Primary School Teachers' Constructions of Mathematics Attainment Differences: A Critical and Bioecological Exploration

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I certify that all material in this thesis which is not my own work has been identified and that no material has previously been submitted and approved for the award of a degree by this or any other University.

Signed: V. Marshall

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Abstract

There is a persistent gap between the mathematical attainment of children from vulnerable groups and their peers. This has a significant effect upon the access of children from disadvantaged backgrounds to educational and social opportunities both in childhood and into their adult lives. It also impacts upon their perceptions of their mathematics abilities. It is therefore important that educational psychologists seek to equalise opportunities for mathematical success, regardless of a child's circumstances.

Teachers' perspectives surrounding the mathematics attainment gap not only impact upon how they interact with students; they can also directly affect students' mathematics performance. Despite this, little research has been undertaken to explore what factors influence teachers' constructions of attainment differences. While some studies have considered teachers' mathematics attainment views as part of intervention evaluations or quantitative studies, there is little in-depth research considering the breadth and origin of their views. This is of importance to educational psychologists as teachers' perspectives will affect their responsiveness to psychological approaches and interventions designed to reduce the mathematics attainment gap.

In this research I present four case studies that explore the ways in which primary teachers conceptualise mathematics attainment differences and how this is influenced by their personal characteristics, contexts and experiences (bioecology). Completing four semi-structured interviews with each participant, I analysed these interviews to identify each teacher's bioecological influences. I then critically examined their views around mathematics attainment differences to identify themes in their

perspectives. Finally, these analyses were combined to consider how each teacher's bioecology influenced their conceptualisations of mathematics attainment differences.

Each of the teachers in this study presented different views surrounding the origins of mathematics attainment differences and how these differences should be approached. Exploration of their bioecology in relation to these views suggested there were multiple interconnected influences upon their perspectives. Teachers' own experiences of learning mathematics at school and the impact of universal attainment expectations were consistently related to teachers' views, although the type of influence they conferred was highly variable. As teachers' views and influences were so varied, different psychological approaches and knowledge would be required when working with each teacher to reduce the mathematics attainment gap within their classes most effectively: one approach would be unlikely to fit all.

The findings of this research suggest that deeper exploration of teacher perspectives can be supportive to understanding their views around mathematics attainment differences. Greater knowledge of teachers' perspectives and influences may support educational psychologists to tailor their training and casework to address mathematical attainment differences more effectively. In addition, exploration of views and influences upon them allows both teachers and educational psychologists the time and space to critically reflect upon their own assumptions and practice. Future research with different teacher groups and demographics is suggested to broaden our understanding of how teachers form their mathematics attainment views. Further exploration of the importance of the wider educational context and teachers' school experiences on their views and practices is also suggested.

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List of Abbreviations

A-level	Advanced Level (UK)
APPG	All-Party Parliamentary Group
BPS	British Psychological Society
DCSF	Department for Children, Schools and Families
DfE	Department for Education
GCSE	General Certificate of Secondary Education (UK)
EEF	Education Endowment Foundation
EPI	Education Policy Institute
ESFA	Education and Skills Funding Agency
ETS	Education Testing Service
HCPC	Health and Care Professionals Council
IE model	The Internal/External frame of reference model
JRF	Joseph Rowntree Foundation
NCSL	National College for School Leadership
NF	Nuffield Foundation
OECD	Organisation for Economic Co-operation and Development
Ofsted	The Office for Standards in Education (UK)
PGCE	Post Graduate Certificate in Education
PMLD	Profound and Multiple Learning Disabilities
SATs	Statutory Assessment Tests (UK)

Chapter One: Introduction

Mathematics is a core feature of school curricula across the world. Attainment is strongly linked to pupils' social and economic success in adulthood (Baker & Ramsey, 2010; Easterbrook, Hadden & Nieuwenhuis, 2020; Fiske & Durante, 2020; Ritchie & Bates, 2013). However, significant differences in mathematics achievement exist between different societal groups, with those from lower socio-economic backgrounds, children in care and those with special educational needs all showing comparatively low mathematics attainment (All-Party Parliamentary Group (APPG), 2012; Education Endowment Foundation (EEF), 2017; Education Policy Institute (EPI), 2019). These differences in mathematics achievement have been termed 'the attainment gap'.

The attainment gap has been a strong focus of educational policy initiatives and research in recent years (Department for Education (DfE), 2016; EEF, 2017; Department for Children, Schools and Families (DCSF), 2007; Joseph Rowntree Foundation (JRF), 2014). Despite this, progress in its reduction appears to have stalled, with recent estimates suggesting it would take 500 years to eliminate the gap based on the current trajectory (EPI, 2019). In addition, there is wide variation in the size of the attainment gap in different regions of England (EPI, 2019) and in different socio-cultural contexts (Croizet, Autin, Goudeau, Marot & Millet, 2020). Many promising initiatives aimed at reducing attainment differences have shown low transferability when scaled-up and applied more widely than their initial study locations (Biesta, 2010; Easterbrook et al., 2020; Lambirth & Cabral, 2017; Moir, 2018).

Rationale

It was my purpose in this research to explore how individual teachers conceptualise differences in mathematics attainment. Much of the existing research in this area has focussed upon how teachers respond to particular training and interventions (Boyd & Ash, 2018; Perry & Dockett, 2018). While this is an important area of research, by focussing upon the success or failure of a strategy or approach, the influences and complexities of those delivering the interventions may be overlooked. There have also been some studies that relate teacher biases and stereotypes around mathematics ability to their students' performance (Campbell, 2015; Kikas, Soodla & Mägi, 2018; Lazarides, Buchholz & Rubach, 2018; Liu et al., 2018). For example, Campbell (2015) identifies teacher biases and stereotypes that influence their evaluation of pupils' mathematics ability and attitude. Campbell's study used a latent class analysis which facilitated the identification of a number of influences on teacher mathematics evaluations such as race, gender and social class. However, Campbell herself noted that the data only allowed speculation as to how the factors identified might interact with each other and vary between individuals. I set out in this research to explore these interactions and individual variations.

From a personal perspective, I chose this research topic having observed for myself the fixed assumptions related to maths attainment that can exist in primary school settings. In my previous career as a teacher, I observed how children may be classified as a lower attainer from an early age, and their future prospects assumed based upon their performance at age four or five. I also experienced the frustration of a system that did not recognise the very real progress of some children in the class. In addition, I mused over the idea that unlike in secondary education, primary school teachers may bring much more varied levels of mathematical skill, confidence and interest to the classroom, but also be required to engage with mathematics teaching every day of their careers. I was interested to explore how these individual teacher differences may impact upon their views and narratives around the mathematics attainment differences within their classes.

Mathematics Attainment Differences and Educational Psychology

It is the professional duty of educational psychologists to foster inclusion, reduce barriers to learning and ensure the promotion of equality of opportunity for all learners (British Psychological Society (BPS), 2002, 2008). As mathematical attainment is a prerequisite for accessing a number of educational and employment opportunities in adulthood (Easterbrook et al., 2020; Rushton & Wilson, 2014), attainment differences are a matter of concern for the profession. There is a growing appreciation that individual circumstances and contexts are of particular importance when designing interventions or implementing approaches to target the attainment gap (Croizet et al., 2020; Educational Testing Service (ETS), 2018; Kelly, 2012; Moir, 2018). In order to advocate successfully for children with low mathematics attainment (Fox, 2015), educational psychologists must also understand the views and experiences of their teachers and how these may impact upon their approaches and assumptions.

Research Aims

The purpose of this study was to explore how different teachers conceptualise mathematics attainment differences. My aims were to identify central themes in each teacher's constructions and explore how their views may be influenced by their personal characteristics, wider context and historical experiences. Using a critical constructivist stance, I adopted the bioecological model of human development by Bronfenbrenner and Morris (2007) to guide my research.

This study explores how primary school teachers from South West England conceptualise mathematics attainment differences. A multiple case study design was used, with four individual interviews conducted fortnightly with four primary school teachers who taught in different school settings. I used these interviews to explore each teacher's personal characteristics, current context and historical experiences (bioecology) and to complete a critical thematic analysis (Lawless & Chen, 2019) of their views around mathematics attainment differences. A further analysis considered how each teacher's bioecology influenced their conceptualisation of mathematics attainment differences.

Thesis structure

This first chapter has provided a brief outline of the rationale, aims and structure of my research and its relevance to the field of educational psychology. In chapter two, I present a literature review of research related to mathematics attainment differences, including the role of educational psychology approaches to managing the attainment gap. The research methodology, including theoretical standpoint and psychological framework, is discussed in chapter three. Discussion of ethical considerations and the quality of the research is also provided in this chapter.

Chapter four introduces the teachers that participated in this study. A profile of their bioecology is provided for familiarisation. This leads on to chapter five, where the findings and discussion related to teachers' conceptualisations mathematics attainment differences are explored; Each teacher's views are discussed in turn with illustrative extracts from their interviews presented alongside critical analysis and psychological literature. In chapter six, the themes and findings from chapters four and five are combined to analyse the bioecological influences upon each teacher's conceptualisation of mathematics attainment differences. This is supported by additional illustrative quotes and academic literature. Within chapter seven, I consider ways in which educational psychologists might tailor their approaches to take account of teachers' bioecological influences and their views around the mathematics attainment gap. This is based upon the findings and discussion contained within chapters five to seven, and relevant psychological knowledge and approaches. A conclusion is presented in chapter eight, returning to my research questions and study aims. In this final chapter I summarise the findings of this research, identify study limitations and avenues for future research and provide a concluding thought around the topical nature of this research in light of the Covid-19 pandemic.

Chapter Two: Literature Review

Mathematics is a fundamental subject within international school curricula, often holding a privileged position in comparison to other subjects (Alderton & Gifford, 2018). Mathematics is one of only three subjects measured in the Programme for International Student Assessments (PISA) to judge educational quality across the globe. More locally, mathematics and literacy skills are the sole measures of English primary school testing on which school league tables are based (Alderton & Gifford, 2018). Research has suggested that some mathematical skills such as quantification systems are innate within humans and the animal kingdom (De Visscher & Noël, 2014; Dehaene, Izard, Spelke & Pica, 2008; Feigenson, Dehaene & Spelke, 2004). However, studies of anumeric societies (where the language does not have words for specific numerical quantities) highlight that some of the mathematical skills that we assume to be innate are in fact a product of the society in which we live (Everett, 2017). Consequently the value of particular mathematical skills, knowledge and practices can vary significantly both between and across cultures (Kankaraš & Moors, 2014; Muldoon, Simms, Towse, Menzies & Yue, 2011; Radford, 2014; Tuohilampi, Laine, Hannula & Varas, 2016).

The high-status position of mathematics can represent a barrier for individuals who do not attain the standards, skills and knowledge expected of them nationally. Mathematical attainment is key to social and economic success within most developed societies and a coveted source of societal status from a young age (Batruch, Autin & Butera, 2020; Easterbrook et al., 2020; Millet & Croizet, 2016; Rushton & Wilson, 2014). Conversely, low mathematical attainment has been associated with a number of negative economic, social and health implications in adulthood. Higher levels of poverty, unemployment, debt, social isolation and depression have all been linked to low mathematical attainment (Baker & Ramsey, 2010; Easterbrook et al., 2020; Ritchie & Bates, 2013). Consequently, mathematical success is inextricably linked to social status and economic gain within many societies.

The Mathematical Attainment Gap

English pupils from vulnerable groups are disproportionately likely to show lower attainment in mathematics (Easterbrook et al., 2020; EEF, 2017; EPI, 2019). This attainment trend has been termed 'the attainment gap'. The attainment gap is most frequently measured in terms of 'free school meals status' or access to the English Government's pupil premium funding. Free school meals eligibility is an entitlement provided for children with current low parental income (Government Digital Service, 2019), whereas the pupil premium is a sum of money paid to government-funded schools where a pupil has been eligible for free school meals at any point in the previous 6 years (Education & Skills Funding Agency (ESFA), 2019). In addition to income measures, pupil premium eligibility is also conferred to children in local authority care, care leavers and children of armed services personnel (ESFA, 2019).

The elimination of the mathematics attainment gap has been the focus of English educational policy initiatives in recent years (DfE, 2016, 2019). For example, in the government white paper 'Educational Excellence Everywhere' (DfE, 2016) the Department for Education established an 'expected standard' in mathematics based on age and regardless of background. This matches international discussion at this time in mathematics education that suggested high expectations are key to improving children's attainment (Organisation for Economic Co-operation and Development (OECD), 2013; 2018). However, political will and reduction of teacher responsibilisation were also considered integral (OECD, 2013; 2018), while more recent English policies have encouraged greater teacher accountability (DfE, 2019).

Despite policy initiatives, differences in mathematics attainment across economic and class divides in England remain persistent. The mathematics ‘attainment gap’ between those eligible for free school meals in the United Kingdom and those not is observable from the age of three, and increases with age (EEF, 2017). The most recent annual report from the Education Policy Institute (EPI) (2019) shows a persistent mathematics attainment gap between pupils eligible for pupil premium in England and those that are not. Although the gap narrowed slightly in primary education from 9.5 months to 9.2 months in 2019, it has shown no such movement in secondary education (EPI, 2019). While trends varied dependent upon educational stage and local authority area, the report stated that it would take 500 years to eliminate the mathematics attainment gap at the current rate of change.

It has been suggested by some authors that the attainment gap is perpetuated by the meritocratic organisation of the education system (Batruch et al., 2020; Darnon, Smeding & Redersdorff, 2017; Wiederkehr & Martinot, 2018). Meritocratic principles suggest that a person’s success and status can be directly attributed to the level of ability they have or the effort that they expend in pursuing a goal (Bourdieu & Passeron, 1977). In practice, this can result in differences in mathematics attainment being internally attributed to either effort or ability (Batruch et al., 2020). Croizet et al. (2020) suggest that social inequalities are reinforced by meritocratic education systems, and influence how both students and teachers perceive pupil attainment relative to normative measures. As a consequence, pupils with lower than average mathematics performance may demonstrate low perceived mathematics competence (mathematics self-concept). Their view of the mathematics that is valued may also be narrowed based on what is presented and assessed in school. The following subsections explore the influence of these attributions on pupils and the mathematics attainment gap.

Low effort.

There is an assumption within the English education system that pupils are in control of whether or not they succeed (Croizet et al., 2020; Keddie, 2016). As Batruch et al. (2020) note, if people are guided by an assumption that society is fair in rewarding those that work the hardest with higher attainment, assumptions are made that low attainment is similarly deserved. This is particularly problematic as strong beliefs in meritocracy reduce the intentions and actions of teachers to reduce barriers to learning (Darnon et al., 2017). Therefore, where teachers perceive students to have been less effortful in their work, they are less inclined to adjust their practice with a view to equalising attainment (Darnon et al., 2017; Keddie, 2016).

Social and cultural factors can have a significant impact upon the way that children's attitude to learning or level of effort are perceived. Children from lower socio-economic groups are required to adapt their behaviours and approaches in the school context to fit middle-class norms (Batruch et al., 2020). A good example of these norms in the context of mathematics attainment is children's behavioural self-regulation within the classroom. This skill has been consistently related to early mathematics attainment (Morgan et al., 2017; Purpura, Schmitt & Ganley, 2017; Wanless et al., 2015; Williams, White & Macdonald, 2016). In addition to being a middle class expectation, for some children in vulnerable groups impulsivity may be an adaptive reaction to the extreme conditions they experience at home rather than an individual failure in impulse control (Sheehy-Skeffington, 2020). In contrast, there is evidence to suggest that where children from lower socio-economic groups have higher self-regulation of their cognitive and affective reactions this may partially mediate the negative impact of their socio-economic status on their mathematics performance (Wang et al., 2017). Effectively, these children attain in mathematics despite their background, rather than experiencing equality of opportunity.

Inequalities in teacher perceptions of student effort are further compounded as pupils may indeed reduce their effort or develop negative attitudes to learning over time. Early environmental cues may reinforce children's ideas that the classroom and mathematics success is not something that is attainable for them (Browman & Destin, 2016; Oyserman et al., 2017). Having a universal expected standard of mathematics particularly highlights attainment differences to children with negative consequences for attainment and self-perception (Alderton & Gifford, 2018; Croizet et al., 2020; Haimovitz & Dweck, 2017). Where status is experienced as unfair or unchangeable, low status members are less likely to adapt their behaviours to the status quo of the mathematics classroom (Onu, Smith & Kessler, 2015). These children may reject aspirations to attain in mathematics, as they view this as futile (Oyserman et al., 2017).

Low ability.

For those who do appear effortful in their mathematics learning, the meritocratic assumption is that their poor attainment is due to lower ability. Overall, children in England identified as having special educational needs show average attainment that is two years lower than their peers in mathematics (EEF, 2019). Both teachers and children have a tendency to view ability as relatively fixed (Marks, 2011, 2013). In England this is illustrated by the use of in-class 'ability' groups organised by table, which are often observable from as early as Year 1 when children are five or six years old (Francis et al., 2017; Hallam & Parsons, 2013; Marks, 2013). That these groups are labelled 'ability groups' rather than 'attainment groups' suggests that there are fixed assumptions inherent in their use (Francis et al., 2017), additionally reinforced by the limited variation in groupings over time (Marks, 2013, 2014). Although the use of ability groups in English primary schools has shown some signs of reduction in recent years, the practice is still relatively common.

Marks (2013) and Francis et al. (2017) have both demonstrated that teachers can have preconceptions about work quality and self-regulation of children based on assumed ability. For example, a teacher may view tangents in learning and procedures as procrastination or inefficiency in low ability learners, whereas those in higher groups may be praised for exploration and self-extension (Marks, 2013). Children in lower ability groups are also more likely to be taught by less experienced staff and be placed in learning environments that are uncomfortable, noisy or frequently changing such as school corridors or temporary classrooms (Francis et al. 2017). This can reduce their feelings of value and belonging to the class and school (Francis et al., 2017).

Despite evidence that children from disadvantaged backgrounds enter school with lower attainment than their more advantaged peers, the universal attainment expectations of the English education system can communicate to children that they are less able at mathematics than their peers (Batruch et al., 2020; Croizet, Goudeau, Marot & Millet, 2017). Even in the pre-school years, children can be aware of, and keen to avoid, evaluations of relative low attainment (Millet & Croizet, 2016). In addition, Coleman (2019) notes that the English government’s current focus upon the attainment of children in receipt of pupil premium may unintentionally lead to an assumption that pupils who are economically disadvantaged have universal difficulties related to ability and developmental potential. This may be further reinforced as low competence and intelligence are thought to be implicitly associated with lower social class (Fiske & Durante, 2020; Lindqvist, Björklund & Bäckström, 2017).

