that are hard-out like, striving to go university … Quite a few [mates] have dropped out this year. It's like they don't think they're going to get their university entrance so they just drop out. (Mid Year 13)

The children's engagement with mathematics can be seen to form part of recognised patterns of social relationship, of which occupation formed a significant part. This identification with what their mates were doing and saying was perhaps a more significant indicator of "class" as a way of self-associating than more traditionally recognised factors that treat class as something one *is* or a *position* one *occupies*. This is illustrated in the way Rochelle and Jared spoke of their decision to leave school:

> Rochelle: I wasn't into [school]. Plus the friends side of it, you know. (Mid Year 13)
>
> Researcher: You decided not to go back to school?
>
> Jared: No, got bored with it really, and decided it was … wanted to get a job … Yeah, one of my mates just dropped out and joined the army.
>
> Researcher: Is that what you'd like o do?
>
> Jared: Yeah, something like that. Might join the police force. (Mid Year 13)

As it happened, despite his mother's encouragement, Jared failed to gain sufficient NCEA Level 2 credits in his study of mathematics by distance late in Year 13 to enable him entry to police training. He took on casual labouring on a building site instead and later enrolled in a plumbing course. His mother was initially disappointed but explained, "It's his own fault. He failed to hand in the assignments or something. He wouldn't let me see his [final] mark." Jared's "failure" seemed to be linked as much to his rejection of his studies, linked in turn to a difficulty in imagining himself in anything other than a particular range of occupations, as it was to his insurmountable difficulties in understanding school mathematics. This tendency for a certain social grouping of boys to give up on their studies and leave school early as Jared had done was observed by Teese et al. (2004) who noted that:

> The attitudes of boys are, in general, less positive towards school, and this is true at all levels of achievement. Lack of interest in schoolwork is one of the largest single motives for dropping out, and when combined with low achievement is a potent influence … there remains greater community acceptance of early entry to work on the part of boys, and this is reinforced by the fact that boys are more successful than girls in finding work (though not as successful as they would wish). However, both school-related motives (such as lack of interest in schoolwork and poor achievement) and economic motives tend to be more strongly represented among students from lower socioeconomic backgrounds (p. 11)

In counting himself out/being counted out of school mathematics, Jared was recognising himself/being recognised in a classed social position. So complex were the processes by which this positioning occurred that is impossible to distinguish between those actions internal or external to the individual.

Rochelle left mathematics behind when she left school, as had most of her friends. She found herself helping her boyfriend who had had less school mathematics than she. With Rochelle's coaching he managed to pass his navy entrance test in mathematics.

> Rochelle: Most of the people I know aren't even at school any more. But my boyfriend he actually wants to go into the navy and he had this pre-test thing and me and him were trying to figure out all these equations with maths and he asked for my textbooks from school. (Mid Year 13)

In the cases of other children such as Toby and Georgina, we can see that their choices were not unlike those of their friends, as were Jared's.

> Father: [Toby's] got a really good group of friends, you know; that's part of it, they're quite lucky that he's got a good group and they're all pretty serious about school as well as sport and other things, so they don't seem to get up to too much mischief.

> Georgina: The people I know don't really like doing [maths], will do anything to avoid it … All of my friends left college and went on to Polytech. It wasn't that I was bad at school or I had truancy problems or anything like that, I just didn't feel that it was for me, you know? (Mid Year 13)

Mathematical subjectivity could be seen to be bound up with friendship groups and belonging, a process of self-*class*ification, in other words. The feeling that something was "for" them, in other words engaging them in ways of being that enabled them to feel as though they were operating comfortably as members of particular social networks, provided a more compelling and intractable basis for the children's occupational decisions surrounding mathematics than arguments of utility or career opportunity.

Ethnicity

Just as class can be seen as a discursive construct rather than a fact of life, so too can ethnicity. DNA research in recent years suggests that race does not exist genetically, but rather in the cultural groupings associated with distinctive outward appearances such as skin colour and hair type that distinguish human beings one from the other and around which classifications of difference have been constructed. When such differences are combined with differences in language and customary practice, *race* or *ethnicity* is often used as an identifier in systems of demographic classification.

Rochelle did not engage in strong identification with her indigenous genealogy as a young child and it was never mentioned by Rochelle, her teachers or her mother as a reason for her successes or failures at school or her occupational aspirations.

Her Māori heritage became a much more significant part of her subjectivity as she grew older and spent time with her father, his family and his indigenous New Zealand friends. She described how she discovered that her interest in Māori language was able to create rather than reduce opportunities when she applied to enrol at a school with restricted entry.