The percentage of pupils reaching the expected standard in mathematics at the age of eleven is a key headline measure in England, appearing in the Government's primary school league tables each year (DfE, 2019). However, these accountability measures can lead to unfortunate, and presumably unintended consequences. Marks (2014) points to processes of 'educational triage' in preparation for these national assessments, where those who are closest to meeting expected standards are re-allocated resources that those who are lower attaining are not. Marks notes that this serves to widen the attainment gap and reinforces ability expectations. Given that primary mathematics education is presented as a foundation to secondary school mathematics learning (DfE, 2016), with GCSEs being predicted from end of primary assessments in many settings (National Union of Teachers (NUT), 2015), trajectories can be set for children before they reach secondary school. This is particularly concerning as some research suggests that the upper primary school years are a time where mathematics attainment gaps are shown to narrow (Mok, Mcinerney, Zhu & Or, 2015).

Low mathematics self-concept.

A person's mathematics self-concept is their perception of their own mathematics competence, judged in relation to their own self-selected standards (Parker, Marsh, Ciarrochi, Marshall & Abduljabbar, 2013). Low mathematics self-concept consistently predicts lower subsequent mathematics achievement in primary aged children (McCauley, Zajic, Oswald, Swain & Nancy, 2018; Sewasew, Schroeders, Schiefer, Weirich & Artelt, 2018; Suárez-Álvarez, Fernández-Alonso & Muñiz, 2014). Although mathematics self-concept appears to be less strongly connected to mathematics achievement in the early primary years (age five to seven), its influence is believed to increase over time (Lohbeck & Möller, 2017). Once children have developed low mathematics self-concept this can be difficult to alter, even in the face of contradictory evidence such as improved mathematics performance (Sewasew et al., 2018).

Children's development of their mathematics self-concept is influenced by their interactions and context. For example, children who perceive themselves to be successful mathematicians show more interest in mathematics, have less concern about making mistakes in their work and have higher subjective wellbeing (Jõgi, Kikas, Lerkkanen & Mägi, 2015; Suárez-Álvarez et al, 2014; Yao, Kong & Cai, 2018). Conversely, those with low mathematics self-concept show lower interest in mathematics as well as higher levels of mathematics anxiety (Ahmed, Minnaert, Kuyper & van der Werf, 2012; Justicia-Galiano, Martín-Puga, Linares & Pelegrina, 2017; Lindskog, Winman & Poom, 2017). Mathematics self-concept also shows correlations with gender, with girls more likely to have implicit ideas that boys are stronger at mathematics and less likely to have a high mathematics self-concept (Cvencek, Kapur & Meltzoff, 2015; Seaton et al., 2014). Even experiencing a mathematics problem as challenging may be enough to trigger negative self-beliefs or impair performance, reinforcing children's negative self-evaluations of ability (Croizet et al., 2020). Where teachers evaluate students as having low mathematics skills, these students are also more likely to show a reduction in their mathematics self-concept (DeLiema, 2017; Lazarides et al., 2018; Lee & Stankov, 2018). Current English education policies which expect children to progress at broadly the same pace (DfE, 2016) overtly highlight differences in mathematics attainment to both teachers and students (Haimovitz & Dweck, 2017; Ng, 2018) and can lead to negative mathematics self-concept (Croizet et al., 2020).

Low-valued skills.

Mathematics is not a single distinct skill: it has no universal definition and there are no cognitive or neurological areas that exclusively cause a person to have difficulties or show success in learning mathematics (Calderón-Tena, 2016; Fuchs, Geary, Fuchs, Compton & Hamlett, 2014; Geary et al., 2009; Shin & Bryant, 2015). Constructions of mathematics ability or inability are therefore socially, politically and culturally constructed based on what mathematics skills and knowledge are valued or prioritised by those who create the curriculum (Radford, 2012, 2014). Ideas about mathematics success in England are often absolutist and narrow, with a primary focus on number and arithmetic (Alderton & Gifford, 2018; Perry & Dockett, 2018) and a preoccupation with 'the right answer' (Ocean & Skourdoumbis, 2016). The current culture of high stakes testing in England also serves to narrow the curriculum and separate mathematics skills that are valued from those that are not (Keddie, 2016). Endeavours to close the attainment gap can be problematic in themselves. Attempts to homogenise mathematical success reinforce assumptions that there is a single universally valued form of mathematics, and that other forms of mathematical learning and development are of lesser value.

It remains acceptable in English society to treat those with difficulties in following the 'normal' curriculum and developmental pathway in mathematics less favourably in their access to education and employment choices (Harpur, Connolly & Blanck, 2017; Perlin, 2009). Easterbrook, Hadden and Nieuwenhuis (2020) and before them Tannock (2008) describe 'educationalism' and 'credentialism' (discrimination on the basis of particular educational standards or academic qualifications) as some of the last acceptable prejudices in the Western world. Within the English education system this is perhaps most observable in the necessity for strong GCSE mathematics performance in order to access many tertiary education courses and employment positions (Rushton & Wilson, 2014). This is despite employers' and tertiary providers' doubts over the suitability or necessity of the mathematics skills gained through the GCSE syllabi (Rushton & Wilson, 2014; Tannock, 2008). That children from lower social classes are more likely to be seen as better suited to vocational qualifications than to formal academic study can further reduce their access (Batruch et al., 2020).

Conversely, functional mathematics skills can be perceived as 'primary knowledge', acquired simply through natural exposure within the environment (Geary, 2000; Sweller, 2008). Consequently, pupils may feel devalued when engaging with these forms of qualification compared to more academic routes (Spruyt, Droogenbroeck & Kavadias, 2015). This is despite evidence from international assessments (OECD, 2014) that suggest the functional mathematics skills required to participate within society are far from intuitive; for example, only ten percent of 15 year-olds who performed well within the international PISA assessments in 2012 demonstrated financial literacy skills such as banking (OECD, 2014).

Educational Psychology and the Attainment Gap

Educational psychologists are tasked with reducing barriers to pupils' learning and promoting equality of educational opportunities (BPS, 2002, 2008). The inequalities that the mathematics attainment gap perpetuates are therefore particularly relevant to educational psychologists. There is certainly no shortage of psychological research to draw from surrounding mathematics development and evidence-based interventions (Andersson & Östergren, 2012; Calderón-Tena, 2016; Geary, 2010 for reviews). However, this wealth of research appears to have had little impact upon the mathematics attainment gap, and psychological interventions and approaches have shown variability in their success in reducing attainment disadvantages for vulnerable learners (EEF, 2018a; 2018b). This is despite promising research findings that specifically focussed upon ameliorating mathematics difficulties within socially disadvantaged areas (Jordan & Levine, 2009; Kirkland, Manning, Osaki & Hicks, 2015; Zhou, Peverly & Lin, 2005).

Educational psychologists consider multiple influences upon attainment when working with individual children, including emotional, environmental and biological influences (Bettle, Frederickson, & Sharp, 2010; Moir, 2018). However, specific efforts to reduce the mathematics attainment gap through the use of psychology often focus upon the systematic design and evaluation of mathematics interventions or training within school settings (Alderton & Gifford, 2018; Butterworth & Laurillard, 2010; National Strategies Primary, 2009; Monei & Pedro, 2017). In the past decade, there has been an increased emphasis within educational psychology upon the use of evidence-based interventions and the 'implementation science' of how to most effectively deliver them (Forman et al., 2013; Kelly, 2012; and Ogden & Fixsen, 2014 for overviews). The aim of much work in the area of implementation science involves improving intervention fidelity and adapting interventions to improve generalisation to different populations (Kelly, 2012; Ogden & Fixsen, 2014).

The Educational Testing Service (2018) based in the United States of America notes that much intervention research is based on relatively small group-level findings that requires adaptation when being generalised to other groups. While the size and demographics of the English population differs from the United States, similar trends are observed in English intervention research. For example, some seemingly successful mathematics interventions such as 'Catch-Up Numeracy' and 'Maths Counts' have shown limited or even negative impact upon mathematical attainment for children in receipt of pupil premium when upscaled (EEF, 2019a; 2019c). The complexity and diversity of any classroom studied makes generalisation inherently difficult (Forman et al., 2013). Croizet et al. (2020) note that social psychological interventions related to social or cultural inequalities in education are only likely to work where all the salient features of the intervention group are the same as those in the research samples from which they are drawn. While educational psychologists exploring the area of implementation science are beginning to utilise broader approaches that take into account contextual and attitudinal factors, this approach remains in its infancy (Moir, 2018).

The importance of context.

Professional practice guidelines for educational psychologists emphasise the importance of selecting interventions and approaches to match the needs of those they are working with (BPS, 2002; Health and Care Professions Council (HCPC), 2016). It is widely acknowledged that no single psychological approach will be applicable to all people in all situations (Biesta, 2010; Croizet et al., 2020; Lambirth & Cabral, 2017). However, some psychological theories gain particular popularity within schools at different points in time. One such example is the theory of growth mindset devised by Carol Dweck, which strongly influences the mastery model of mathematics learning. Where teachers use a growth mindset approach to mathematics attainment differences, they acknowledge the potential of all children to change and develop with practice and effort, and reject the idea that current attainment is a predictor of future ability (Dweck, 2008, Haimovitz & Dweck, 2013).

Dweck (2008) suggests that both teachers and pupils either show a fixed mindset related to mathematics where their ability is thought to be predetermined, or a growth mindset where they believe they can change their learning potential through effort and persistence (Dweck, 2008). It is argued that while students with a fixed mindset may avoid academic challenge and seek shallow success such as high test scores or correct answers, those with a growth mindset are more likely to persevere in the face of challenge, value personal progress and view mathematics success as within their control (Dweck, 2008; Haimovitz & Dweck, 2017). The mathematics mastery approach seeks to adapt children's mindsets to value growth mindset-related 'mastery goals' over fixed mindset-related 'performance goals' (Boyd & Ash, 2018; Skaalvik & Federici, 2016). By emphasising mastery goals such as problem-solving and creative reasoning rather than performance goals such as test results and competition, pupils' academic performance in mathematics has been shown to improve (Bonnett, Yuill, & Carr, 2017; Boyd & Ash, 2018; Katz & Stupel, 2016; Lee, Ning, & Goh, 2014; Skaalvik & Federici, 2016)

While backed by a substantial evidence base, the positive effects of growth-mindset and mathematics mastery approaches can vary significantly depending on the context and individuals involved. For students to benefit most from a mastery approach, there needs to be low emphasis upon performance goal structures within the school context; namely, less of a focus upon testing and individual competition (Lee et al., 2014; Skaalvik & Federici, 2016). Indeed, performance goal focus is thought to negatively affect mathematics performance (Lee et al., 2014). As teachers are unable to avoid national assessment measures and pressure to measure student performance (Done & Murphy, 2018; Moore & Clarke, 2016) this is a significant barrier to the potential success of mastery approaches, which teachers may ultimately be held accountable for (Done & Murphy, 2018).

Some authors are critical of the growth mindset model itself. For example, Li and Bates (2019) question whether the approach is successful because of pupils' beliefs that learning ability can be changed, suggesting it is their belief that they can improve with effort and practice that is the reason for the approach's success. The growth mindset model is consequently criticised for its lack of explicitness that some learning expectations may be unattainable for some learners, especially within the normalised timescales and narrowed foci of some education systems (Li & Bates, 2019; Ng, 2018). Reiterating arguments that anyone can succeed with sufficient effort, without directly acknowledging environmental barriers, can again perpetuate meritocratic narratives and reinforce hidden inequalities (Augostinos & Callaghan, 2020). It may also add to teacher dissonance between the expectation of universal attainment standards and the reality of their daily experiences (Gable, 2014; Hamilton & Hamilton, 2010).

Problematic narratives.

Educational psychologists seek to reframe assumptions and narratives in their work, using psychological knowledge and skills to aid understanding of children and advocate for them (BPS, 2002; HCPC, 2016). While educational psychologists share psychological knowledge in order to provide educators with the tools they need to support children, this knowledge can be interpreted in different ways, both by teachers and psychologists themselves. This can result in theories being applied or interpreted in ways that reinforce or exacerbate existing inequalities rather than addressing or improving them. For example, the implicit assumption that 'low ability' and low socio-economic status are somehow linked may have been strengthened rather than dissipated by some recent developments in psychological research (Peach, 2015). Trends in both psychology and neuroscience that have suggested 'critical windows' for developing certain skills and 'optimal periods' for intervention can lead to deterministic ideas around future learning potential if they are not carefully presented (Rose & Abi-Rached, 2013). Other theories around early child development and the influence of primary caregivers can lead to suggestions that underperformance is due to within-child or within-family factors, taking attention away from children’s development potential and other within-school environmental barriers (Peach, 2015).

Conversely, some areas of psychology that may challenge assumptions of mathematics ability are infrequently presented. For example Sheehy-Skeffington (2020) points to evidence that children experiencing economic hardship such as food shortage re-allocate cognitive resources to different executive functions rather than experiencing cognitive overload related to their situation. They noted that while the impulse control of children with this experience was negatively affected, cognitive flexibility and working-memory updating in these children was often higher relative to those with more stable economic backgrounds. Sheehy-Skeffington also reviews evidence suggesting that when more affluent people are presented with the same level of uncertainty around meeting their basic needs, they too demonstrated increased impulsivity in their decision making. This identification of relative strength is not intended to negate the profound negative impacts that poverty can have upon children, but to challenge deterministic ideas. Sheehy Skeffington’s work would suggest that pupils have relative cognitive strengths during times of hardship and their levels of impulsivity should not be assumed to be biological or the result of poor parenting (Peach, 2015) but a product of their situation.

Educational psychology practice can also serve to reinforce ability narratives within the current education system. The identification of need that is ‘additional to or different from’ those of others is the statutory duty of educational psychologists and teachers alike (DfE, 2014). However, this can result in ‘othering’ of young people who do not follow age-related normative expectations in mathematics (Alderton & Gifford, 2018; Florian & Florian, 2014). Through the process of statutory assessment the longstanding nature of a person's difficulties are conferred to them. Just as low performance may signal to pupils and their teachers that they are likely to have a lower learning potential over time (Haimovitz & Dweck, 2017) an education health and care plan may explicitly set out alternative or reduced learning outcomes based upon current levels of attainment, limiting performance expectations for children with such plans. Educational psychologists therefore manage similar dilemmas to teachers when promoting inclusion and advocating for children within the constraints of school systems and funding formulas.

Advocacy, inclusion and pupil voice

Educational psychologists are in a position to advocate for those with relatively low power and influence (BPS, 2002; Fox, 2015; HCPC, 2014). In the case of mathematics learning, as is the case in many areas, it can be assumed that attaining success in mathematics should be a goal for all learners. While success in mathematics may be a key aim for the adults in their lives, young people are rarely consulted or provided with choice around the interventions they receive, such as their separation from peers, the activities they miss to receive this support or the methods by which their attainment is improved (Alderton & Gifford, 2018). This may mean that children appear disengaged from the learning process and lead to accusations of low effort. However, it is the role of educational psychologists to draw attention to alternative perspectives such as a lack of role models, perceived futility in attaining normative standards, low mathematics self-concept or a feeling that mathematics 'isn't for people like them'. Children should not feel they have to normalise themselves to be successful mathematicians or indeed members of society (Peach, 2015); a capabilities approach (Nussbaum, 2000; Sen, 2005), allowing people to pursue what they choose to value, do or be, is one way of working towards this aim. The challenge, however, is to accept and value the perspectives of children without excluding them from the skills and qualifications they require for future economic success and social status as a consequence.

Educational psychologists also have a role in highlighting children's areas of strength related to mathematics that may not have previously been acknowledged or are less frequently celebrated. Where individuals do not meet the required standards of numeracy, their 'deficit' may be seen as burdensome (Norwich, 2014), with teachers reluctant or unable to slow the pace of learning for other children to ensure all can participate (Peers, 2015). This mirrors wider societal trends where young people with the potential to be economically active members of society are valued more highly than those who may be less likely to be so (Done, Knowler & Murphy, 2015). Norwich, (2014) argues that while it is a common assumption that external barriers such as the curriculum are alterable and impairments not so, the opposite can be true. He points particularly to the difficulties inherent in altering school-wide external factors such as the curriculum because of the costs, both social and personal, to the majority. However, in an age of academies, curriculum changes are increasingly common within schools, suggesting that perhaps this is an ideological rather than a practical barrier. The American-based Education Testing Service (2018) note that personal interests (e.g. in computer coding), emotional skills (e.g. resilience) and personality traits (e.g. agreeableness) will all contribute to the value of a person's mathematics skills that may not be explicitly taught or valued within a typical mathematics curriculum; While education systems vary, similar skills are likely to be valued in English employment sectors and the broader societal culture of the United Kingdom.

Summary

In this literature review I have discussed key narratives and assumptions which can reinforce and maintain the mathematics attainment gap between disadvantaged children and their more affluent peers. Teachers and their pupils can quickly develop negative assumptions of mathematics potential despite unequal starting points, which can negatively affect children's levels of effort and mathematics self-concept and be difficult to later redress. Messages within the school context that confer which behaviours and mathematics skills are valued and which are not can lead students to perceive mathematics to not be 'for them'. This is of particular importance as social status and economic success are bound to these narrow measures of mathematics attainment, despite their lack of representativeness of the skills required to successfully use mathematics in daily life and employment.

The psychological skills and knowledge applied by educational psychologists to tackle the attainment gap must be tailored to the particular contexts and situations within which they are working. This is particularly important as some psychological theories may prove ineffective, or even counterproductive when applied within different contexts or situations. Understanding both pupil and teacher perspectives is an important part of this process, in addition to the school and home culture within which they are enacted. In order to advocate effectively for children, educational psychologists must not only explore and understand the views, context and experiences of the child, but also the views, context and experiences of their teachers. In doing so, they can identify hidden barriers or supports within teachers' narratives and approaches to maximise children's mathematics learning potential.

This thesis is structured around what Silverman (2012) terms a “mystery story approach”, where the research story is allowed to unfold and develop as it did over the course of the research itself. As such, this literature review has provided a broad introduction to relevant areas of research, while additional literature is drawn upon and presented throughout my analyses chapters as it arose. Additional literature that is presented in later chapters is provided specifically and purposefully to illustrate and develop the themes and narratives identified(Silverman, 2000; Wolcott, 1990).

Chapter Three: Methodology

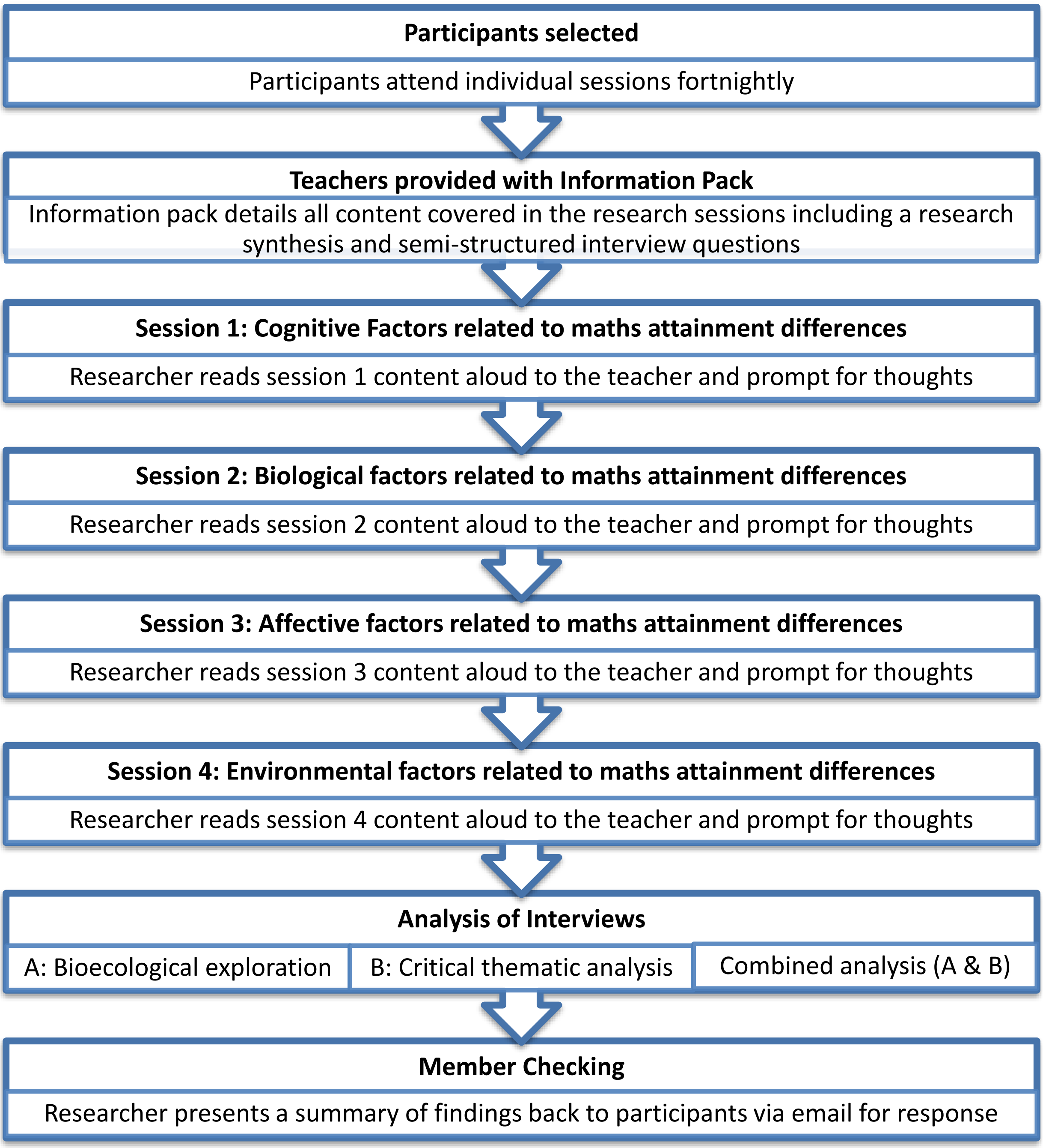
The purpose of this study was to explore teachers' views around mathematics attainment differences. My aims were to identify central themes in these teachers' conceptualisations and explore how this may be influenced by their personal characteristics, historical experiences and wider context (their bioecology). In order to achieve these aims, I selected the following interconnected research questions:

1. **How do primary school teachers conceptualise mathematics attainment differences?**
2. **How are primary school teachers' conceptualisations of mathematics attainment differences influenced by their personal characteristics, wider context and historical experiences?**

In order to answer these research questions I used a multiple case study design to explore the 'bounded system' of each teacher. Each teacher was interviewed four times at two-week intervals. Within each interview, the teacher was asked semi-structured interview questions, presented with psychological research related to mathematics attainment to reflect upon, and asked additional questions related to recurrent themes. This information was analysed in two ways: A critical thematic analysis (Lawless & Chen, 2019) was completed to identify central themes in teachers' views around mathematics attainment differences, and the teachers' personal characteristics, context and experiences were explored using the bioecological model (Bronfenbrenner & Morris, 2007). These analyses were then combined to consider how teachers' bioecology influenced their conceptualisations of mathematics attainment differences. A summary of this research process is shown in Figure 1.

Figure 1

Overview of Research Process



In this chapter I will detail the methodology of this study and my reasoning for selecting this approach. I will begin with a discussion of the theoretical standpoint and psychological framework that guided this research. This is followed by greater detail related to the study design and procedure, including ethical considerations. The two forms of analysis I used are then outlined and discussed before a final section evaluating the quality of this research.

Theoretical standpoint

As my aim in this research was to identify and better explore teachers' conceptualisations, it was integral that I accepted their self-reports as a 'true' reflection of their reality. As such, my ontological perspective (how I conceptualised 'truth') and my epistemological perspective (how I conceptualised 'knowledge') were rooted in the ideas of critical constructivism. Critical constructivism was first popularised by Freire (1970) in his seminal work 'Pedagogy of the Oppressed'. Freire suggests that knowledge is not tangible (like books in a library that can be readily accessed as required) but is instead created by people in interaction with their world. While critical constructivism presents knowledge and truth as socially constructed it also emphasises that knowledge is not equally valued by individuals and societies, as while some knowledge is privileged other truths and realities may be rejected (Freire, 1970; Kincheloe, 2008).

In his book 'Knowledge and Human Interests', Habermas (1987) discussed the need to uncover personal biases and misrepresentations to understand social inequalities. To do this, Habermas noted that self-awareness requires the seeking out of lower power narratives and perspectives that differ from our default assumptions. Critical analysis however can also be performed through identifying the beliefs and assumptions of those in positions of relative power (Lawless & Chen, 2019), in this case teachers. By highlighting these unspoken views and the influence they have on maintaining inequalities, teachers have the opportunity to identify and change these perspectives (Moon, 2004; Olafson, Schraw & Vander Veldt, 2010). In the course of this research I hoped to uncover some less powerful and privileged knowledges and address imbalances of status (Kincheloe, 2008) both identified by teachers or observable in their constructions of mathematics attainment differences. It was my hope that this identification would be beneficial for the participant teachers, for myself as a researcher and practitioner, and as a contribution to understanding in this field of research.

Psychological Framework

In line with critical constructivist ideas, my research aim was to develop a thick, complex and detailed understanding of how teachers construct mathematics attainment differences (Kincheloe, 2008; Knoble, 1999). I therefore chose to use the bioecological model of human development (Bronfenbrenner & Morris, 2007) to inform both my study design and analysis. Although frequently associated with developmental psychology, this model has also been used as a theoretical framework in educational psychology research (Heath, 2015) and in educational research evaluating the impact of interventions (Farrant & Zubrick, 2011; Jaeger, 2016; Perry & Dockett, 2018). While earlier versions of the model focussed upon the interaction between a person and the systems within which they exist (Bronfenbrenner, 1979), the most recent iteration, the bioecological model (Bronfenbrenner & Morris, 2007), outlines four interacting elements: person, process, context and time. Bronfenbrenner and Morris (2007) further divide the four elements of their model into subcategories as presented in Table 1.

Table 1
Elements and sub-categories from the bioecological model (Bronfenbrenner & Morris, 2007)

Element	**Sub-category**	**Example Features**
Process	Form	Type of interaction
	Content	Content of the interaction
	Power	Who controls the interactions
	Direction	What initiates the interaction
Person	Demand characteristics	Age, gender, physical appearance
	Resource characteristics	Past experiences, skills, access to education
	Force characteristics	Temperament e.g. resilience
Context	Microsystem	Home, school, other regular environments
	Mesosystem	Microsystem – microsystem interactions
	Exosystem	Systems of indirect influence
	Macrosystem	Cultural norms, values and beliefs
Time	Micro-time	Individual processes e.g. single interactions
	Meso-time	The frequency/consistency of a process over a period of time
	Macro-time/ Chronosystem	Historical events and circumstances

While some categories within the model such as demand and force characteristics might be considered at odds with the critical constructivist orientation of this research, the features of each subcategory are more nuanced. Indeed Bronfenbrenner and Morris (2007) themselves note that the subjective experience of each category is as important as the physical property itself. For example, seeing yourself to be ‘a mathematics person’ could be deemed a demand characteristic in the context of this research despite this being a subjective attribution, as the person sees this as an innate or unchangeable state. Further examples of features that may be influential or relevant to understanding primary teachers' views around mathematics attainment differences are presented in Table 2.

Table 2
Primary teacher example features for bioecological model sub-categories

Element	Sub-category	Example Features
Process	Form	Method of teaching, barriers to learning
	Content	What is taught, how much and when
	Power	Level of choice over content and methods of teaching, value assigned to different areas
	Direction	Teacher-led vs child-led sessions, impacting on home, school or child?
Person	Demand Characteristics	Experiences of gendered mathematics expectations, years since qualifying as a teacher.
	Resource Characteristics	CPD opportunities, past experiences of mathematics
	Force Characteristics	Level of resilience to challenge, temperament
Context	Microsystem	School policies, classroom approaches, home life
	Mesosystem	Parental expectations, local support networks, teacher's work-life balance
	Exosystem	Children's engagement with mathematics outside of school, parental working hours
	Macrosystem	Curriculum expectations, measures of success, cultural mathematics perceptions
Time	Micro-time	Identification of difficulties within a mathematics session, impact of children's mood or current events on learning.
	Meso-time	New initiatives and approaches in mathematics, changes of staff or head teacher.
	Macro-time/ Chronosystem	Own experiences of mathematics at school, curriculum changes, teaching experience

Bronfenbrenner and Morris (2007) particularly emphasise the importance of proximal processes in their bioecological model; those frequent actions and interactions undertaken in the course of an individual's daily life. Bronfenbrenner and Morris (2007) describe the primacy of proximal processes as their first proposition of the theory. As Perry and Dockett (2018) and Jaeger (2016) note, the complexity, regularity and sustained interaction of teaching environments fits the key characteristics of the proximal processes. However, while these two authors focus their attention upon the ongoing development of skill or knowledge of a child, my own focus is to analyse how the interactions, experiences and characteristics of teachers shape their views. second proposition of the bioecological model states that variations in the power and direction of interactions should be considered (Bronfenbrenner & Morris, 2007). This mirrors the critical constructivist stance of this research as hidden assumptions, inequalities and hierarchies are explored in relation to the views held by participating teachers to address research question two.

Study Design

To match the contextual and exploratory nature of this research, I chose a multiple case-study design to explore and answer my research questions; Each participant teacher was defined as a 'case', given that their particular personal, procedural, contextual and temporal characteristics represented a 'bounded system' (Creswell, 2007; Stake, 2006; Yin, 2012). In line with case study design, detailed information was collected from each teacher across several information sources (Creswell, 2007), in this case four semi-structured interviews at fortnightly intervals of between 50 and 90 minutes in length. The interview sessions were presented to the teachers as a professional development opportunity. Teachers were provided with up-to-date academic findings around the psychology of mathematics through an information pack which was handed out to each teacher and read aloud to them each session. An example of the information pack content for one of these sessions can be found in Appendix 1. Teachers were asked to reflect upon their own experiences relative to the research findings and asked semi-structured questions to elicit their views across a range of contexts and time periods. Each of the four interview sessions was delivered individually in a quiet room within the participating teacher's school. Sessions were audio-recorded for later transcription.

Participant Selection

I approached schools across a single county in South West England to participate in this study. The county chosen contained types of schools and communities that are representative of South West England, having a mixture of urban, rural, coastal, faith and specialist settings within it. The region also has a higher than average attainment gap compared to the national average (EPI, 2019). As this was an exploratory study, it was not my intention to select a specific type of school, but to offer new perspectives and avenues for consideration within the field (Malterud, Siersma & Guassora, 2016). Therefore, opportunistic sampling based on which headteachers and teachers showed interest in participation was utilised.

Headteachers throughout the study region were contacted via email with study information to ensure that the requirements of participation were acceptable and the study aims were clear (Appendix 2a and 2b) . Headteachers were asked to disseminate this information to staff, who were asked to contact me directly if they were interested in participating. A requirement for selection was that the teacher must be teaching mathematics sessions at least twice per week, to ensure sufficient opportunities to view and reflect upon mathematics attainment differences. When teachers contacted me to express their interest they were sent a participant information sheet providing further details of what the study would entail to ensure they were fully informed of the expectations of the research from the outset (Appendix 3).

Creswell (2007) recommends that no more than four or five case studies be presented in a single piece of research. Therefore of the eight teachers who expressed an interest in participation, four teachers were selected to participate, based on date of expression of interest.

Data Collection

In order to achieve my study aims, it was important that the information I gathered from participants was both broad and detailed. To achieve this, I used a combination of questioning and psychological research presentation related to mathematics to elicit participant teachers' views. An information pack was handed out to each teacher at the beginning of session 1. This contained all of the interview questions and psychological research that would be shared within all four sessions. An example of the information pack content can be found in Appendix 1. The interview questions were semi-structured in nature; therefore they may have been rephrased or supplementary questions asked in order to develop and extend participant narratives. In the tradition of critical constructivism, there were also occasions where additional questions were asked to facilitate critical discussion and self-reflection, and to open up new conversations (Freire, 1970).

Semi-structured interview questions.

In order to increase the depth and richness of the data collected, I designed semi-structured interview questions and prompts based on the sub-categories from the bioecological model (Bronfenbrenner & Morris, 2007) that I posed at the beginning of each study session. Examples of these questions are provided in Table 3. While the questions were designed to cover particular elements or sub-categories that might otherwise not be elicited such as teachers' own experiences of learning mathematics at school, teachers often provided information that was relevant to additional or different categories during this process. I therefore ensured that I analysed interviews in their entirety to identify themes and influences, rather than specific parts of each interview.

Table 3
Examples of bioecological questions posed within each session

Session	**Example questions or prompts**
Session 1: Introduction and Cognitive Factors	Tell me a bit about yourself/this school/your class How would you rate your mathematics skills? What do you remember about learning mathematics when you were at school? What cognitive barriers do you observe in your classroom?
Session 2: Biological Factors	Have there been any big changes since we last met? Do you have any personal experiences of biological conditions that have affected your family or friends?
Session 3: Affective Factors	How do you feel when you hear the word mathematics? Do you think the children in your class enjoy mathematics?
Session 4: Environmental Factors	How has mathematics teaching been since we last met? What environmental barriers do you think there are to pupils' math learning in your class?

I also gathered rich narratives throughout the sessions when the participating teachers were engaging with the psychological research presented. This research and its presentation is described in more detail below. Teachers were prompted for their perspectives related to this research to elicit their views. This allowed me to explore elements or sub-categories that had been explored less extensively, or where teachers showed particularly strong influences within a category. Examples of the types of questioning and themes of inquiry that I explored within each subcategory are presented in Table 4.

Table 4
Example bioecological prompts and discussions used throughout the research

Element	Sub-category	Example questions/prompts/discussions
Person	Demand Characteristics Resource Characteristics Force Characteristics	How did you react to that? Which parts of mathematics do you like teaching most? What is a good mathematics session to you?
Process	Form Content Power Direction	Is that something you do in your class? Has the curriculum changed a lot? Is knowing the right mathematics word important? Who chooses the pairings/groups?
Context	Microsystem Mesosystem Exosystem Macrosystem	How does the classroom impact upon learning? What environmental barriers do you notice? What involvement do you have with parents? How do assessments influence classroom practice?
Time	Micro-time Meso-time Macro-time	What do you see in your classroom? How have things been since our last session? How does that compare to your own schooling?

Presentation of psychological research.

As I wanted teachers to consider a broad range of views and possible contributing factors related to mathematics attainment differences, I presented them with a research synthesis of psychological factors that influence mathematics learning. This research synthesis was presented to the participant teachers by way of an information pack, a sample of which can be found in Appendix 1. Teachers were provided their own copy of this information pack in the first session. During each session, I read aloud each of the findings in the information pack chronologically and asked teachers for their views on these findings at regular intervals. Teachers were under no obligation to read or engage with the information pack before or after the sessions. The intention of providing the research synthesis was not to alter the participating teachers' behaviour (as might be seen in action research), but to better understand teachers' views related to mathematical attainment differences through a case study approach.

To create an exhaustive list of all research findings would have been impractical: searches for psychology and mathematics in journal databases retrieve tens of thousands of articles. However, I wanted to ensure that the breadth of psychological influences was represented with my own biases limited. I therefore created a research synthesis of academic literature from the last five years, summarised for ease of dissemination. Details of the synthesis procedure, including exclusion criteria can be found in Appendix 4. The synthesised research was divided into four categories: cognitive, biological, affective and environmental; each category formed the research section of one of the interview sessions. Each category was further divided into pupil-related, teacher-related and intervention-related findings to structure each session. An example of the structure and topics covered in a session is presented in Table 5. Examples of the content of this research are further illustrated in Appendix 1.

Table 5
Example of the structure and topics covered in an interview (from interview 1: cognitive factors)

Section	**Subsections**
Semi-structured interview questions	About the teacher About the school they work in and current class Cognitive factors they observe at school Cognitive factors experienced by themselves or those close to them
Pupil-related	Visuo-spatial skills and memory Self-regulation and meta-cognition Cognitive flexibility and updating Fluid reasoning, knowledge and long-term memory Processing speed Verbal working memory, phonetic coding and reading Short-term and working memory
Teacher-related	Teachers' own cognitive skills Teacher awareness of the impact of cognitive skills Teacher assumptions and misconceptions around cognitive skills
Interventions	Pupil related interventions Teacher related interventions

Ethical considerations

This study was approved by the ethics committee of the Graduate School of Education at the University of Exeter (Appendix 5). It was designed in accordance with ethical guidelines published by the British Educational Research Association (2018), the British Psychological Society (2014), and the Health and Care Professions Council (2014). Participants were provided with detailed study information through a participant information sheet prior to completing the interview sessions and their consent was gathered both in writing and verbally at the beginning of the first interview session. Participants were informed of their right to withdraw from the research up to the date of thesis submission. In addition, a summary of my analysis of their interviews was presented back to each teacher via email at the end of the analysis process as part of ‘member checking’ (Creswell, 2007; Driessen, Van Der Vleuten, Schuwirth, Van Tartwijk & Vermunt, 2005) to ensure participants were satisfied with the way in which their views had been presented.

As sessions were completed on an individual basis, confidentiality could be fully maintained during the sessions using appropriate storage of audio recordings and data in line with data protection guidelines. However, due to the detailed nature of information gathering in the case study design, additional efforts were required to ensure participant anonymity in the study write-up phase. The name of both the school and the local authority have therefore been omitted. Names and specifics of former teachers, family members or other school staff were also modified (e.g. using job titles or the word ‘family member’ rather than names or specific relationships such as sister). Additional characteristics that might make a teacher or school identifiable were also discussed during the member checking process and edited to ensure anonymity as required.