> Rochelle: I think I kinda [studied Māori language at secondary school] to impress my Dad, I don't know if I was doing it for myself, like my Dad always wanted me to know, [to] learn our language and stuff, and I wanted to, but probably not as much … I should have done something else. [Māori language] is good to have. I'm not Catholic and my chances of getting into Crossover College were very low but I said I wanted to learn the Māori language and she brightened up and said, 'Oh, really?' But it's good, it's [part of] New Zealand you know … (Mid Year 13)

Toby's mother, who was the child of New Zealand immigrants, talked about Toby's father who had died shortly before I first met Toby at the beginning of Year 3.

> Toby's mother: My parents are Dutch and I understand and speak a little [Dutch]. Toby's Dad is Malaysian, Chinese Malaysian.

She described how Toby's father would spend time teaching Toby to solve mathematics problems. There is a danger in making generalisations about parents' fostering of mathematical skills in their children, but the possibility that cultural differences exist in what parents value about education and the skills they encourage their children to develop is something that has captivated the interest of researchers.

Jessica's mother identified herself as the child of Polish immigrants and a speaker of Polish. She talked of the opportunities that were not open to her parents who had had very limited schooling. Emigration is often undertaken by those who wish to provide greater occupational chances for their children, and Jessica's maternal aunt had broken the barriers of social origin by studying for a PhD. Jessica and her brothers attended private schools, and education was highly valued in her family.

These case stories suggested that while "class" or "ethnicity" as categories in quantitative studies of schooling are useful as broad indicators of disparities in achievement in mathematics for particular social groups, there are limitations in treating these categories as fixed as though they were an unchangeable characteristic or quality of the child as a mathematical subject and in leaping to conclusions based on singular determinants of class and ethnicity. At the same time, the children demonstrated that *class*ification can be considered to be a significant if nuanced and contingent component of mathematical subjectivity.

Chapter 13
Contemplating a Child-Friendly Mathematical Education

Everyone seems to learn maths differently, and, you know, the teachers have to identify that… they can't just expect people to be able to do stuff … they have got to make more of an effort to make sure each person understands it, or else it will come to a test or exam or something and then they'll just fail it because they haven't been taught well enough … out of the classroom, people just say, 'I had no clue how to do that.'

Toby, 17 years

I always questioned things and wanted answers to my questions: 'Why does x = a, why when you times two minuses [negative integers] together they become a positive?' Teachers never explained these things, or showed us when we would use this.

Fleur, 16 years

This study has investigated a discursive domain where, at the capillaried extremities (Foucault 1997) of centralised education systems and within the contingent arenas of school and family, children are *produced* as mathematical subjects through the classifying apparatuses and techniques of management called *schooling*. The children's accounts show this process as engaging both power and knowledge – the power of discourse to describe and enact children into being as subjects and to capture them in subject positions, and the knowledge comprising and governing the field of mathematics and its pedagogies that specifies children as "mathematical". This can be seen as a process of bio-power in which the child as mind/body is (self) groomed and extruded, in an act of choice that is also one of recognition of the self, into demographically ordered futures laid out in the choosing.

Most studies of mathematics classrooms set out to show that better teaching creates better learning of mathematics. The discourse surrounding improvement in mathematics education often takes up and reinforces existing binary thinking – *traditional* classrooms must be replaced by *progressive* ones or vice versa, *relational* understanding is better than *procedural* understanding, *abstract* thinking is more advanced than *concrete*. In framing our thinking around oppositional pairing, there is a danger in believing that since only two polarised positions exist, "improvement" requires some kind of transformation from one state to its opposite and that the power to create such a transformation

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is best exercised from without, as an operation upon children through classroom practice.

This study has taken a very different approach. It focuses on children in situ, as mathematical subjects-in-process, on the subjectivities of these children and on practices of subjectification. In this investigation, the production of children as subjects including issues of power/knowledge that Foucault explored in his studies of self as subject in society could be seen in the accounts of the children as selves in narration. It is their words as the subjects of a mathematical education that provide us with visions of a mathematics education friendly to children.

When the children were nearing their 18th birthdays, I asked them what they thought might make a positive difference to children's learning of mathematics. As discussed in Chap. 8, the quality of teacher–student interactions was most often mentioned. In his statement which opened this chapter, Toby spoke passionately about a relationship that is developed through mathematics education – that is, the positioning of teachers, children, and the subject of mathematics in a power/knowledge bond. He spoke of the elusiveness of understanding mathematics, the ever-looming spectre of failure, the disempowerment of having "no clue" how to do things. He spoke of tests and examinations as the chief determinant of success or failure, and of teaching methods that "expect" uniformly of children, that is, that do not take account of children's unique, distinctively different ways of being as learners. Above all, he was calling for a reconfigured teacher–student positioning – an attention to and noticing of children that he felt was insufficient in his experiences of learning mathematics. In his vision of a child-friendly mathematics, Toby suggested that being "taught well enough" demands more than current classroom approaches can offer. It is important that in his statement, Toby unquestioningly accepted the content of the mathematics curriculum as a subject and the tests and examinations that are used to assess children's learning of this content, as a constant – as part of life. He saw children's failure not as a problem with the curriculum nor with a system which in its very conception, design and implementation produces successes and failures, but as a deficiency in teaching approaches that fail to recognise the subjectivities of children. This is echoed in Fleur's plea for teachers' answers to her burning mathematical questions.

Dominic's suggestions also identified the teacher/student relationship as a critical area of subjectivity.

> Researcher: You've had this wide experience of different countries, different kinds of schooling systems. If you were to give us advice about learning mathematics that works well for you, what would it look like?
>
> Dominic: I reckon it's probably smaller class sizes and sort of more emphasis on teacher-to-student relationship kind of thing, rather than just everything you can get your answers out of a textbook and you can get your questions out of a textbook and you can just live off a textbook because a textbook doesn't tell you how to do it, it sort of has a few steps in writing, you know, a textbook doesn't talk back … and um, yeah you can look in the back of the book for the answer to a question but it doesn't tell you how you got there and that's what you really need in a test because you're basically stuffed otherwise so … yeah, but um, yeah, 'cause I remember when we used to have like class size of 30, 35 in England, and nowadays we've got like 10, 15 and like [the teacher] can actually get around and talk to you and tell you what you need to do and that kind of thing …

> Researcher: (Later) What about the subject matter itself … the kinds of things that you learn? And the way you learn?

> Dominic: [We need] sort of practical activities … what I learned in the Alpine School [an outdoor education programme Dominic was selected to attend] is people learn in different ways as well, and I think, well some people can look straight from the [black/white] board and apply that into their own sort of thinking but I can't, and lots of other people can't, and if you sort of had a good way of sort of describing that say, with linear equations you know, a good example, and something we might actually use in real life, which often there isn't but you still have to do it anyway, and um, yeah, just sort of practical examples rather than ones which, you know, rather than ones that the textbooks make up. (Mid Year 12)

Like Toby, Dominic suggested that children learn in different ways, that is, children are subjective beings who cannot be treated as a uniform body of identical thinkers. Those who could learn "straight from the board" were the exception, in Dominic's experience, and yet this was the primary mode by which mathematics was taught in the majority of classrooms, by all accounts. Dominic also suggested that the textbook's "made up" questions did not provide sufficiently compelling examples of mathematics in practical application.

Rochelle too identified the teacher–student relationship as critical. Like Toby, she did not suggest any alteration to mathematical content or systems of assessment.

> Rochelle: Maybe spend a bit more of one-on-one time with students, and maybe smaller classes. Mind you, the teacher can't do much about that can they? I find older teachers more helpful and they know heaps of different ways of doing different things, whatever way is easiest for you. (Mid Year 13)

Some of the children, Georgina and Liam for example, advocated greater connection between mathematics and things that were "real" to them, as they reflected on what it was that had made mathematics make sense, or not, throughout their schooling.

> Georgina: I remember the questions, 'Josh had 4 oranges and his friend wanted 2. How many will Josh have left if he gives his friend 2?' That would make sense to me. But they'll [the teachers] be like, 'This is called subtraction. Four take away two, what is it?' and you will be like … that's what happened to me … I'd be like, 'I don't know' (*in a small voice*) Because I think kids refer themselves to um, like, objects, you know, like I wanna play in the playground, I want to play with the ball, or I wanna draw, kind of thing, skills with paper, things like that … (Early Year 12)

> Liam: Last year we done some stuff outside, we were doing angles and stuff, instead of getting us, for our test, like, here is an example on a piece of paper, we had to go outside on the court and measure, like. There was a point on the outline and we had to measure from the goal post to the point, we had to measure the angle. It makes it clearer for me in my head like I've got a mental picture of it. (Mid Year 13)

Liam later suggested a greater connection between the mathematics learned at school, children's interests, and the use of mathematics in authentic contexts.