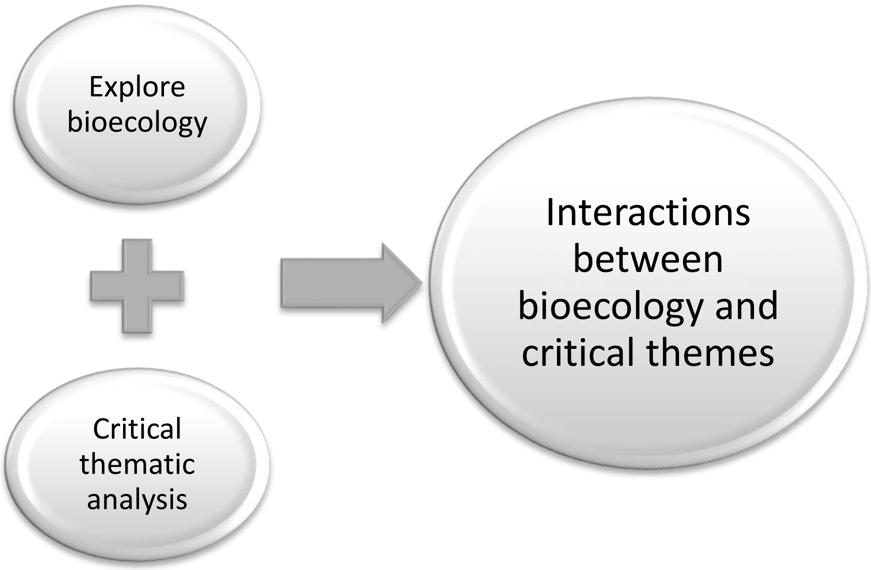
I followed the example of Alderton and Gifford (2018) when writing up and discussing teacher views, treating them with sensitivity. I endeavoured to avoid value judgements of teachers’ views and perspectives and instead explore the influences and interactions that may have led them to develop these views. I also acknowledged explicitly the difficulties teachers faced in balancing tensions such as maintaining inclusion in the face of accountability measures. However the possible impact of the views that teachers hold is also fully explored, in order to ensure that the influence of these perspectives upon pupils’ mathematics attainment can be critically analysed.

Analysis

After each interview session, I transcribed the audio recordings myself using word processing software and audio transcription tools. Transcribing the data myself allowed me to review and re-familiarise myself with the interviews and begin to identify key features and themes. Recordings were anonymised, for example through the replacement of names for titles, but otherwise were transcribed word for word. Italics and underlining were used to indicate emphasis or exclamation, to aid later critical thematic analysis (Lawless & Chen, 2019). Where I identified potential themes in the interviews, I adjusted and developed my questioning in order to further explore this in subsequent sessions, whilst retaining the planned breadth of questioning.

Having transcribed each interview, I conducted an exploration of each teacher's personal, historical and contextual influences using the bioecological model, and a critical thematic analysis of their views around mathematics attainment differences. Both of these analyses are described in more detail below. These analyses were considered in isolation and in combination in order to gain a deeper and more complex understanding of how each teacher views differential attainment in mathematics (as shown in figure 2). A coded interview extract can be viewed in Appendix 7.

Figure 2
Separate and combined analysis of the interview data



Exploring teachers' bioecology.

The elements and subcategories of Bronfenbrenner and Morris's (2007) bioecological model were used to analyse the personal, contextual and historical experiences of the participant teachers (their bioecology). I identified statements from each teacher's interviews that matched the elements and sub-categories of this model using multiple readings. While my semi-structured interview questions had been designed to elicit particular information such as the teacher's own school-based mathematics experiences, evidence from all parts of the interview were considered and collated during this process. It should be noted that I categorised interview information in terms of how the individual ascribed meaning, using their construction rather than a research-based or personal viewpoint. For example, one teacher viewed her abilities in creative writing to be unchangeable and a consequence of how her 'brain works' and consequently this was identified as a demand characteristic, despite academic views that such learning abilities are in fact malleable (Haimovitz & Dweck, 2017).

Critical thematic analysis.

My second form of analysis involved identifying critical themes in each teacher's conceptualisations of mathematics attainment differences. While thematic analysis (Braun & Clarke, 2006) can and has been used by critical researchers to effectively identify critical themes (Lawless & Chen, 2019), I chose to use an explicit critical framework for this purpose. Lawless and Chen developed critical thematic analysis for precisely this purpose. Drawing from the work of William Owen (1984), the open coding process of critical thematic analysis involves identifying three types of occurrence within the study data:

1. **Recurrence:** where a thought or idea repeatedly emerges.
2. **Repetition:** where a particular word or phrase is frequently repeated.
3. **Forcefulness:** where use of emphasis, exclamation or emotive tone suggests it holds particular importance.

Lawless and Chen suggest that these instances of recurrence, repetition and forcefulness are used to identify oppressive ideologies, status hierarchies and power inequalities. In my analysis, the critical themes identified include examples of ideologies, hierarchies and inequalities that teachers may be actively attempting to reduce, as well as those that they actively or implicitly support. Multiple illustrative examples of repetition, recurrence and forcefulness were required to identify a theme in order to provide 'categorical aggregation' (Stake, 1995). These themes were discussed alongside related academic literature, combining research findings with critical discussion.

Combined bioecological and critical thematic analysis.

My second research question concerned the influence that each teacher's bioecology had upon their views around mathematics attainment differences. In order to answer this question, I explored the relationship between the themes identified through critical thematic analysis and the bioecological influences reported by each teacher. As part of this analysis I categorised which bioecological aspects appeared to be either supporting and maintaining or challenging and diversifying the teacher's thoughts around each critical theme. In this analysis I included observations of influences that appeared to be connected to their views (e.g. valuing the characteristics of a teacher considered to be a role model) as well as those that were overtly noted to be influential by teachers (e.g. wanting children to have or avoid the same experiences as the teacher themselves).

Evaluating Research Quality

Qualitative researchers including those involved specifically in case study designs such as Lincoln and Guba (1994,2000) propose that the use of evaluative criteria supports research quality. As this research uses a qualitative design, traditional quantitative evaluation measures such as reliability, objectivity and validity are not appropriate to this study (Creswell, 2007; Northcote, 2012). I have instead used Northcote's (2012) guiding principles and questions, amalgamated from the work of multiple authors in this field to evaluate my research methodology. Northcote's principles suggest that qualitative research should be contributory, rigorous, defensible, credible and affective. Each of these features will be discussed below in relation to my study design.

Contribution.

Northcote (2012) defines the contribution of the research as its advancement of wider knowledge or understanding in the field, and its benefit to the research participants involved. While this research does not aspire to produce generalisable findings, it does provide new insights and a richer picture of teachers' views around mathematics attainment differences. In addition, it provided the participant teachers with research knowledge related to the psychology of mathematics and opportunities to critically reflect upon their own views, assumptions and classroom practices. While the participating teachers may have preferred more practical or directive models related to the psychology of mathematics teaching and learning (Cain, 2015a, 2015b; Laski, Reeves, Ganley & Mitchell, 2007; Vanderlinde & van Braak, 2010), opportunities to critically reflect on academic research have been shown to be highly valued by teachers and beneficial to their perceived competence as teachers (Cain, 2015a, 2015b). Indeed, teachers within this study reported appreciating the opportunity to sit and think deeply about the pupils in their class and how they approach mathematics teaching in their classroom. These extracts from the interviews of Teacher B and Teacher C illustrate this point:

> It's really thought provoking. It's sort of taking the time to sort of think about things in a different way, and it gets me looking at children and trying you know thinking about different factors that I might not have considered before. (Teacher B, interview 1)
>
> Just...giving you some time to stop and think about how you're teaching and think oh that'll be useful, that wouldn't ..." (Teacher C, interview 4)

Defensibility, rigour and credibility.

It was important that my study design and methodology demonstrated defensibility (ability to adequately address the research aims) rigour (transparency and systematic application) and credibility (well-developed evidence-based findings) (Northcote, 2012). These factors directly affect its relative contribution to the field, and the perceived value and trustworthiness of my findings (Northcote, 2012). The use of a multiple case study design with longitudinal interviews allowed for the in-depth exploration required to adequately answer my research questions. My choice of psychological and analysis frameworks were also clearly linked to the study aims and explicitly and systematically used throughout this study (Northcote, 2012; Tudge, 2016; Tudge, Payir, Merçon-vargas, Cao, & Liang, 2016). Credibility was demonstrated using multiple quotes to illustrate my themes that were collected from several interviews over an extended period of time. Credibility was further developed by presenting contradictory or divergent excerpts related to the themes identified (Creswell, 2007; Stake, 1995) and through member checking of my analysis by participating teachers (Creswell, 2007; Driessen et al., 2005). An exploration of my own bioecological influences (Appendix 6), also supported identification of my own characteristics, contexts and experiences that may influence my critical analysis.

Affect

Northcote (2012) also proposes that good quality qualitative research should capture frustrations, passion and emphasis of both research participants and the researcher. Representing teachers' affect was addressed routinely through the critical thematic analysis process, where forcefulness was explicitly reported and integrated. In order to capture my own affective responses, I document times where themes or ideas particularly provoked my emotional reactions in the discussion and findings sections of chapter five: Teachers' conceptualisations of mathematics attainment differences.

Chapter Four: Introduction to Research Participants

This research explores the views and influences of four primary school teachers from a variety of school settings within South West England. This introductory chapter is included to allow readers to familiarise themselves with the teachers who participated in this study. It will allow the reader to build a picture of each teacher from the personal characteristics, wider contexts, teaching practices and historical experiences that they shared during our multiple interviews ahead of subsequent analyses.

The teachers within this research have been assigned the labels Teacher A, Teacher B, Teacher C and Teacher D for ease of reference and to protect anonymity. Each teacher represents a case study or 'bounded system' with multiple influences and interactions that may shape their thinking. A bioecological profile for each teacher is provided using the bioecological model (Bronfenbrenner & Morris, 2007) as a guiding framework. The influences most frequently or emphatically mentioned by participants are included in this profile. A summary of other bioecological features less frequently mentioned but nonetheless present is provided in tables six to nine. The chapter concludes with a brief summary contrasting the most prominent influences for each teacher and tentatively identifying some emerging similarities in the bioecological categories that show greatest prominence.

Teacher A

Teacher A teaches in a lower key stage two class in a special school for children with learning disabilities. Teacher A's class predominantly includes children with autism, Down syndrome and combined autism and Down syndrome diagnoses. A number of the children in her class experience 'mathematics phobia' and react negatively to the word 'mathematics' being mentioned. Teacher A rejected some curriculum expectations and progress measures as unsuitable for the children in her class, and discussed the need to recognise children's 'limits' and what was realistic for them to achieve. She noted that parents too could have unrealistic expectations of what their children may achieve relative to their learning difficulties.

Teacher A has been in her role for less than a year, having recently returned to teaching after a career break. She reported enjoying reading professional develoment material to 'catch up' on knowledge to improve her teaching. Her previous experiences include working with children with Profound and Multiple Learning Disabilities (PMLD) since her childhood and some of her family members being autistic or having attachment needs. She also had experience in mainstream settings. She disliked the flippant use of words such as 'depressed' or 'autistic' as they trivialised the profound impact of these conditions.

Teacher A described herself as a 'rules person'. She reported enjoying the 'logical' nature of mathematics although she did not think she could have studied it at University level. Teacher A fondly remembered her mathematics teacher from high school. Her teaching focus was to improve children's practical mathematics skills and enjoyment of mathematics; She reported supporting children to see how mathematics is a skill for life and could be a source of wonder. Table 6 further illustrates Teacher A's bioecology.

Table 6
Biolecological elicitation for Teacher A

Element	Sub-category	Features identified
Process	Form	Practical exploratory lessons, real life applications, repetition and familiarisation, making learning fun.
	Content	Practical skills supported, considering interests of the child and relevance in society e.g. money and 'Candy Crush', knowing when to 'stop' and what is not realistic for children.
	Power	Discussed feeling the need to justify diverging from the curriculum or traditional lessons. Letting children explore equipment and activities themselves.
	Direction	Encouraging independence in task completion and child choice in how to do so.
Person	Demand characteristics	'Rules person' who visualises things and is logical, difficulty in creative writing, 'unable' to achieve in mathematics past A level.
	Resource characteristics	Experience working with children with PMLD, family members who are autistic, does own reading outside of school about teaching mathematics (CPD). Returned to teaching after career break and period of time as a teaching assistant.
	Force characteristics	A 'rules' person, difficulty identifying alternative ways to explain or repeat what she finds easy to understand, motivated to make lessons enjoyable for children, dislike of labels (e.g. depressed) being used flippantly as the impact of conditions is high.
Context	Microsystem	Lower key stage 2 class, autism, Down syndrome and combined autism and Down syndrome most prominent needs. Some children show 'mathematics phobia'.
	Mesosystem	Specialist setting, tiredness of children caused by travel time, own family members with attachment needs or autism.
	Exosystem	People 'taking advantage' of children's low mathematics skills in the future, parental beliefs about 'not being good at mathematics', unrealistic parental perceptions of children's progress.
	Macrosystem	National measures of progress and national curriculum not seen to be relevant to children in her class, expectation children will always be pushed to continue progressing, cultural perception of mathematics as 'hard'.
Time	Micro-time	Transitions between lessons, knowing when to 'throw the lesson plan out of the window'.
	Meso-time	How mathematics is described to reduce anxiety (e.g. not mathematics but number or shape), lots of change in class with children switching classes and previous teacher long-term sickness, seeing children succeed when it seemed they would never 'get it'.
	Macro-time/ Chronosystem	Enjoyed mathematics at school but not literacy, teacher training and the way things are taught has changed since her school days (positively, own teacher being direct, logical and precise, wonder of mathematics at expense of grades at A-level, previously worked as a teaching assistant in specialist setting and as SENDCo in early years as well as mainstream teaching, has observed the progress of children with additional needs in schools since childhood.

Teacher B

Teacher B teaches in key stage one in a medium-sized faith school and is the school mathematics lead. She has been a teacher within her current school for around 12 years (since qualifying). Children in her class are mainly making expected progress in mathematics, with a small group of lower attaining learners. Teacher B reported that the school had previously been rated “requires improvement” by Ofsted but school leadership was now “really good”. She reported feeling supported in her role as mathematics lead by leadership meetings within the area, although reduced levels of teaching assistant support and the possible pressure to use a scheme of work for mathematics were reported difficulties.

Teacher B attended a grammar school and described needing to work hard at mathematics as it ‘did not come easily’ to her. She particularly reported that teachers did not “invest in” her or believe she was capable of achieving in mathematics. Teacher B described how she was determined to achieve despite this. A positive experience of mathematics learning during her teacher training altered Teacher A’s views around her mathematics abilities. She reported now wanting to demonstrate to others that they ‘can do mathematics, while not expecting others to find mathematics easy.

Teacher B discussed the time and curriculum pressures associated with national assessments in most school years in either mathematics or literacy. She noted that the pace of mathematics learning expected prevented effective consolidation and was keen to ensure that children have the foundational skills they needed in mathematics to allow them to succeed in future academic years. She also observed difficulties in ensuring that mathematics methods and the value ascribed to mathematics were consistent between home and school. Teacher B described inconsistencies between home and school as ‘a challenge’ and a source of confusion.

Table 7 further illustrates Teacher B’s bioecology.

Table 7
Biolecological elicitation for Teacher B

Element	Sub-category	Features identified
Process	Form	No ‘one way of doing things’ in mathematics, time needed for consolidation. schemes of work negative for mathematics teaching.
	Content	Needing to have the basics before being able to progress, ‘high achievers’ struggle with some areas more than mid-attainers.
	Power	Avoids formal methods at early ages while parents may introduce them early, needing to teach particular things for formal assessments, lack of availability of teaching assistant support.
	Direction	Children showing each other their methods encouraged, hierarchy/stages of progression in mathematics skills and methods identified as important.
Person	Demand characteristics	More ‘inclined’ towards English than mathematics, 12 years teaching experience, previous experience of anxiety.
	Resource characteristics	Had supportive parents, now more confident in mathematics skills, is mathematics lead within school, experience of visual and hearing impairment in family.
	Force characteristics	Doesn’t expect others to find mathematics easy, has a determined attitude to learning, thinks everyone can ‘do mathematics’ prioritises security, wellbeing and safety of children.
Context	Microsystem	Small class size and pupils ‘lovely’, 3 learners identified as low attaining, medium-sized faith school.
	Mesosystem	Supportive group of mathematics leads, supportive leadership, Own child is particularly interested in mathematics, other family members have low belief in their mathematics abilities.
	Exosystem	Parents confuse their children with different methods or not engaging with mathematics at home, valuing the TV programme numberblocks.
	Macrosystem	Government focus on formal assessments challenging, doesn’t demonstrate progress of some children.
Time	Micro-time	Teaching different inputs or shorter inputs to particular children to meet their needs.
	Meso-time	‘Liking mistakes’ and valuing different perspectives in mathematics sessions, making this part of classroom culture, elation when children succeed having struggled in the past, culture of acknowledging that who succeeds may change over time.
	Macro-time / Chronosystem	Did not feel invested in or believed in at secondary school, particularly in mathematics, negative experience of grammar school education, mathematics booster course during PGCE changed her perceptions of her own ability to learn mathematics.

Teacher C

Teacher C teaches part-time in a key stage two class in an urban school. She has been teaching for 10 years, mostly within her current school. The school catchment is within a disadvantaged area and the school was rated “requires improvement” in its last Ofsted inspection; Teacher C reported that levels of disadvantage led to the school struggling to meet national expecations. She identified children in her class to have low self-esteem, low language skills, slow processing speed and low reading skills. Teacher C described how the school have recently become part of a multi-academy trust and there have been changes in the curriculum to focus upon skills that they would need outside of mathematics and literacy.

Teacher C enjoyed mathematics at school as she is a “rule person”. She generally “didn’t mind school” noting that this was not the same for some children she teaches. She recalled mathematics being more rigid and less practical when she was at school but that teachers continued with a topic until all had understood. She found statistics at university made more sense than the work she completed at GCSE because it “had a reason”; she reported making efforts to contextualise mathematics and make connections for children in her class in a similar vein.

Teacher C is told that one of her strengths is “the ability to explain things in different ways”. She noted that the school’s low results and the level of deprivation of the area within which she teaches meant there had been more consistent funding for mathematics professional development opportunities than there might be in other contexts. She also stressed the importance of working on learning behaviours such as resilience rather than solely mathematics specific skills. It was important to her that all children enjoyed mathematics and left the school with lower levels of disadvantage than when they arrived, which she felt was a sentiment that all staff shared. Table 8 further illustrates Teacher C's bioecology.

Table 8
Biolecological elicitation for Teacher C

Element	Sub-category	Features identified
Process	Form	Uses problem-solving models which value variety of answers and making mistakes. Contextualises mathematics skills.
	Content	Too much to cover in curriculum to consolidate it effectively. Not always relevant or accessible to children.
	Power	Restricted by what the government measure, but still focussed on problem-solving with success in later assessments.
	Direction	Encouragement of children to share ideas, learn from each other, teacher learning from pupils' different approaches
Person	Demand characteristics	Is a 'rules' person, finds mathematics easier to understand when it has a purpose. Enjoyed mathematics and school generally. Teaching for 10 years in the same setting. Early years trained.
	Resource characteristics	Lots of CPD opportunities due to low performance of pupils in mathematics and additional funding. Has a psychology degree.
	Force characteristics	Wants children to enjoy mathematics – makes this her "mission". Determined that children make progress despite starting points. Good at explaining things in different ways.
Context	Microsystem	Variety of needs within the class, frustration at trying to cater for wide range of ability in class without adult support, 'most settled class in the school'.
	Mesosystem	Lack of parental engagement and limited mathematics activities at home, school has high levels of free school meal uptake, has young children at home, curriculum changes to fit class needs.
	Exosystem	Has observed family and friends to have difficulties with dyslexia and low self-belief.
	Macrosystem	Expectations of everyone being at age related standards impossible despite progress and hard work, content in assessment seems deliberately inaccessible at times, graded as requires improvement due to grades not being high enough.
Time	Micro-time	Certain learning sessions particularly difficult for some children, important how children complete a task as much as the right answer.
	Meso-time	Previous initiative related to learning behaviours had lasting positive impact.
	Macro-time / Chronosystem	Enjoyed mathematics at school and school generally, has seen many changes in teaching approach and education initiatives, recalled mathematics being more rigid and less practical but all moving along at the same pace.

Teacher D

Teacher D teaches in a mixed early years and key stage one class in a small rural school. The school is part of a federation of small schools in the area. She has been teaching for three years, and has been working at the school since she qualified. Teacher D enjoyed teaching mathematics in her class as it is “more practical” than in key stage two classes. She saw some of the technical mathematics language and rigid learning of particular mathematics skills as a barrier at times, particularly where they might be “unnecessary” for progression and understanding. Teacher D was well supported within her school and valued advice from her mathematics coordinator and her experienced teaching assistant. As a relatively young teacher she noted she was better able to remember her schooling than other teachers might, which was a strength.

Teacher D described having always known she would end up working in education, and that her first primary school teacher “made me want to be a teacher”. She particularly valued how kind this teacher was when she experienced a family bereavement at a young age, making sure she was happy at school and being sensitive to what was happening in her life. She stated that “being happy” would improve everything at school, including mathematics.

Teacher D described her mathematics knowledge as sufficient for key stage one and reported she performed well at mathematics GCSE. However, she described her memory for properties of shapes as a persistent difficulty and shape as an area of mathematics that she disliked. Teacher D had a family member with an additional need and noted that this impacted upon his ability to learn mathematics at school. Teacher D reported adjusting activities and learning to match the interests and preferred environments of class members to increase their motivation, particularly those with special educational needs. Table 9 futher illustrates Teacher D's bioecology.

Table 9
Biolecological elicitation for Teacher D

Element	Sub-category	Features identified
Process	Form	Elicitation and open-ended tasks seen as difficult for students less confident in mathematics and problematic for self-esteem.
	Content	Sees need for children to have exposure to number breadth but finds complicated/varied vocabulary for mathematics operations unhelpful.
	Power	Pressure from external advisors and system to use certain methods (e.g. problem-solving for all at start) and language.
	Direction	Values other class members verbalising what they know to support other children's understanding.
Person	Demand characteristics	Been teaching for 3 years in same school, close family bereavement when she was the same age as her students, enjoys teaching mathematics that's practical.
	Resource characteristics	Supportive mathematics lead who she can access to ask questions. Good mathematics skills in most areas.
	Force characteristics	Comfortable to admit not knowing and takes advice willingly from others, questions the reasoning of what she teaches, wellbeing focus.
Context	Microsystem	Teaches in mixed early years KS1 class, focus upon presentation in books at school level and new behaviour management policy brought in (traffic light model).
	Mesosystem	Many parents 'relatively old' and less aware of current approaches in mathematics, 'mathematicsy' parent that is child's idol increasing his motivation in mathematics relative to literacy. Family member had additional need which impacted upon his mathematics.
	Exosystem	People running CPD that puts you on the spot disliked, negative experience.
	Macrosystem	Phase advisors and other CPD contradicting/providing different messages, questions remaining about how to manage the needs and confidence of those on SEN register., unrealistic expectations of performance of SEN children.
Time	Micro-time	Children more engaged if the mathematics is physical/practical / outside/ matched to interests, feels starting with elicitation 'waste of time' or negative for children with lower mathematics knowledge.
	Meso-time	Relatively young compared to other teachers in school and so recalls own school days better.
	Macro-time / Chronosystem	Remembered mathematics teacher not being very engaging in secondary, low mathematics technical language when went to school, change of headteacher two years ago, memories of 'best teacher' at time of bereavement that provided positive distractions.

Summary

All four of the teachers that participated in this study showed high variation in their bioecological influences despite being of the same gender and working within schools in the same local authority area. In addition, each teacher identified a multitude of bioecological influences that were pertinent to their discussions of mathematics attainment rather than a single element or subcategory. Various categories appeared to interact and influence each other, although these interactions were not always straightforward. For example, chronosystemic experiences such as learning mathematics at school interacted with the content, form and direction of mathematics teaching processes, but these were also influenced by macrosystemic expectations and assessment standards.

All teachers reported being influenced in their teaching by their own experiences of learning mathematics at school. However, this influence was not always based upon positive experiences and the form of this influence was highly variable. For example, Teacher B described widely negative experiences of learning mathematics at school but the interaction of this with her force characteristics of determination and resilience and her subsequent positive experiences in teacher training had increased her resolve to support children in their mathematics learning. Pressure for children to reach baseline standards was also frequently raised by the participating teachers, and this too interacted with their force characteristics and proximal processes such as content and form of lessons. Overall, while some similarities could be identified between the teachers in this study, their bioecological profiles were markedly different to each other.

Chapter Five: Teachers' Conceptualisations of Mathematics Attainment Differences

The teachers in this research conceptualised mathematics attainment differences in a variety of ways. My aim in this chapter is to explore these conceptualisations to answer my first research question: How do primary school teachers conceptualise mathematics attainment differences? In order to address this question, the views of each of the case study teachers related to mathematics attainment differences were gathered using their research interviews. These interviews were interpreted using a critical thematic analysis (Lawless & Chen, 2019), identifying reiteration, repetition and forcefulness in their discussions.

This chapter combines research findings and discussion related to each teacher's conceptualisations of the mathematics attainment gap. Each teacher's case is presented in turn as a sub-section of this chapter. For each case, I will describe the central theme and sub-themes that emerged from my analysis alongside critical discussion of these themes, supported by relevant psychological research, theory and models. These themes and subthemes are named and illustrated using 'in vivo' quotes from the interviews conducted. At the end of this chapter, a brief summary of each teacher's conceptualisation is provided alongside discussion of some common viewpoints that emerged across the cases examined.

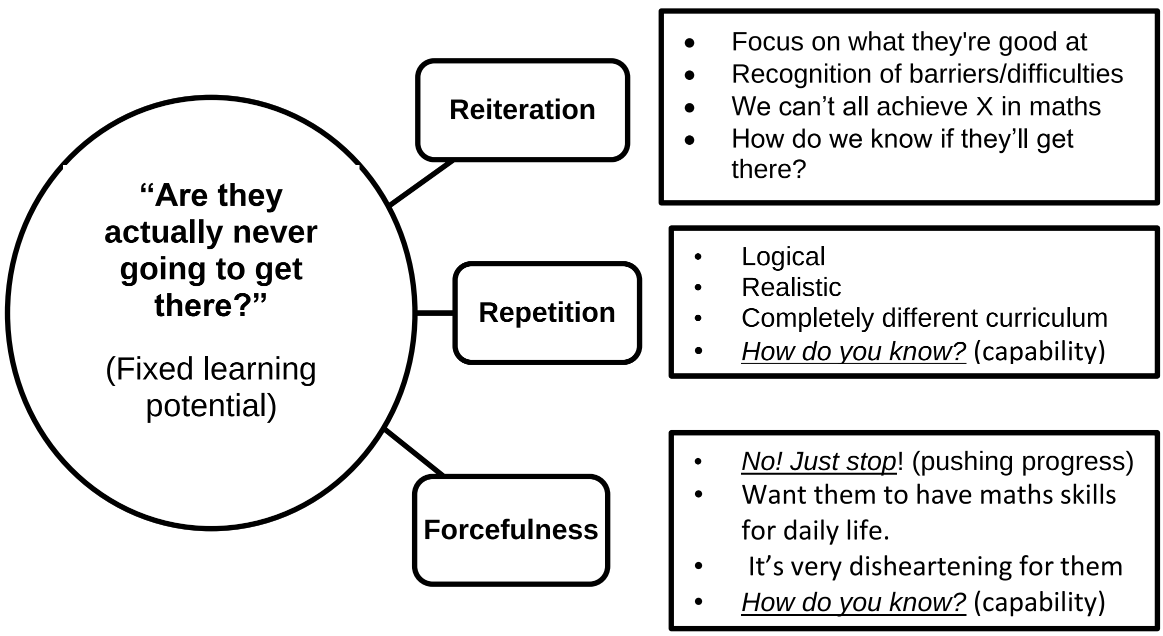
Teacher A

"That six-million-dollar question... How do we know what they will be capable of?"

Central Theme: "Are they actually never going to get there?"

Repetition, reiteration and forcefulness within Teacher A's interviews showed her most prominent construction of mathematics attainment difference was that pupils have different underlying capabilities and learning potentials. She frequently commented on the relentlessness of the quest for progress in children's attainment, often forcefully opposing this. She also talked extensively about the need for children to be able to focus upon areas of strength or relevance for themselves, both within mathematics or in other areas of interest and skill. A summary of the critical thematic analysis of Teacher A's interviews is presented in Figure 3.

Figure 3
Reiteration, repetition and forcefulness related to Teacher A's central theme



“Am I trying to get their brain to do something it will never be able to do?”

Teacher A often referred to biological explanations for fixed abilities in mathematics. She noted, “Some people are just more mathematically minded aren't they,” and reported specific examples such as spatial awareness, stating, “You can't obviously change that; that is the way your brain perceives things.” While there are genetic and biological influences upon children’s mathematics learning, a number of environmental influences can significantly alter this trajectory, including formal schooling (Plomin & Deary, 2015; Stern, 2017). In addition, there are no direct brain to cognition correspondences or cognitive skills that can predict mathematics attainment (Calderón-Tena, 2016; Siugzdaite et al., 2020). Consequently, while biology and cognitive differences may influence mathematics attainment, they are by no means predictors of it as Teacher A may assume.

Teacher A discussed a broader limit or ‘ceiling’ to children’s mathematics learning, particularly where they have a learning difficulty. She showed concern that she might have expectations of children which were beyond their capabilities. She reported:

> You're thinking actually, cognitively, has this child...are they actually never going to get there? Because they're just cognitively…their brain won't allow them. I'm trying to get their brain to do something it will never be able to do. That's really tricky.

Stern (2017) notes that some young people with severe and genetic learning disabilities may follow different cognitive development pathways to typically developing children. Much research into educating children with severe disabilities however has shown that learning curricular mathematics skills is possible with adaptations in teaching methods, additional support and practice (Courtade, Spooner, Browder & Jiminez, 2012; Meier, 2020). Stern (2017) also emphasises that the majority of children, including those with moderate learning difficulties, might better be described as at a different point on the same learning trajectory rather than qualitatively different in the way they develop. Teacher A showed awareness of this trajectory, noting, “All of a sudden it just clicks. Even when you're about to give up and think ‘Oh they're fed up of that now.’ It might be it takes a year and they can do it.”

Some authors argue that fostering children’s development potential and acknowledging their limitations are not mutually exclusive where intrinsic motivation and hard work is promoted (Li & Bates, 2019; Ng, 2018). Teacher A appeared to make particular efforts to develop intrinsic motivation for mathematics within her class, and she remained committed to supporting children’s progress despite her reservations around their potential limits. For example, she reported, “I want [them] you know to be curious and have wonder about their world, which includes mathematics … For me personally that's what it's about. Get them wanting to explore and investigate and find out.” She particularly identified ‘hidden’ mathematics as we talked, discussing the joy of mathematics activities for their own sake:

> That's why people do sudoku, there's no particularly...it's because it's fun, and they like it, and because it's ...you know it's not going to do anything! It's not purposeful...but I think sometimes for some people mathematics is that isn't it. Or on their phones, doing patterns you know Candy Crush, it's all mathematics. But without realising it...never thought of that before.

However, in relation to progress against curriculum targets, Teacher A’s views were markedly different. On several occasions, Teacher A emphasised that teachers should “stop” when children have achieved a difficult goal, noting that the pressure to constantly progress limited their opportunities to celebrate success and feel positive about their current level of skill. She proposed, “It's helping them feel comfortable in their own skin: actually being a circle's brilliant! Rather than always wanting to be a square." Despite this, she could identify occasions where persistence with difficult tasks had been beneficial, for example reporting, "He discovered that and the look on his face was just…priceless. Like, 'I'm doing this aren't I, and I've got it.' That was just magic." This contrast in Teacher A's views represents a dilemma she faces similar to the 'tragic choice' suggested by Norwich (2014): If Teacher A continues to pursue curricular progress, children may consistently feel inferior. However, if she does not, they may not reach their potential and experience these moments of revelation.

Teacher A voiced particular concern around the impact of persistent task failure on the confidence of the children in her class. For children who have lower mathematics attainment, failure to complete a task can reduce motivation and interest and confirm their own perceptions of themselves as poor mathematicians (Jõgi et al., 2015; Sewasew et al., 2018). Teacher A illustrated this in her own observations, stating "They've already put themselves as 'I'm a rubbish learner'," And, "They know they can't do it as well some of them. and I think that's really hard. They just know they don't get it. So what do you do? It's very disheartening for them." Teacher A noted that when she started teaching the class, several of the children were so averse to mathematics that "even the word mathematics" would cause them to disengage and physically leave activities. As a consequence, she taught "mathematics by stealth" in order to reduce these children's anxieties around mathematics. To do so she removed the word 'mathematics' from the timetable and encouraged play exploration of mathematical equipment rather than formal mathematics learning. Teacher A may be rightly concerned about the effects of persistent mathematics difficulties on children's anxiety: Mathematics anxiety develops in a similar pattern to a phobia, with negative environmental triggers fuelling a downwards cycle of anxious feelings and thoughts and avoidance behaviours (Lindskog et al., 2017).

Teacher A observed that curriculum expectations themselves reinforced children’s negative self-evaluations, as they highlighted attainment gaps and relative difficulties of children (Haimovitz & Dweck, 2017; Ng, 2018), particularly where they were repeating the same skill day after day. Teacher A protested:

> Because the framework that's set up for them they're just not going to achieve that and that's not fair is it. It's unrealistic expectations for the child. They're going to feel that they're not getting anywhere.

While Teacher A aimed to celebrate difference and avoid negative self-concept, she appeared to make some assumptions around the inevitability of low mathematics performance of pupils within the school. She suggested, “Actually almost the very fact that they're here in this kind of school, that isn't really going to happen, that's why they're here. Because they are going to struggle, they're going to need support.” Indeed she reported, “That's one of the huge challenges I found teaching....having a realistic goal…What can we realistically achieve next?” However, children’s conceptualisations of what a ‘realistic path’ or potential future are often based upon what they can observe in their own environment and social group (Oyserman & James, 2011). Within a specialist setting with diverse, severe and complex learning needs, it may be additionally difficult for pupils, parents and teachers alike to know where to pitch their expectations. Teacher A herself acknowledged that where students are aware of these lowered expectations they may develop the perception that their potential to succeed is low (DeLiema, 2017; Easterbrook et al., 2020; Kikas et al., 2018; Lazarides et al., 2018; Lee & Stankov, 2018). Through engagement with the psychological research presented she observed, “because other people are categorising me...So that's what I am... So I can't change, because I'm me. Fait Accompli. Interesting.”

“A completely different curriculum”

For Teacher A, there appeared to be a balance to strike between adequately recognising the difficulties that the children she teaches have in accessing the curriculum without negating their potential to progress. While Teacher A did not see national curriculum expectations as suitable for the children in her class, she described feeling the need to justify where she strayed from this curriculum, stating, “They need to revisit so much more and I think part of me as a teacher thinks I’m copping out by doing the same thing again, you know, what are we doing? The same thing; but they need that.” The dissonance between curriculum expectations and the reality of pupils’ learning needs has been noted in previous research (Gable, 2014; Hamilton & Hamilton, 2010; Norwich, 2014). Strong emotions were noted around this tension when Teacher A spoke of it, as she reported “I don't want to feel I'm either letting them down by not making them work harder at something, or actually just ...*stop it*! You're actually… they're not going to want to learn.”

Teacher A proposed that there was a certain point, though difficult to define, at which an alternative curriculum and expectations would be most beneficial for the mathematics development of children with learning difficulties. She frequently sought advice to this effect during our interactions, for example noting “I would really love to know what point you think actually ...let’s be a bit radical about our mathematical teaching and go ....put a completely different curriculum than the standard.” While current skills are often viewed as an indication of learning potential (Haimovitz & Dweck, 2017), Stern (2017) notes that genetic influences on cognitive development should not be confused with inevitability. Environmental factors, which could involve anything from nutrition to formal education, have a significant impact upon how genetic influences are expressed (Plomin & Deary, 2015; Siugzdaite et al., 2020; Stern, 2017).

In addition, between the ages of seven and nine, improved mathematics performance and general cognitive development have been shown to be reciprocally connected, with development in either area improving the other (Cowan, Hurry & Midouhas, 2018). Therefore the children in Teacher A's class may be simultaneously improving their mathematical and cognitive skills through their daily exposure to mathematics lessons, which may not be the case if mathematics sessions are altered or replaced. This adds to the difficulty that Teacher A faces in making a decision around what and how she teaches.

Particularly, Teacher A felt mathematics of greater relevance and importance to her students was functional skills; practical mathematics skills that would enable children to participate effectively in their adult lives. This is an area she reported researching for herself through books she had purchased. For example, she described the 'dollar first' strategy to learning money (Gurganus, 2017) in several interviews. Teacher A saw functional mathematics skills as particularly important for children's future independence. She wondered aloud, "How can we help them have those really important independent as much as possible life skills? I keep coming back to that." Teacher A described functional mathematics as "such an important skill for life. So empowering.", and illustrated its importance, for example to "get on a bus and know that if I buy that I won't have enough to get the bus home." She showed forcefulness and some anguish around her students' potential future vulnerability within society when discussing the consequences of low mathematics skills, stating, "When they get to 18 here … you dream for them… You just want them to be able to go to a shop or a pub and buy a drink and know they're not getting short changed."