> Liam: The children in the class who struggle to be interested in [maths], [teachers] should sort of try and find out what their interests are, not hard out, just something a little, like encourage them, something like that could make a big difference. Like for me it might be relating it to cricket, sports. It might make it more interesting … They should relate it to what it would be used for, I think that would be like a big thing, especially when we use those long formulas and stuff, we can't remember them. If we knew what they were for we might remember them better … (Mid Year 13)

The profound sense of disconnection that Georgina described became a defining component of her mathematical subjectivity. Her reflection, “I think kids refer themselves to objects”, is a concept that appears in dominant cognitive theories of mathematical learning, usually recognised as a developmentally “earlier” and therefore inferior mode of thinking since it is rooted in the tactile and tangible. The discourse of mathematics as a discipline creates a sharply defined polarity between body and mind, real and abstract, hard and soft (Mendick 2006). In this binaried structuring of human thinking, reliance on objects or any other point of reference that can be construed as “real” cannot be regarded as purely mathematical since the use of objects or images does not exist as a distilled, generalised, transferable truth. As all of the children in this study showed, the subjectification created through pedagogies that increasingly divested mathematics of its worldliness presented a significant barrier to their enjoyment, achievement, and participation in the subject.

This disconnection was echoed by Jared who was happy to leave school behind. He described his school teachers as strict and suggested they needed to be more lenient. He was enjoying his plumbing course.

> Jared: [It’s] pretty cool. I’m learning heaps of stuff doing it. It’s way better than school. There’s no pressure to come, so more turn up. There’s more freedom. (*Later*) At school, they never told us where [maths] would be used. [I now need] the basic number stuff, measurement, and angles. We have to measure 45° angles for cutting pipes. [We don’t need] trig or Pythagoras. Teachers need to make maths more fun, so we’re not all bored, crammed up in a classroom. (18 years)

Some children experienced difficulties in contemplating any other ways of doing mathematics partly because their subjectivities were so caught up in familiar discursive structures, whether as a student who was succeeding at mathematics and wanted more of the same, or a failing student who railed against a subject that had counted them out, that they could not conceive of themselves as mathematical learners in any other relationship. Dominic, for example, said he was happy to work to a structure in learning mathematics in which he could see himself. His issue was mainly with the lack of perceived purpose in what he was expected to do.

> Dominic: Yeah, I sort of work well when I know what I need to do and when I need to do it by, ‘cause otherwise I probably wouldn’t do it at all, I don’t know, I don’t do something if I don’t need to do it, it sounds pretty lazy but, if it’ll benefit me, and whether I’ll get anything out of it and if, otherwise I wouldn’t really bother with it, it’s just choices and I’d rather go out and kick a ball than spend 3 hours doing maths problems which I don’t need to do, which may help me but generally it won’t, yeah. I don’t mind working to a structure. If I have to do it, I’ll do it, and yeah I can sort of see the point in that because you have to cover everything in the year, but, um, yeah, work for the sake of work just annoys the crap out of me. It really does, like when they give you, say, Question 1, do all these different examples of the same rule, all you need to do is the first two and then you know what the next one’s going to be, it may not be the same answer but you do exactly the same steps to get … and you may as well just move on to the next one and challenge yourself with something else rather than wasting time on it. (Late Year 12)

Mitchell’s recommendations centred on the help that he felt would have enabled him to perform to the demands of a subject that had remained largely inaccessible throughout his years of schooling. Because the provision of a teacher aide had been of the most assistance to him, this was the best he could imagine for himself. Educational discourse had produced Mitchell at the margins, and like Toby, Dominic, and Rochelle his suggestion focussed on how children could more successfully insert themselves into existing pedagogies of mathematics.

> Mitchell: Probably just have a teacher aide to help me out all the time. They used to always just write what I said, like what I thought [the answer] is.
>
> Researcher: Maths has been pretty hard for you the way they do it at school?
>
> Mitchell: Yeah
>
> Researcher: You think they should have done better to help maths make sense for you?
>
> Mitchell: Yeah, kind of, yeah.
>
> Researcher: Can you remember some things that really worked for you?
>
> Mitchell: I remember [the teacher] did explain things to me, but then I forgot, he did, like, helped me a bit. (Mid Year 13)
>
> Mother: Ideally, for kids like Mitchell, trying to get him into that classroom where he was going to be with one teacher for mainly all of his subjects, but they only took the more intelligent children into those classes, he was not eligible then I think, I know that he would have achieved more if he had been in that environment, but high schools are geared up for this separate teaching, specialised teachers in specialised areas so you rotate. Maybe if they, high school's so big and got so many teachers, even if they got a group of say 100 kids that rotated between main teachers so that they all knew that group of kids, because he learns better that way but, um, it's just always been the norm, that's the way high school goes. (Early Year 12)

For these children, the possibility of mathematics learned in ways other than those to which they had become accustomed was almost unimaginable. The nature of mathematics as inscribed through school practices tied subject and practice together, so the changes suggested by the children were more about helping them to understand mathematics, and creating greater connections between mathematics, its utility, and relevance in everyday life, than about any change in the substance of the subject itself or its general delivery. Mathematics was presented to the children in the discourse of schooling as a powerful corpus of rules and facts whose social, historical, and cultural origins were obscured from its learners. In a liturgical-like reverence to this distant originating source, school mathematics lessons paid homage to mathematics as reality, making visible the mathematical subject as a worthy (or not) purveyor of a sanctified episteme. The children in this study came to recognise from a young age the links between mathematical knowledge and power, and as they resisted mathematics' subjectification, they were inexorably trapped in its webs of signification and used their mathematical positioning to account for themselves and manoeuvre among the choices offered them as mathematically occupational beings.