There has been much debate around the relative importance of functional skills and curricular knowledge in the education of children with severe learning difficulties

(Ayres, Lowrey, Douglas & Sievers, 2011; Browder et al., 2012; Courtade et al., 2012; Graham, 2015; NUT, 2015; Meier, 2020). On one hand, having the practical mathematical skills and confidence required to participate in daily activities are highly important to ensure the independence of younger people and their ability to participate, contribute and be valued within society (Ayres et al., 2011; Batruch et al., 2020; Björnsdóttir & Traustadóttir, 2010; Meier, 2020; Tilly, 2019). On the other hand, the prioritisation of functional skills over curriculum participation can be problematic. Changing this curriculum assumes the inability of children with learning difficulties to achieve alongside their peers (Courtade et al., 2012; Graham, 2015; Meier, 2020). The requirement of specific mathematics qualifications to access a wide range of education and employment options remains a legitimate form of discrimination (Easterbrook et al., 2020; Tannock, 2008). This can lead to the exclusion of those with learning difficulties from various forms of employment or education and ultimately to anything other than low paid or unpaid work (Courtade et al., 2012; Graham, 2015). People who have a learning disability are often perceived by society as incompetent or dependent on others and their voices are habitually under-represented in equality debates (Björnsdóttir & Traustadóttir, 2010). This exclusion can exacerbate the longstanding low levels of social acceptability of those with learning disabilities (Deal, 2003; DeLambo, Chandras, Homa & Chandras, 2007; Stewart, 2004; Thomas, 2004).

Teacher A also expressed a wider frustration with the prioritisation of mathematics and literacy standards over other skills and attributes (Alderton & Gifford, 2018). Other research suggests that some special school teachers would agree with Teacher A, seeing the focus on literacy and numeracy as less relevant to their pupils than the development of ‘life skills’ (Ayres et al., 2011; NUT, 2015). However, this can serve to strengthen the perception of functional mathematics skills as a prerequisite or lesser skill relative to academic mathematics learning (Spruyt et al., 2015) and reduce the social status of children with learning difficulties still further (Courtade et al., 2012; Easterbrook et al., 2020; Tannock, 2008). This is despite the fact that the majority of academically successful students may not possess the functional numeracy skills at age 15 to manage their money effectively (OECD, 2014). Teacher A raised this argument in reverse, noting, “There are very proficient people in society who are functioning as adults very well without still being able to calculate, because that's what calculators are for. Or because they can function that way.” It therefore appeared that Teacher A disagreed with the narrow definition of mathematics skills as purely calculating (Alderton & Gifford, 2018; Perry & Dockett, 2018) and was more concerned with individual success than prescribed criteria as set out by the education system.

Teacher A talked about considering the particular strengths of the child when deciding what might be an appropriate curriculum or learning task for them, sometimes to the exclusion of mathematics learning altogether, noting, “What are they actually really good at? They're really creative - do that! Make that their thing.” This appeared to stem from a wish to see all young people achieve success and find “their place” in society, whether this was valued by the education system or not. For example, Teacher A shared this anecdote about an autistic young person she had worked with who took a job in a hairdressers:

> He was really sociable (bizarrely for an autistic person) but he *was* with certain people, old ladies particularly. And he loved tidying so he sweeped the hair up - he loved it! I mean that was just perfect. Isn't that wonderful? He wouldn't have been able to do the till, or...that would have made him feel really anxious and rubbish and … but actually, focus on what they're really good at.

Teacher A smiled and expressed delight that this young person had found a vocation that highlighted his strengths and his personal value. This reaction is understandable as negative evaluation of the potential autonomy, contribution and employability of people with learning differences is common, and leads to high levels of social exclusion for young adults with learning disabilities (Björnsdóttir & Traustadóttir, 2010; Tilly, 2019). However, the perception that this young man would be unable to develop the functional mathematics skills required to use the till was more problematic for myself, and has been noted to be a common assumption by researchers within the field of severe learning disability (Meier, 2020). If these assumptions are replicated in the employment setting, the chances of this young man progressing in his employment are low (Easterbrook et al., 2020; Tannock, 2008). Therefore, by removing the expectations of attainment for individuals with learning disabilities, there is a risk of further limiting their potential for social status and economic gain within society (Graham, 2015).

In summary, Teacher A viewed mathematics attainment differences to be largely but not exclusively biological in origin. She was concerned with the negative self-perception that children may develop through their difficulty in attaining mathematics skills over considerable periods of time, although she reported teacher and pupil delight when this was achieved. Teacher A saw efforts to equalise attainment to be minimising children’s difficulties and overlooking other strengths that they may have. She also disputed the relevance of the mathematics curriculum to children in her school, preferring a functional skill focus that would support children’s future life-skills and independence, as well as a broader interest in mathematics in all its various forms. Overall, she appeared to view acceptance and inclusion of children, whatever their strengths and learning needs, as a more important societal aim.

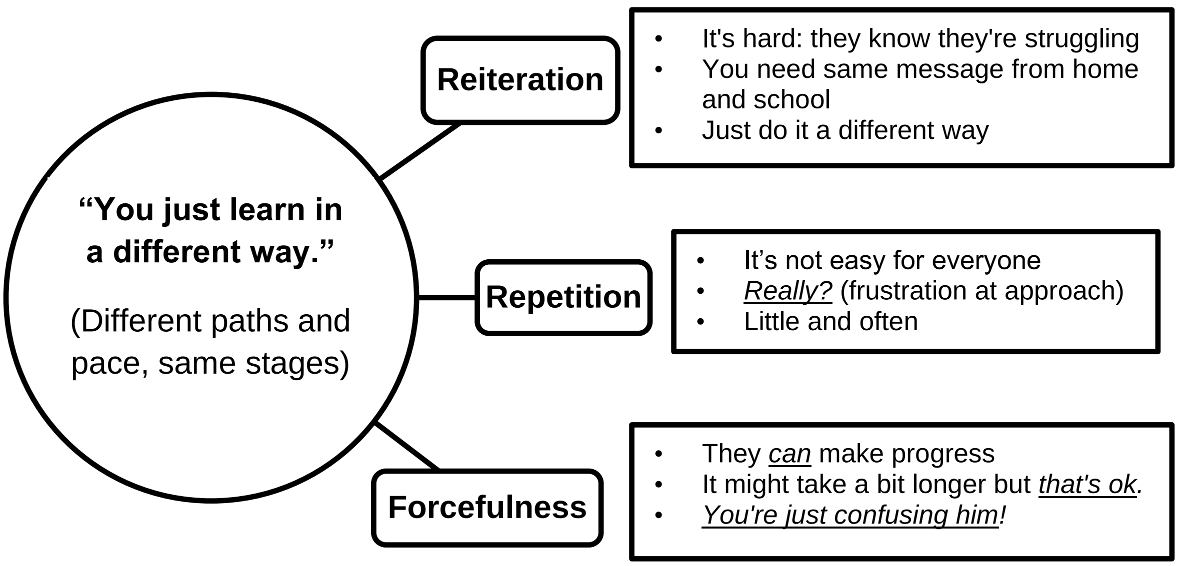
Teacher B

"It's not something I've ever found easy. So I don't anticipate everybody else is going to find it easy either."

Central Theme : "You just learn in a different way."

Repetition, reiteration and forcefulness within Teacher B's interviews suggested to me that Teacher B saw mathematics attainment difficulties to be linked to differences in the way that children learn. Teacher B conceptualised mathematics as a subject that children either did or did not have a natural affinity for. However, this is not to say that Teacher B perceived mathematics attainment differences to be inevitable over time and with appropriate intervention. In fact, Teacher B was forceful in her narratives that although children may learn mathematics skills in different ways and at different times, they "*can* do mathematics." Figure 4 summarises the critical thematic analysis of Teacher B's interviews.

Figure 4
Reiteration, repetition and forcefulness related to Teacher B's central theme



“It’s not easy for everyone.”

Teacher B reported some children were more ‘mathematically minded’ than others. It has been acknowledged in the literature that both teachers and children have a tendency to view genetic or ‘innate’ factors as more influential upon mathematics performance than environmental factors, and therefore assume ability to be relatively fixed (Marks, 2011, 2014). However, acknowledging genetic influences on mathematics attainment need not lead to a fixed conceptualisation of mathematics ability (Li & Bates, 2019; Ng, 2018) as illustrated by Teacher B. While she was aware of the differences and difficulties that individual children in her class were experiencing, she reiterated their ability to ultimately succeed in mathematics. She reported for example:

> You know who is secure and going to follow that line that they're supposed to and who's not necessarily going to follow that line. But that's not to say they won't get there eventually. They... It just might take a different path.

Teacher B’s conceptualisation that children are likely to attain key mathematics skills but at a different pace to each other is reinforced by longitudinal research related to cognitive development generally and mathematics more specifically (Klesczewski et al., 2018; Mok et al., 2015; Starr, DeWind & Brannon, 2017; Stern, 2017). However, educational policy in England is based upon an expectation that all children will develop at a pace that is broadly similar (DfE, 2016). Where progress is slower than this it can be difficult for teachers to not view current skill levels as an indication of mathematics attainment potential (Haimovitz & Dweck, 2017). Teacher B’s identification of children she ‘knows’ will struggle suggests that while she sees the potential of all to learn, ability categorisations are difficult to avoid.

Teacher B saw negative perceptions of mathematics ability to develop at an early age, suggesting, “If they decide they can't do it then they stick with that and they have that mindset.” The early development of these negative ability perceptions is perhaps unsurprising. Children will have arrived at school with a variety of different backgrounds and experiences, and those from disadvantaged backgrounds particularly are likely to already have lower mathematics skills than their peers (EEF, 2017; EPI, 2019). The universal attainment expectations of the English education system communicate to children their underachievement at an early stage, through subtle and overt cues of comparison and grouping (Haimovitz & Dweck, 2017; Ng, 2018), without reference to inequality of starting points (Batruch et al., 2020; Croizet et al., 2017). As a consequence, some children’s first experiences of classroom mathematics may highlight their low mathematics skill in comparison to their peers, negatively impacting upon their mathematics self-concept (Croizet et al., 2020). Teacher B identified how ‘low ability’ perceptions could also emerge in teacher evaluations without careful consideration:

> I think sometimes you kind of can pigeonhole them can't you, they're a lower ability child, they're this they're that, and actually well are there other things which are going on? What are the other things that could be helping?

Even in their first years of schooling, children can be aware of, and keen to avoid, being perceived to have low academic skills (Millet & Croizet, 2016). Teacher B noted the implications of low mathematics self-concept on children’s emotions and sought to actively avoid this in her classroom. She reported, “Like I always say, you have these children who say, ‘Oh that's easy’ and I say I don't like the word easy,...it's not a concept I want them shouting about, because it doesn't make other people feel very nice.” However, Teacher B noted a level of inevitability to categorisations and comparisons within the classroom, reporting:

> Although you don't necessarily ability group them, and you don't sort of kind of label them as such and such group anymore, they do work it out for themselves very early on. “Oh I'm the one who gets a lot of support, I'm the one who's you know I'm doing different work to you.”

Teacher B is correct that group names and ability tables are just one potential indicator for children of their relative ability. Pupils may gauge their relative low ability through withdrawal from class, proximity of a teaching assistant or use of additional resources for example (Browman & Destin, 2016; Marks, 2014). Alderton & Gifford's (2018) research identified a dilemma for primary school teachers between withdrawing children to differentiate content or including children in lessons they were unable to access. Alderton & Gifford likened this to the conceptualisation of a necessary but tragic choice between nominal inclusion and purposeful exclusion, as proposed by Norwich (2008). Some of Teacher B’s discussions around supporting struggling mathematics learners mirrored these arguments. For example she observed that “What one child needs is almost on a completely different curriculum to what some other child needs.” Discussing a small group of ‘low ability’ learners in her class, she noted, “They weren't staying in for the input because I didn't see the point: they couldn't access any of it. It wasn't the objective that they were covering.” For Teacher B, acknowledging children’s difficulties while supporting them to identify their progress was key to reducing their assumptions of failure (Augostinos & Callaghan, 2020; Croizet et al., 2020) and avoiding the ‘tragic choice’ dilemma. However she reported this could be difficult in certain situations such as speeded questioning or whole class discussion. For example she noted, “You know who's going to shoot their hand up straight away and who's sat there trying to work it out, who’s looking at the number line on the wall.” She talked of metaphorically “sitting” on children who “instantly can see an answer” to allow others thinking time, but described this as a challenge.

Teacher B also demonstrated considerable sadness and frustration around the negative perceptions parents may have around mathematics. She reported that parents who have concerns about their own mathematics ability tended to view mathematics as 'something for school' and disengage even from tasks within their abilities. She recalled:

> We had a parent activity session on multiplication and I had one Mum who said, "Oh I didn't come this morning because I'm rubbish at mathematics." It was just like *Ooooh! That's why you should have come!* … I think obviously she's got this perception that mathematics is too difficult for me and therefore I can't possibly support my son at home. It's like…I'm pretty sure you could put 20 in your head and help him count back 3."

This disengagement trend and its negative attainment consequences has been observed in parental educational involvement studies generally (JRF, 2012; Nuffield Foundation (NF), 2013; Wilder, 2014), with parents feeling schools inter-generationally do not represent their family's values or needs (Easterbrook, 2020). Research suggests that Teacher B is correct in her assumption that increasing engagement with reluctant parents would have a large positive impact upon their children's attainment (National College for School Leadership (NCSL), 2011). However, increasing parental engagement with home learning tasks is not wholly unproblematic. Soni & Kumari (2017) note that mathematics anxious parents can in fact increase their children's mathematics anxiety and reduce their mathematics self-concept when supporting them with mathematics at home. For this reason, increased parental support with home learning may need to be promoted with caution and supplemented with empathy and support for anxious or disengaged parents.

“If they haven't got it, then they really can't progress.”

Teacher B emphasised the necessity of foundational mathematics knowledge and skills. She stated, “You've got to get those basics embedded and then if they’re not, they struggle all the way through.” She reported that the success of some struggling students was due to “focussing on that one single objective, rather than kind of trying to teach everything else as well.” As suggested by Teacher B, children’s understanding of the concepts they learn in Key Stage 1 is believed to deepen over time (Nezhnov, Kardanova, Vasilyeva & Ludlow, 2014). Understanding of key mathematical ideas and concepts such as number lines (Anobile, Cicchini & Burr, 2012; Dehaene et al., 2008; Gersten, Schumacher & Jordan, 2017; Siegler, Thompson & Opfer, 2009) and estimating relative magnitude (Andersson & Östergren, 2012; Mejias, Grégoire & Noël, 2012; Woodward, 2017) have been consistently linked with mathematics attainment. However, the fast-paced and content-heavy curriculum within the English education system appears to complicate this, as teachers attempt to balance exposure to mathematics ideas and approaches with the repetition required to support consolidation and retention of learning (Alderton & Gifford, 2018). However, the assumption that children with difficulties learning mathematics will require explicit instruction in ‘the basics’ before they can progress to independent or problem-based tasks is strongly questioned by authors such as Kohli, Sullivan, Sadeh, and Zopluoglu (2015).

Teacher B did not solely focus on foundational mathematics skills, but also the importance of wellbeing, emotional security and emotional readiness to learn. For example, she noted, “I always say, unless you feel happy and safe, you can't learn,” and, “Definitely home life is certainly having an impact.” The negative effect of low wellbeing on attainment has been well documented (Parhiala, Torppa, Vasalampi, Eklund & Poikkeus, 2018; Public Health England, 2015; Yao et al., 2018). However Sheehy-Skeffington points to some cognitive skills (e.g. 'shifting' between different ways of completing a task) which may become demonstrably stronger in those experiencing deprivation than their peers. In addition, a number of resiliency factors within the environment can reduce the impact of adverse childhood experiences, enabling children to learn effectively despite their difficulties (Bellis et al., 2017; Longhi, Brown, Barila, Reed, & Porter, 2019). For example, additional emotional support within the classroom has been associated with improved engagement in mathematics classes where additional instructional support has not (Martin & Rimm-Kaufman, 2015). Talking about the impact on a child of working with the school pastoral teaching assistant, Teacher B reported:

> We were doing one more one less this morning and he was really confident with it, and I was really surprised … and now he's starting to be able to talk about it [difficulties at home], he's starting to move forward. It's just like a different child suddenly in the classroom.

At times, Teacher B's suggestions that emotional wellbeing must be prioritised led to an assumption that mathematics support during this time was not advisable. She reported for example, "I mean those two there's no point starting a mathematics intervention with them this year because there's other stuff going on for them and I think that's just… that's the priority." However, evidence suggests that access to mathematics support and challenge remains important for children who have difficult home circumstances (Longhi, Brown, Barila, Reed, & Porter, 2019; Mccormick, Connor & Barnes, 2016). Indeed, some research has suggested that increased task engagement and building up of focussed attention is particularly beneficial for children demonstrating poor attachment (Mccormick, Connor & Barnes, 2016). The importance of continued high expectations has also been emphasised by The All-Party

Parliamentary Group (2012) who brought to the fore the narratives of care leavers who felt there were chronically low expectations of their mathematics attainment during childhood. This is particularly important to highlight as for some children, emotional wellbeing and adverse experiences may be frequent and repetitive themes within their lives.

In contrast to her suggestion that specific secure foundations were required to access some mathematical tasks, Teacher B was more flexible in her ideas of the ways in which children might reach their mathematical understanding. She was a strong proponent of using different methods, explanations and resources to reframe mathematical concepts until children understood. Research related to brief experimental analysis has highlighted that the effectiveness of different methods and approaches vary considerably for each individual when mathematics attainment differences are present, supporting Teacher B's argument (Mong & Mong, 2012; Reisener, Dufrene, Clark, Olmi & Tingstrom, 2016).

Teacher B illustrated the positive effects of providing multiple conceptualisations in mathematics through her discussion of a particular child over the course of her four interviews with me. Through exploring different methods of calculating, the child eventually found a method of subtraction that he used confidently:

> [Session 1] 8 plus three. So he was like, "Oh!" and he found 8. And then he just almost did one jump, and sort of picked a number … He wasn't counting on.

> [Session 4] He had obviously really found something in the find the difference method, because straight away on his own he was counting the jumps between … But it was just bizarre that he "Wow!" you're actually doing this and it's just the way he seemed to be a lot more confident approaching it.

Perhaps due to the importance Teacher B placed on flexibility of approach, she highlighted the difficulty children face where parents place higher value on the “right answer” or “formal methods”. She saw this as a particular difficulty in the early stages of learning mathematics, noting they did not understand “there's a process and they’ve got to get through this process before they’re even able to get anywhere near those methods”. Teacher B viewed parental interactions where they “want to make sure they’re doing the same thing and clarify things with you” as more positive, as it retained the school message at home. Conversely, she reported that having a mixture of emphases and approaches resulted in children becoming “muddled” about how they should approach mathematics, as they attempted to appease both teacher and parent.

> When they've been taught a particular method at home and it's not necessarily a method that we’re particularly using in school and then they get in a real muddle … they're kind of like trying to switch between the two, trying to keep everybody happy.