As social acts, classroom practices operate within regimes of truth, knowledge, and power. The truth told about children in such acts is tied to epistemological systems that operate on a cognising of knowledge, including self-knowledge, as something that can be accurately gauged, proven, represented and in so doing, grasped and controlled. In this acquisition/possession metaphor of knowledge as a material truth, and knowing as “having” such truth, we believe we can know who we *are* as mathematical learners. Such knowledge is powerful, since we can act, and justify our acts, by referring and deferring to this prescient, eternal reality. Ontologies – our understandings of who we are – founded on such regimes of truth, require ongoing demonstrations to confirm and validate. Assessment for grading and ranking and differentiated/differentiating practices, for example, justified as the means to *determine needs* with the ultimate aim of *success for all*, are invoked to reveal and uphold the truth about children. In educational discourse, assessment is not recognised as the apparatus by which such truths about children as subjects are created, recreated, and reified. In structures that provide mechanisms by which children’s achievement can be measured and thereby “known”, interventions to cure children’s failure in mathematics or reduce disparities in their achievement make little difference since the underlying presumption about where failure comes from – from within children themselves – remains untouched. If we are unable to see that children’s failure/success comes from our acts of recognising and therefore producing failure, and that it is only in changing our acts surrounding the constitution of failure/success in doing mathematics that the failing subject and its attendant stigmatisation and exclusion has any chance of disappearing, then the gaps we battle so valiantly to close will be endlessly recreated and maintained in the performances of measurement in which such mathematical children are made.

Children as Mathematical Subjects

Does the idea of thinking of children as mathematical *subjects* matter, we might wonder? The children’s stories in this volume beg that we do.

First, this view of children asks that we recognise our classroom practices as discursive acts, productive of children’s mathematical subjectivities; our tests and examinations – mentioned by Toby in the quote above, our Quick Tens, Flying in Fives, Mad Minutes and games of Around the World, our homework and worksheets and set pages of the textbook, our group work and diagnostic interviewing – are *acts of subjectification*. As we have seen from the children’s accounts, children are made visible, confirmed, confused, or destroyed in their own and others’ eyes as mathematically (in)capable subjects in such acts. This view asks that we recognise the normalising gaze operating within technologies of power and knowledge in our governments, communities, and classrooms that authorises such subjectification.

Second, if we perceive teaching and learning as processes of subjectification in which particular ways of knowing mathematics and power are linked, rather than as improvement and enlightenment of the deficient child existing in a state of unfulfilled potential, teacher *and* child are repositioned in such discourse in a new relationship. The teacher as subject herself can consider her role not simply as a coach or trainer, a disseminator of knowledge, but as a critical collaborator in the production of mathematical meanings including mathematical subjectivities.

At Foucault's urging, it is, indeed, possible to refuse to be who we are. In such a relationship, parents might likewise come to view their children not as failed, average, or successful mathematics students who need us to drill the facts into them as they were drilled into us, to exhort them to do their homework, test them on the basic facts in the car or to persuade them that mathematics is good for them, but rather as active beings making mathematical sense of their world, beings with whom we can communicate and discuss old and new mathematical meanings. When we regard ourselves as subjects-in-becoming, active making of meaning including making meaning about ourselves, becomes the raison d'être of a critical, democratic education. Making meaning is a co-constructive process, and in classroom cultures which emphasise and encourage active meaning making rather than acquisition of pre-existing knowledge, power can be shifted from its traditional frameworks since knowledge – the *having* of it or not – is not the primary exclusory/inclusory identifier.

If we were to see teaching mathematics as an act of making children as mathematical subjects, rather than as a revelation of a truth about their natures upon which we must act, we might in turn see our teaching of mathematics as acts structuring inequalities which do not, and need not exist. Teaching mathematics in this view could become one not of identifying existing truths and obeying universal laws, but a conscious and flagrant contestation of them in the act of producing new and salient ways of seeing. The principle of creative disobedience regarding mathematical laws in teaching and learning mathematics would be seen as necessary to doing mathematics since doing mathematics itself would be regarded as an act of invention rather than discovery or in the case of schooling, learning about others' mathematical discoveries (Burton 2002). Children as mathematical subjects in this view of mathematics education might engage as active, communicative, collaborative, agentic participants in a continuous discursive process of subjectivity, which considers how they might become as mathematical subjects, rather than reveal, accept, and defend who they are/are not.

This view of children constituted in curriculum has yet to come of age in the creation and implementation of curricula worldwide. The production of children in contemporary curriculum discourses can be clearly seen in New Zealand's Curriculum framework (2007) for example, which provides a vision of how power/knowledge works in education. The following characteristics of the well-educated child listed in the framework present a culturally constructed version of the ideal child:

Confident

Positive in their own identity

Motivated and reliable

Resourceful

Enterprising and entrepreneurial

Resilient (p. 8)

Identity is presented in this list of characteristics as an essence, an innate quality, fixed rather than in process, as something that education secures rather than makes. Here the ideal child is viewed as one who acts autonomously, is singular, self-supporting, self-seeking, and socially hardy. This child is self-regulating – she/he makes herself visible in, and accountable to the discourses of self-actualisation, self-direction, hard work, competition, and survival. Classrooms are expected to act as the sites of subjectivity where this well-educated child will emerge (or not) in practice. Those children who exhibit the listed characteristics will be privileged through processes of recognition and confirmation and those who do not will remain invisible, become subjected to correction or remediation, or be discounted. As a mathematical subject, such an ideal child would present as confirmed in her/his self-recognition, accepting of her/his strengths and weaknesses since ability is part of identity, conscientious, working independently within the limits of his/her potential, treating failure as motivational, and finding ways to make the most of the available opportunities in a competitive learning environment.

Learning mathematics in this view of the ideal child is necessarily a process of equipping the child for her/his Pilgrim's Progress-like solo journey through life. Indeed, the words "Learning pathways" and "equipping" appear a number of times in this document as metaphors which envision the child as a lone voyager who must be prepared to tackle their learning (and life?) without help. Those who argue for equipping children with mathematical knowledge in order to empower them see children as unitary (solitary, not social or connected) objects, they envisage children as locatable (made visible) as points on a pre-determined learning pathway along which they travel and where progress is made in one direction only. Teachers are directed in this discourse to capture children in a panoptic gaze, determining their position on this continuum, plotting their course and deciding where and how they must "move" next, as the following statement from *The New Zealand Curriculum* (Ministry of Education 2007) shows:

> What is important (and therefore worth spending time on), given where my students are at? This *focusing inquiry* establishes a baseline and a direction. The teacher uses all available information to determine what their students have already learned and what they need to learn next. (p. 35)

In this view of the child as an object accountable to the authoritative functions of schooling, the child is expected to adopt an emotional toughness or *resilience* in the face of the success/failure dichotomy that structures the social space of school. The term "resilience", another *mot de jour* in education policy statements of the early twenty-first century, suggests that children must learn to accept without question even the most unpalatable of judgements delivered to them by systems of educating in which they are made as succeeding/failing subjects, since such systems, it is widely believed, are capable of revealing to children the incontrovertible truth about themselves. For the majority of the children in the study, this truth included the "fact" of their lack of natural talent at mathematics. Once accepted, this truth shaped their occupational subjectivities, their life choices, and their understanding of the substance of mathematics itself.

By shifting our production of children in discursive practice from *object*, that is, a unitary and rational student of mathematics - a view of the subject strongly challenged by Henriques et al. (1998) - to *subject* (the student participating in mathematics as a social and intersubjective being), we also shift our view of subject from noun to verb, our view of ourselves as children, teachers and parents from fixed to mutable, our view of learning from passive to active, and our view of mathematics from absolute to fallible, not to suggest that these moves are in any way oppositional, but to refigure the relationships and the (inter)actions of the participants in educational discourse. It is within the discursive possibilities that are opened in such a shift that we might unfix children from their binaried positions (Mendick 2006) as subjects ranked on performance continua, as subjects in gendered opposition, and as subjects defined and constrained by their origins. Such unfixing extends to positions of power that exist within classrooms and between children and researchers. It allows for the emergence of subjectivities more conducive to the participatory vision afforded children in the Convention on the Rights of the Child, and more suited to the demands and challenges of rapidly changing social and physical climates of the early twenty-first century, as Walkerdine (2002) recognised in advocating a critical stance that would take account of subjectivities remade in times of social turmoil:

> Globalism and economic rationalism are ravaging a world also caught in the grips of ecological suicide. Psychology and subjectivity are absolutely caught up in these changes. Economic rationalism, for example, demands an autonomous subject who can cope without work, social, family and community supports … it is … necessary to propose alternative ways of understanding and acting … (p. 2)

Rochelle and Georgina, who left school without completing Year 13, were able to reflect on their learning of mathematics and its place in their occupational lives, particularly the usefulness of the mathematics they had learned at school for the kinds of mathematical tasks they found themselves using in their workplaces. The mathematics needed in their jobs appeared to them to differ significantly from the skills they had learned in the classroom; to handle workplace mathematics they had developed their own invented systems or relied on the use of calculators.