DeFlorio & Beliakoff (2015) suggest that while some parents may assume that practicing more formal mathematical procedures at home will be beneficial for their children, exploratory, context-based activities such as assisting with the shopping are more effective in the early stages of mathematics home learning. However, by asking parents to adapt their methods of calculating to support their children, Teacher B is asking parents to make a conceptual shift in how they approach the subject, which may be experienced with a level of discomfort. This may particularly be the case where parents have had negative experiences of learning mathematics at school themselves (JRF, 2012; NF, 2013; Wilder, 2014) and where they view the rejection of the mathematics they use as a threat to their mathematics self-concept (Easterbrook, 2020). Teacher B’s suggestion that some methods should not be taught in early mathematics learning stages despite her support for flexible calculation approaches suggest it is the lack of underlying understanding and the unquestioning use of formal methods that she seeks to avoid.

In summary, Teacher B viewed mathematics attainment differences to be influenced by how easy or difficult a person found mathematics. However, she believed that by providing different approaches to mathematics and explaining concepts in multiple ways she could find a way that would suit each child, given enough time. She conceptualised that good foundational skills and knowledge in mathematics and feelings of safety and security were highly important, viewing deficits in these areas to be an additional source of mathematics attainment differences. She also viewed parental attitudes and interactions related to mathematics to affect both self-concept and attainment where they differed from the perspectives and approaches promoted at school.

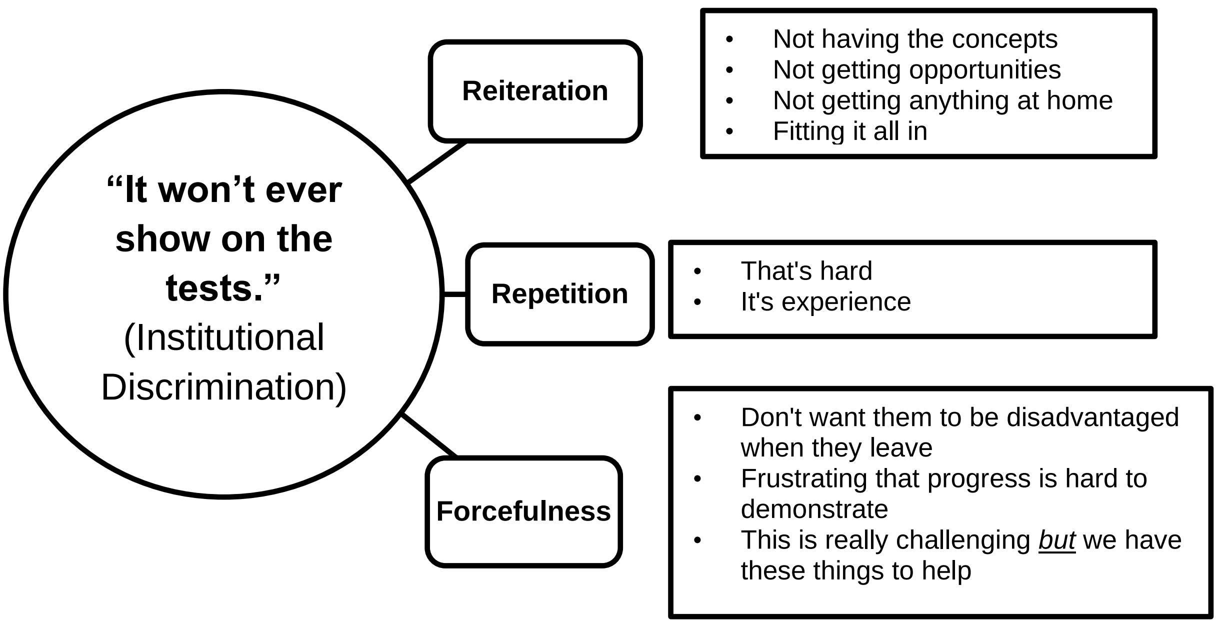
Teacher C

"We're striving all the time to make sure those children that are disadvantaged, it doesn't show when they leave us."

Central theme: "It won't ever show on the tests"

Themes that were frequently repeated, reiterated and emphasised by Teacher C centred around the demographics of the school catchment area. Teacher C reiterated the differences in language, experience and skill that existed between the pupils in her class and those of children in more affluent areas. She often talked of the challenge of standard measures of attainment and assessment where entry levels and skills of children were low. Teacher C emphasised the unfairness of these assessments, which required subsidiary skills unrelated to mathematical knowledge and understanding such as processing speed and reading comprehension. Figure 5 further illustrates the critical features of her Teacher C's narratives.

Figure 5
Reiteration, Repetition and Forcefulness Related to Teacher C's Central Theme



“There’s a lot of assumption that we’d just have that experience.”

Teacher C noted that children in her school had qualitatively different experiences of mathematics outside of school compared to more affluent children, and that this was evident on entry. She observed for example, “I think sometimes if your experience is that you bake at home, and you're given kilograms, you're like, ‘Oh ok, that's when I baked’. If you haven't had that experience then…[shrug]”. She also believed this affected how children understood mathematics concepts, as illustrated by this extract:

> Again though, it's experience. Those kids that you need to give 100 things to and tell them to physically play with a hundred things and see what that is like, isn't it. Because the concept of a hundred, you can't put it on a number line if you don't know what it is.

DeFlorio & Beliakoff (2015) and Kocayörük (2016) suggest that these exploratory, context-based activities are particularly influential in developing children’s mathematics attainment. Indeed, DeFlorio and Beliakoff note that as parents from lower income backgrounds are more likely to use formal structured practice (e.g. workbooks or apps) to enhance their children’s performance in the early years, their children may benefit less despite parents’ efforts and input. Teacher C saw this as particularly important given that a significant proportion of the children at her school had not attended a pre-school setting. She noted:

> So running around is brilliant, but are they getting those opportunities? And again quite a lot of them don't always come to nursery … it's a good place to be because there's lots of those skills and things on offer to practice and do. But they don't always come.

Pre-school attendance is associated with improved educational outcomes, particularly for those from low socio-economic backgrounds (DeFlorio & Beliakoff, 2015; Melhuish et al., 2006; Morgan, Farkas, Hillemeier & Maczuga, 2014). It is known that on average, children from lower income backgrounds arrive in the classroom already at an attainment disadvantage relative to their peers (DeFlorio & Beliakoff, 2015a; EEF, 2017; EPI, 2019). In addition to specifically improving formal mathematics skills such as numerical comparison and one-to-one correspondence (Sorariutta & Silvén, 2018; Starr et al., 2017), preschool attendance provides a significant amount of the cultural capital required for academic success. As a result, children from lower income backgrounds who have not attended these settings may have to adapt their behaviour to match the behavioural expectations of the classroom in ways that their peers do not (Batruch et al., 2020). Teacher C also highlighted peer interactions and gaining different perspectives as areas that children were missing out on by not attending a pre-school setting, which is supported by research in this area (Melhuish et al., 2006; Taggart, Sylva, Melhuish & Sammons, 2015). Overall, she observed that a lack of classroom-relevant experience may reinforce to children that they are less able in mathematics than their peers from the outset; a theme also identified in the literature (Croizet et al., 2020, 2017; Easterbrook et al., 2020). She stated, “Where [other] kids have been in a peer setting [already], you're gonna feel straight away behind aren't you, or not up to speed with what everybody is doing. And also then their own temperament at that point.”

Teacher C noted that her school aimed to ameliorate the effects of a lower or slower start in education by adapting the curriculum to the characteristics of the children they teach. She reported:

> So on our last Ofsted we are requiring improvement. We can't be good because the results aren't good enough. So that's something as a school we're trying to work on by changing the curriculum and making it fit these children better. I think we’re changing that emphasis now to sort of PE, computing and sort of

life skills things that they would need outside of their mathematics and literacy.

While there was some suggestion in her discussions that a more vocational curriculum would better suit the children in her school, this assumption can be problematic. It is often assumed that children from lower income backgrounds may benefit more from vocational courses (Batruch et al., 2020) but this also limits their access to other higher status knowledge and qualifications (Batruch et al., 2020; Spruyt et al., 2015). As Teacher C suggests, children's initial low attainment may be strongly related to environmental factors. As such, their current attainment is not suggestive of differences in mathematics ability, but a measure of current skill and access (Alderton & Gifford, 2018; Haimovitz & Dweck, 2017; Plomin & Deary, 2015). There is therefore a dilemma between ensuring the curriculum is relevant to the experiences and lives of children, and ensuring their access to more formal academic opportunities is not reduced (Graham, 2015; Tannock, 2008)

Teacher C showed frustration at standardised age-related achievement measures as children "can't show progress" where entry levels are so varied. Given the intense pressure upon schools to attain these targets and the negative assumptions made of teachers and schools where these standards are not met (Done & Murphy, 2018; NUT, 2015), Teacher C's frustration is understandable. Teacher C was aware that Ofsted grades correlate strongly with the proportion of children receiving pupil premium in the school (NUT, 2015). However she appeared resigned and dejected at times around the futility of achieving benchmark standards. The following extract illustrates this:

> There's no leeway. They're not doing national: you're failing them. That's kind of how it feels after a while I think. Some of these things we're trying to do that obviously are working really, really well, but your results don't show it.

Teacher C noted that poor mathematical skill was inter-generational for many of the families she had contact with. She identified a cycle of negative attitudes to mathematics, lack of support of home learning and low perceptions of mathematics ability across parents and even grandparents of the children in her school, as has been highlighted in other research (Croizet & Millet, 2017; Easterbrook et al., 2020). She reported, “Sometimes attitudes from parents can be 'I was no good, so therefore I understand why they just don't get it' which kind of okays them not trying really.” She also wondered aloud about the impact that low parental skills may have upon children’s access to support at home, particularly where parents are innumerate and haven’t attended school themselves. Interestingly, parental level of education is not thought to be a significant influence on mathematics attainment over time (Salihu, 2018) but their understanding of number (particularly approximating magnitude) was significant, and thought to be related to their resultant levels of ‘mathematics talk’ at home (Braham & Libertus, 2018). Consequently, where parents’ foundational mathematics skills can be improved, their level of prior attainment such as GCSE mathematics grade or indeed attending school at all may be far less relevant than their current engagement with mathematics and the school generally.

Teacher C reported that successfully engaging parents in school-based mathematics was difficult, but observed that once engaged, this was a positive endeavour. She shared a particular example of an initiative set up by a staff member in the past to engage parents in their children’s mathematics learning:

> I know as a school our mathematics coordinator at the time did a parents mathematics group to support parents who think they're no good at mathematics and I think the ones that came, it's hard to get them to come, but the ones that did really got a more positive feeling about mathematics out of it…We'd be surprised actually, the amount of people that turned up to that because their kids were so eager. And they used to write a letter to invite them, it used to be like at a time when parents would be home from work if they did

> work. It was very accessible to everybody. it was a long night you know but …I used to see the value in it you know it's...a nice thing to do.

Teacher C recalled that those parents that had attended mathematics workshops previously had been motivated either because they were engaged within a supportive group of 'people like them' or by positive affirmation from their children and school staff that their attendance and participation was valued. This correlates with previous research in this area (NCSL, 2011; Wilder, 2014).

"The wordiness of problems is a real challenge."

Teacher C observed a number of areas of skill that were integral to mathematics attainment but not directly related to number or calculation. One such area was children's levels of vocabulary and language comprehension, which she reported was generally low across the children in the school. Interestingly Teacher C suggested that the language difficulties experienced by members of her class were solely environmentally based. She reported, "We have language difficulties in terms of vocabulary and in terms of exposure to language, but not language difficulties like a biological language difficulty if that makes sense." Given that speech, language and communication difficulties are the most prevalent special educational need (Sedgwick & Stothard, 2019; Vivash, Dockrell & Lee, 2018) it would be difficult to rule out biological factors as a contributory factor in some cases. Although Teacher C's perception of children's verbal difficulties as malleable is positive to her approaches to ameliorate this (Dweck, 2008). this default position may result in a feeling of blame for parents where their child's difficulties are presented as a product of their environment (Millei, 2015; Peach, 2015), and lead to further disengagement from the school system more generally, as parents deem their efforts to be doomed to failure (Browman & Destin, 2016; Oyserman et al., 2017). Of course this balance is a difficult one, particularly when a majority of the class experience similar levels of difficulty in understanding vocabulary, and causation is extremely difficult to identify categorically.

Teacher C identified low language skills as a barrier to the children's ability to demonstrate mathematics learning, as they had more difficulty in connecting language to the mathematics required. She reported for example needing to explain the words bought or sold to children. She also observed its influence on their understanding of concepts, saying "If you don't know bigger and larger and all the words that go with that. It's hard to give it...it needs a concept doesn't it." Research knowledge would confirm that a lack of mathematical vocabulary can impact significantly upon children's understanding and consequent performance in mathematics (Byrd Hornburg, Schmitt & Purpura, 2018; Moffett & Eaton, 2019; Perry & Dockett, 2018; Purpura & Reid, 2016; Riccomini et al., 2015).

In addition, general vocabulary knowledge and associated skills such as comprehension presented difficulties for the children in Teacher C's class (Riccomini et al., 2015), particularly during written assessments. Teacher C reported that these assessments often had unrelated terminology that children had low awareness of. She reported:

> When they have some of the SATs questions about 'they go on a coach trip to the theatre', they didn't know what the theatre was so ...that threw them. Do I need to know this is? …Is this a mathematics word?

Teacher C noted that low vocabulary knowledge was not the only barrier that children faced that was not directly related to their mathematics skills. She identified the requirement for reading comprehension skills within formal assessments as equally "unfair". She reported that assessment questions could be "nastily wordy" with "so much extraneous information that doesn't matter". Teacher C's concerns around inequality of attainment based on reading ability are strongly supported in related research. Those with mathematics difficulties are reportedly twice as likely to experience reading difficulties than those without (Joyner & Wagner, 2020), and children with difficulties in both reading and mathematics show lower attainment than those with mathematics difficulties alone (Forsyth & Powell, 2017). Reading skills can impact upon mathematics attainment even where mathematical skills are age appropriate (Forsyth & Powell, 2017). In fact, reading comprehension has been shown to be more influential on mathematical reasoning than number (Wu, Kuo & Wang, 2017), perhaps because word problems contain many linguistic challenges (Jitendra et al., 2013). Teacher C reported particular frustration where these additional barriers obscured children's progress. Talking about a particular girl in her class, she stated:

> She has made progress within her band, and we're trying to now show what progress she's made, because it won't ever show on the tests that we're using, you see. Which is frustrating. But then that's meant that she had to do the year X [current year group] and the vocabulary's too hard.

Teacher C was keen to reinforce the idea that many of the difficulties faced by her students were both connected to and exacerbated by each other, causing exponentially greater barriers than those experienced by more affluent children. She talked about how needs were "interlinked" and "you can't really separate some things from others". She illustrated this with an example of parental attitudes to mathematics, reporting, "So they're coming from a background where mathematics isn't valued, or mathematics is not day to day, you know they're not discussing it because their vocabulary is not...and then their reading's not... It kind of has that ...impact across."

Perhaps as a result of her understanding of the diversity of needs within the classroom, Teacher C's particular hope was to identify practices that would be beneficial across subjects and tasks, in order to make the task of supporting children more manageable. She suggested that the breadth of approaches required to target needs was unsustainable, particular where additional adult support was limited, reporting, “Trying to find the time in the school day to do constant repetition when you've got to get mastery of mathematics in as well is where the challenge is.” She remarked, “You really need to do something different and...it's difficult to model that well based on the needs for all the different children all at once.” Teacher C therefore saw small tweaks as having a larger impact at times than large-scale changes. She mused:

> An overwhelming classroom practice that you could do that would actually help … it sounds like the magical cure for everything! But no, …you do something as a general thing in class and one little thing that you could change and do it slightly differently; but you know that would impact on a lot of those children in your class, which is the little things you're trying to look for all the time isn't it.

In summary, Teacher C identified a number of environmental barriers that caused mathematics attainment differences, not least the low levels of mathematics experience of the children in her class. However, she saw other skill areas such as vocabulary, reading comprehension and processing speed as equally influential. She was eager to point out the inequalities inherent in the measurement of mathematics achievement for those from disadvantaged backgrounds and the exponential impact of multiple barriers. She also identified the value in engagement with parents to improve support of children’s mathematics outside of school.

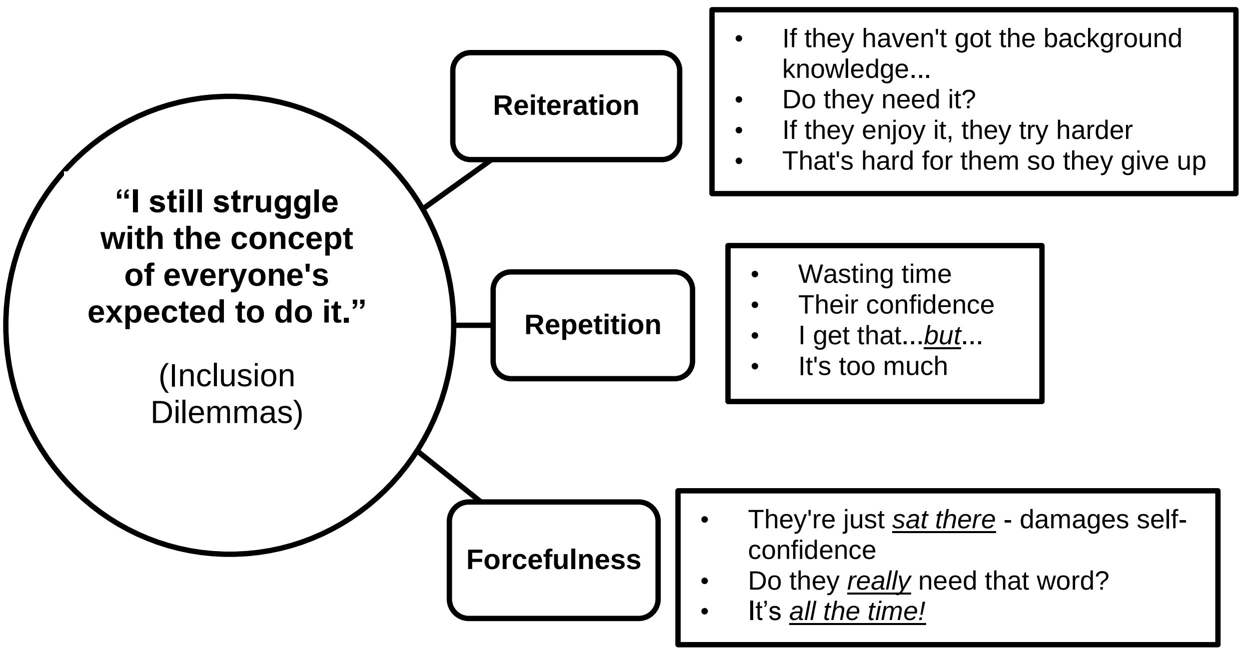
Teacher D

"You want everyone to make good progress. But I also believe that the curriculum is not made to fit everybody."