> Georgina: I consider myself a logical person, like I don't need maths in my life, so I can use other things to substitute for maths … I don't think I'm a mathematical person but I think I strategise when I'm doing things at work, I'm dealing with numbers all day like people calling me, that's numbers, I'm doing filing, that's numbers, I'm dealing with clients their client number, that's numbers, it's all maths but I don't see it as maths … My main job is filing all the job sheets numerically from highest to lowest, but I found chronological order a lot harder, like the dates. I'm real good at it when I do it. I found it a lot harder at school, putting [numbers] in order.

> Rochelle: I actually got tested for my job. The maths [part of the test] was pretty good. We didn't have a calculator or anything, it was just basically adding and subtracting but they'd have like, say there's two thousand and ra-dee-ra-dee-ra, and minus this many of this, so you've got to, there's lots of minusing. Pretty easy but it gets confusing. But I do work with just money. We pay out the money to the clients, so you know, it's to do with maths, but I've got a calculator.

This perceived lack of connection between school mathematics and the realities of the workplace had led Georgina to speak of mathematics as something she did not need in order to lead a full and functional life, recognising herself as “a logical person” who could work things out as needed. Rochelle had secured a job through passing a numeracy test, but saw her daily work as requiring little mathematics that could not be easily done with a calculator. She was not convinced that the mathematical skills identified by the test – lots of minusing – were necessary to the job, rather the test demanded demonstration of particular mathematical skills as an entry pass to a world of work where mathematics acted as gatekeeper. In their talk, the beliefs Georgina and Rochelle once expressed as young children about the importance of learning mathematics at school was reconfigured in new realities of workplace and adulthood.

Jessica recognised the discursive domain of mathematics education as much wider than classrooms and beyond the control of teachers to effect changes that might better suit students. Even as she suggested that learning fewer mathematics topics but in greater depth would be a more useful approach for children, she dismissed such change as managerially out of the question.

> Jessica: Spending more time on [particular mathematics topics] and eliminating some of the [NCEA] standards which I think wouldn’t necessarily hinder your learning at all, just focusing on a couple of standards and learning them really, really well. But [teachers] can’t really do that. It’s set down by people that are up so many levels above them that you can’t, like, change that. (Mid Year 13)

In reflecting on leaving school at the age of 16 years of age and entering the world of paid work, Rochelle was still wondering what to do. She had found work first in the delicatessen section of a supermarket, then in two temporary secretarial positions in government departments.

> Rochelle: It feels good actually to be able like, to know that I can do what, you know, these people can do in their 30s and 40s maybe. I am only a temp, but they said to me if I do well, then they might look at a permanent job, but I don’t know if I want to take it if they offer it to me because it’s quite hard and I don’t actually enjoy the work that I’m doing. I think that to be able to work every single day you have to enjoy it. You can’t just do something that you don’t want to do. But to work, everyone was to do it. (Mid Year 13)

Her description of work as necessary to her immediate survival – as something everyone has to do – as productive of her subjectivity as occupationally successful, but as stressful and challenging for its unrelenting and unrewarding demands on her occupational space, speaks of the conflicts produced in our children on the verge of adulthood as they contemplate occupational possibilities, possibilities laid down in their mathematical schooling. Without the required levels of NCEA mathematics, Rochelle’s options had been markedly reduced.

The last word in this collection of storied selves goes to Georgina who had considered a range of possible future occupations over her time in this study.

> Georgina: I don’t know what I want to do, just want to make some money and doing something I love preferably, and change the world. I couldn’t change the world if I tried. No one I know has done anything for the economy, the atmosphere. ’Cause everything’s going to die, I reckon, like the grass needs nutrients, like genetics being modified and in twenty

> years' time it will be so bad for us, the robots will take over. I'm like, 'Tell me why. I want to know why.' So when I think about what I want to do in life there's a little part of me that wants to be an inventor. (Mid Year 13)

In this reflection, Georgina spoke of herself as a subject subjected by the social and physical changes going on around her. She imagined herself as a person who might wield some control in an environment which must have felt overwhelming for a young person confronting occupational decisions that needed to take account not only of personal fulfilment and economic survival, but also of ecological sustainability in the uncertain times of rapidly changing geophysical, political, technological, and social climates. Her wish "to be an inventor" could not have been more telling. Year by year, learning mathematics had shut down Georgina's curiosity and actively sought to dissuade her from thinking inventively beyond the given rules of a static mathematics that permitted her little room to move.

Georgina's closing thoughts demonstrate the threats and challenges facing young people in Millennium 2000 as they self-orient, configure, and reconfigure who they believe themselves to be in response to global changes with which no previous generation has had to contend. For the children in this study seeking to accommodate themselves in a world of constant change and unimaginable futures, doing mathematics had not served their personal endeavours of adaptation and survival as best it might. Their candid talk about their mathematics lives inspires us to work strenuously to provide more compelling channels through which our children, as critical collaborators in determining the shape, substance, and direction of their learning of mathematics, might be made as mathematical subjects in educational discourse that takes an actively child-friendly account of the times in which they are rapidly coming of age as a new generation of parents and teachers.

Epilogue

As this book was going to press, the children in the study had not long celebrated their 18th birthdays – recognised by the United Nations as the age at which children pass into adulthood. Those who had stayed on at school had just completed Year 13 (Year 12, in Dominic's case) and had received their final external examination results.

Fleur had finished her year's student exchange in Sweden and had returned to New Zealand to study at university for a degree in psychology. Her highest mathematics qualification – 14 Level 1 NCEA credits, the majority at "Achieved" level.

Georgina had reduced her hours at the call centre where she had gained work using her Certificate of Business Administration and Secretarial Studies to pursue a 2-year Diploma in Beauty Therapy. Her highest mathematics qualification – 10 Level 1 NCEA unit standards credits.

Jessica had set off for England for a gap year working as a sports coach and teacher aide at a girls' school. Her highest mathematics qualification – 6 Level 2 NCEA achievement standards credits, all at "Achieved" level.

Rochelle had moved on from temping in a government department office and had secured herself a fulltime permanent position as a data entry clerk. Her highest mathematics qualification – 30 Level 1 NCEA achievement standards credits, all at "Achieved" level.

Dominic received an Enter Score of 72 in his VCE exams in Victoria, Australia. He had received an offer for a Bachelor of Business at a local university, but had decided to defer for 12 months. He was seeking work at the local supermarket and had been selected for a regional representative soccer team. His highest mathematics qualification – a B grade for VCE Further Mathematics in Year 12.

Jared worked as a casual labourer on a building site for several months before he enrolled in a certificate of plumbing and gas fitting at the local polytechnic. He needed ten Level 1 NCEA mathematics credits to enrol in the course. His highest mathematics qualification – 13 Level 1 NCEA unit standards.

Liam failed to achieve the Level 3 NCEA mathematics achievement standards in the external examinations he sat at the end of Year 13 and had withdrawn from the others. He enrolled in a Diploma of Exercise Science at the local technical college. The minimum qualification for entry to the course was 40 Level 2 credits in any subject. Mathematics was not a specific requirement. His highest mathematics qualification – 6 Level 3 NCEA achievement standards credits at "Achieved" level.

Mitchell had completed the school's transition to work programme including basic numeracy and was working part-time in the kitchen at the rest home. He did not gain enough unit standards overall to achieve the NCEA qualification, which requires a minimum of eight numeracy credits. His highest mathematics qualification – 6 Level 1 NCEA unit standards credits.

Peter gained 15 credits in the NCEA external examination. He had decided to enrol at the local university for a degree in Geography, History and Political Science. His highest mathematics qualification – 24 Level 3 NCEA achievement standards credits in Mathematics and Statistics, including 2 credits at "Achieved with Merit" level and one "Achieved with Excellence."

Toby gained 15 credits in the Level 3 NCEA external examination. He had decided to enrol at the local university for a double degree in Commerce and Arts including French. His highest mathematics qualification – 24 Level 3 NCEA achievement standards credits in Mathematics and Statistics, all at the "Achieved" level.

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APPENDIX: Childrens Questionnaire Sheet[1]

Example: Jared, Late Year 3

Date ____________________

How I feel about maths

Finish this sentence.

Maths is ....OK...

How do you feel when you do maths? Record on the scale.

unhappy 0 1 2 3 4 5 6 7 8 9 10 happy

Do you think you are good at maths? Record on the scale.

no 0 1 2 3 4 5 6 7 8 9 10 yes

Why do we learn maths at school? To get good at Writing.

What do you like most about maths? Times Tables.

What don't you like about maths? Teste.

What do you do when you don't understand something in maths? ask the Techa.

You do lots of maths at school. At what other times do you do maths? no.

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[1] From Beesey and Davie (1991): *Macmillan Mathematics, Level 2b, Children's Recording Book*, p. 3.

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