Central Theme: "I still struggle with the concept of everyone's expected to do it."

Repetition, reiteration and forcefulness within Teacher D's interviews showed her most prominent construction of mathematics attainment differences was that children should be supported from their various starting points rather than being taught in uniform ways. She frequently commented on the appropriateness of mathematics terminology and problem-solving activities both for children experiencing difficulties with mathematics and younger children more generally. She viewed universal approaches as detrimental to the motivation of learners, who may show reduced effort and engagement as a consequence of low accessibility. A summary of the critical thematic analysis of Teacher D's interviews is presented in Figure 6.

Figure 6
Reiteration, repetition and forcefulness related to Teacher D's central theme



“They *are* special educational needs…”

Teacher D appeared to have lower expectations of performance for children with identified learning difficulties. While Teacher D conceptualised children as progressing in the same way but at a slower rate, she appeared to view their rate of progression as relatively fixed and beyond external control. For example, she said, “Some of them are just like can't … physically focus.”, and, “he’s just really, really behind”. Mathematics and literacy are positioned within the English education system as the two key indicators of success (Alderton & Gifford, 2018); therefore this comorbidity of difficulty may result in assumptions of a ‘general’ difficulty in learning that reduces expectations and explorations of individual needs and strengths (ETS, 2018; Meier, 2020; Moscardini, 2015). Teacher D noted that she believed “the curriculum is not made to fit everybody” even though “you want everyone to make good progress”. Having universal expectations of attainment appeared to be considered by Teacher D to minimise or ignore the differences between children, and the barriers that they may face in attaining in mathematics; a perspective supported by some research (Croizet et al., 2020; Haimovitz & Dweck, 2017; Ng, 2018). However, lowered expectations are likely to result in lowered mathematics self-concept for these children (Cvencek et al., 2015; Parker, Marsh, & Ciarrochi, 2013; Sewasew et al., 2018).

While Teacher D could see the benefit of exposing all learners to a variety of mathematics to “know it’s there”, she did not see this as particularly productive for children who did not have strong underlying mathematics skills and knowledge. For example she identified problem-solving activities as beneficial for “pushing your higher abilities” while other children required more scaffolding and support in their learning, noting:

> And it's like your SEN ones. It's just a waste of their time. And you almost think we could have started doing what they need to learn by now. They could have had that little bit of information… If they don't have that like bottom concrete knowledge at the bottom they've got nothing to build it on. So for ten minutes you're wasting time.

Teacher D’s conceptualisation that students would require fluency in mathematics skills before being able to apply these to wider practice may be influenced by the instructional hierarchy framework (Haring, Lovitt, Eaton & Hansen, 1978) and to some extent the mathematics mastery model (Bonnett, Yuill & Carr, 2017). According to the instructional hierarchy framework, children would first need to acquire the relevant mathematical knowledge and be fluent in its application before being reliably able to generalise their knowledge to different situations and adapt it to new situations. Mathematics mastery approaches focus upon ensuring all children progress at the same pace in this learning, although some children will require additional practice or alternative approaches to achieve this (De Visscher & Noël, 2014; Hofstadter-Duke & Daly, 2015; Moscardini, 2010; Reisener et al., 2016; Riccomini et al., 2015; Sundhu & Kittles, 2016), as well as additional time to develop cognitive skills (Klesczewski et al., 2018; Mok et al., 2015; Starr, DeWind & Brannon, 2017; Stern, 2017). Of course, hierarchies and models are rarely designed to be interpreted in such a rigid fashion, but the level of flexibility can sometimes be overridden by the need for a clear and consistent message. Although there is evidence to suggest that children with both mild and moderate learning difficulties can successfully access and benefit from problem-solving approaches (Meier, 2020; Moscardini, 2010, 2015), this does require adaptation; it appeared that Teacher D did not think that the possible detrimental effects of these activities upon her lower attaining students had been duly considered.

Another area within which Teacher D perceived demands to be unrealistically high and alienating for some learners was mathematical vocabulary. Teacher D supposed that the complexity and variety of mathematics language was both unhelpful and unnecessary, particularly for children with more difficulty in mathematics. She reported:

> I think if you start bamboozling these children with really long words they, the ones that have low self-esteem and aren't overly motivated about school in general, are just like, 'Well I don't know what that means; I'm gone'.

Language complexity as a form of exclusion is a recognised inequality that prevents people from demonstrating their skills equally (Ng, 2007). However, 'Number talk' initiatives in primary mathematics education have grown in response to the mathematics vocabulary-mathematics attainment correlation and evidence that early mathematics language tuition can improve both of these areas (Byrd Hornburg, Schmitt & Purpura, 2018; Moffett & Eaton, 2019; Perry & Dockett, 2018; Purpura & Reid, 2016; Riccomini et al., 2015). Nevertheless, the perception of mathematics vocabulary as most relevant for those with better conceptual understanding remains (As demonstrated in Moffett & Eaton, 2019; Riccomini et al., 2015). Those children that do not have this language exposure, or have more difficulty in retaining it, are therefore at a continued disadvantage relative to their peers.

Teacher D acknowledged the barrier of low mathematics vocabulary but appeared to view the solution as to minimise or simplify mathematics language where possible, rather than to increase mathematics vocabulary. She observed, "I think you have to be really selective in where you put it in, the language stuff. I think if you try and do it all.... Yeah it's a bit intense." She also noted, "Sometimes I get carried away because I've got such a high number of SEN [special educational needs] I get carried away in simplifying things." Teacher D particularly objected to the use of language that she saw was not necessary for the understanding of students, stating, “If I can explain that if I do this and this and like if I swap the numbers they still make the same answer, that's fine. Well I don't need to use that word [commutability].”

Teacher D also highlighted that the current push on the use of mathematical language can be alienating for parents and cause them difficulties in supporting their children at home. She observed:

> When you have parents come in…quite often one of the first targets you will get as a year one child in your parents meeting will be to use mathematical language such as:… and the parents are going ‘Well what's that? And What's this?’ And I'm thinking if you don't know and your child’s coming home saying ‘oh in mathematics we did commutability’ that’s like…what?

New language and approaches are likely to be daunting for parents, particularly for those who had negative experiences of school themselves or have anxiety around their mathematics skills. Unfamiliar language is more likely to be seen by these parents as further evidence that school is not for people like them and their family (Batruch et al., 2020; Croizet et al., 2020) and cause them to reinforce their negative perceptions around their ability to support their child with mathematics at home (Easterbrook et al., 2020; JRF, 2012; NF, 2013; Oyserman & James, 2011). Levels of mathematics vocabulary have also been linked to level of parental education, suggesting that low mathematics language may be generational (Purpura & Reid, 2016). Parents who experience mathematics anxiety have already been found to detrimentally affect their children’s confidence in mathematics through supporting them with homework (Soni & Kumari, 2017) and unfamiliar terminology is unlikely to ease their concern. However, as mathematics vocabulary is promoted within the education system through ‘number talk’ initiatives, gaps in this knowledge are likely to further widen if students are unaware of terminology. In addition, without access to this language, their ability to understand and discuss mathematical concepts may be negatively affected (Byrd Hornburg et al., 2018; Moffett & Eaton, 2019; Perry & Dockett, 2018; Purpura & Reid, 2016; Riccomini et al., 2015).

“That’s enough for them to not try.”

Teacher D was keen to tailor her approaches to meet the needs of individual children in her class. She was dubious about the benefits of universal mathematics activities, particularly where she saw this as too difficult for the lower attainers in her class. The image of a “blank piece of paper” where a student was unable to engage with an elicitation task was seen by Teacher D as particularly demoralising, and she had concerns about the impact of this upon the mathematics self-concept of the children in her class, stating “...and that's like saying look at this! You can't do this because you don't know the mathematics.” She reported, “They're just going to be sat there, and I think it isolates them even more.”

Teacher D is correct in thinking that some aspects of mathematics performance affect mathematics self-concept (Sewasew et al., 2018). While self-graphing can be useful for both cognitive and motivational progress in mathematics (Chiesa & Robertson, 2000; Wells, Sheehey & Sheehey, 2017) the nature of how this task was presented may lead to a competitive atmosphere in the first instance, undermining mastery goals within the classroom (Lee et al., 2014; Luo et al., 2014). Teacher D reported similar scepticism around children starting a session with a problem-solving or reasoning activity, as suggested by her phase advisor. She noted the effect that a ten-minute problem-solving or reasoning activity might have upon some of the children in her class, stating, “I think if I gave them 10 minutes to go and access this problem or reason. It would just totally demoralize them and their confidence would be broken…”

While Teacher D believed children to require different approaches and support to make progress in the classroom, she was also aware of the impact that this differentiation could have upon the mathematics self-concept of lower attaining learners. Teacher D noted that negative perceptions of mathematics ability were often reinforced by the logistics of the classroom. For example she reported, “I think sometimes if they've got an adult with them they know that they need that adult, and it's like ‘Why do I need that adult? Oh because I can't do this can I.’” Teacher D noted that this was further reinforced by the presence of ability grouping within the classroom, a factor that has been identified in research to reduce the mathematics self-concept of learners in lower ability groups (Hallam & Parsons, 2013; Marks, 2014). Teacher D explained that, “because they are red and you know and they are it [red] for both [literacy and mathematics], they kind of know that they're that and then that's enough for them to not try.” The stable nature of the ability groups in Teacher D’s class also has implications for children’s perceptions around their ability to change, and indeed Teacher D’s perceptions of their potential development (Francis et al., 2017; Hallam & Parsons, 2013; Marks, 2014). She described the reactions to some of her lower attaining students to mixed ability group-work activities in mathematics, stating, “They'll just sit there. They know ...they're better than me so they're doing it.”

Teacher D noted that where children knew they were in a ‘lower’ group, or were not getting the correct answer, they disengaged from mathematics learning and expended less effort in mathematics sessions; a suggestion which correlates with research findings (Ahmed et al., 2012; Justicia-Galiano, et al., 2017; Lindskog et al., 2017). Teacher D observed that society generally reinforced this performance goal orientation because, “It’s good to be right.”, and this has particularly been noted in the case of mathematics (Ocean & Skourdoumbis, 2016). She reported that children in her class were not motivated to challenge themselves or to persevere with a task to its conclusion; They were instead motivated by getting ‘ticks’ and avoiding corrections, particularly where they found mathematics difficult. She stated, “If they've got loads of crosses they're like ‘Oh I don't want to do this anymore.’” This mirrors research related to mastery goals in mathematics, which show a reduced positive impact where performance goals (e.g. ticks and crosses) are present within the classroom (Lee et al., 2014; Skaalvik & Federici, 2016). Teacher D observed that this could particularly impact and demoralise those who have difficulties in learning mathematics:

> If you're wrong and you're anxious about mathematics anyway, and then you get a pink dot, it means you've got to go back and try again. That must be ten times worse. It's like making them doubly anxious about the same problem.

Teacher D also observed that children often did not realise when they had performed well without external validation, relying on positive feedback from adults as a measure of reward. Her reports suggested that performance goals and teacher praise may be skewing children’s self-evaluations (Lee et al., 2014). For example she reported, “They're not always ...proud of it. Unless you make a big thing of it, they're not always...you know ‘Oh I've done it, I can do that again now.’”

To increase the motivation of children in her class during mathematics activities, Teacher D focussed upon task engagement and enjoyment. She viewed this as an easier process in mathematics sessions than in literacy, as she saw mathematics as a more ‘practical’ subject with greater potential for variety. She reported, “If they've got something that they can manipulate they will try harder.” Teacher D also saw value in adapting activities to take account of individual interests or preferred. For example, she stated, “I think if it's something he's really into like football he'd enjoy that, it would make him make the link even more.”

Teacher D is right in her assumption that motivation and interest may have a significant positive effect upon children's mathematics attainment and self-concept (Lazarides et al., 2018; Yao et al., 2018). In addition, where children view their teacher to be invested in improving their mathematics learning they show improvements in mathematics self-concept (Stephanou, 2014; Villavicencio & Bernardo, 2016). Interestingly, weak or insignificant correlations have been found between internal motivation of younger primary pupils and mathematics attainment (Garon-Carrier et al., 2016; Weidinger, Steinmayr & Spinath, 2017). Teacher D's attention to the needs and interests of each child is therefore likely to have a positive effect upon the mathematics attitudes of children in her class, particularly where their intrinsic motivation is initially low.

In summary, Teacher D had lower expectations of attainment of children with additional needs within her class, particularly in activities such as problem-solving. She saw presenting such activities to low attaining children to be alienating and demoralising for them. She was similarly concerned to avoid overloading children with information such as technical vocabulary that may be difficult for them to access. She noted that this vocabulary could be equally alienating to parents as it could for children. Teacher D thought that enjoyment and engagement with learning was highly supportive to mathematics attainment and could reduce differences in attainment.

Overall Summary

In this chapter I have outlined the central theme and subthemes that I identified for each of the four case study teachers using a critical thematic analysis. Reference to psychological models, theories and research has been used throughout to capture how these conceptualisations may affect teaching and learning within each of these teachers' classrooms. While the conceptualisations teachers demonstrated were both complex and nuanced, they appeared stable across the course of the four interviews. Even where they had adapted or become more aware of particular approaches presented to them over the course of the interviews, their views around attainment differences did not appear to change.

Teacher A demonstrated some fixed notions around children's learning abilities in mathematics. She voiced concern that she was placing unrealistic expectations upon children by asking them to work towards skills that she perceived as unachievable or less relevant to those with learning difficulties. Particularly, Teacher A saw the expectations of the age-related national curriculum as unfair and disheartening for children in her class, especially where they were asked to repeat activities consistently that they had great difficulty in accessing. She instead envisaged that children in her class would benefit from a functional skills curriculum, focussing upon the unique value and strengths each individual had, rather than numeracy attainment goals. At the heart of her discussions, Teacher A appeared to wish for her students to become functioning and valued members of the community and avoid future vulnerability associated with low functional numeracy.

Teacher B conceptualised mathematics as easier for some than others, but she believed that all could make progress with a different pace and approach. She highlighted the importance of recognising that not all children will easily acquire mathematical skills, and how these difficulties could affect their mathematics self-concept, motivation and interest. She also identified the necessity for children to have a clear understanding of mathematics concepts before progressing to formal methods and more complex mathematics. Teacher B saw categorisation of children as inescapable, as it was reinforced by classroom activities, comparison with peers, and the perceptions of adults. Although she identified a ‘tragic choice’ between including these children meaninglessly in classroom inputs or providing support outside of the classroom, she appeared to have largely resolved this tension through a strategy of acknowledging difficulty and valuing difference explicitly. However she continued to experience frustration related to incongruence between school and home perceptions of mathematics, particularly around negative mathematics perceptions and the promotion of traditional methods.

Teacher C saw mathematics attainment differences to be primarily affected by environmental barriers to learning both within and beyond school. The impact of low access to relevant experiences outside of school and low levels of preschool attainment were identified as leaving children unprepared for the school environment, and at a lower starting point than more affluent children. Teacher C viewed attainment as affected by other curriculum areas such as reading comprehension and wider influences such as vocabulary knowledge and processing speed. While she expressed frustration that children’s attainment and progress was not accurately measured by standardised assessments, she was highly motivated to improve mathematics attainment through adjusting both the environment and learning behaviours of the children in her class, preparing them for the rest of their schooling and beyond.

For Teacher D, attainment differences were viewed as an inevitability for some children with special educational needs. She viewed it as unfair to expect all children to access mathematics at the same level as each other. Teacher D perceived universal activities and expectations as detrimental to the mathematics self-concept and general ‘self-esteem’ of learners, who had little foundational knowledge to draw from. The use of technical mathematics language in the early primary years was seen as particularly unnecessary and a potential barrier to children who had difficulties in understanding mathematics. Teacher D focussed upon motivation and interest as determining factors in improving mathematics attainment; she viewed mathematics that was relevant or fun to lead to higher levels of engagement from children and improvements in their perseverance and overall success.

Each of the teachers interviewed varied in their constructions of mathematics attainment differences. While some common themes did emerge related to accessing the curriculum and ‘natural’ affinities for mathematics, these were expressed in different ways, to varying degrees and resulted in different perspectives and actions. For example all teachers had differing perspectives around what would support the mathematics self-concept of children within their class, although they all identified this as important for mathematics learning and attainment. Therefore, a full exploration of each teacher’s conceptualisation of mathematics attainment differences shows that even where commonalities exist, this may not translate into similarities in approach within the classroom or with individual children.

While teachers’ conceptualisations of mathematics attainment differences appeared stable over the course of the research, this is not to say that they were binary or uncomplicated. Teachers’ views were more akin to a spectrum of thoughts rather than a single idea to which they rigidly adhered to. For example, while

Teacher A identified functional mathematics skills as of most use to the children she worked with, she also promoted the importance of ‘wonder’ and interest in mathematics and for learning to be an enjoyable experience, as well as considering the idea of abandoning mathematics learning altogether. It therefore appeared that while teachers were guided in their behaviour by their conceptualisations, these concepts had not developed in isolation, and may be strongly influenced by the variety of different characteristics, experiences and contexts of each teacher and the salience of these influences in different times and circumstances. In the next chapter, I will explore how the particularities of each case and the teacher within it may be interacting with how each teacher constructs mathematics attainment differences.

Chapter Six: Bioecological Influences upon Teachers' Constructions of Mathematics Attainment Differences

In chapter five I established that teachers within this research had varied and nuanced conceptualisations of mathematics attainment differences and these were expressed in different ways dependent upon the individual. In this chapter I explore my second research question: How are primary school teachers' conceptualisations of mathematics attainment differences influenced by their personal characteristics, wider context and historical experiences? In order to address this question, I will compare the bioecological profile of each case identified in chapter four, with the constructions of mathematics attainment differences held by each study teacher identified in chapter five. These comparisons were facilitated by questioning during my interviews, critical analysis and connections that teachers themselves identified.

In this chapter I will discuss the most prominent influences I identified upon each teacher's conceptualisations of mathematics attainment differences for more detailed discussion. Prominence was established through the degree to which this influence was repeated, reiterated or emphasised by teachers. This discussion will be supported by illustrative quotes as well as relevant psychological theory, models and research findings. As in chapter five, each case study will be presented in turn with discussion and findings combined, and a summary of findings is presented towards the end of the chapter.

Teacher A

"I can't think that way."

Teacher A presented complex and at times conflicting ideas around the learning potential of children in mathematics, and the applicability of the national curriculum across all learners. Consideration of her bioecology suggested that there were a mixture of factors that influenced her construction and may be contributing to this conflict. However, the most prominent of these was that she viewed her own ability to learn skills to be fixed and limited, and saw it as important that difference should be valued and accepted.

Teacher A demonstrated a perception that a person's performance in a subject was a result of innate strengths. She identified as being more of a 'mathematics person', noting, "It's very logical and that's my kind of brain really. ... You follow the instructions and the rules and there's a process. A = B = C …Great! A will always = B = C." She contrasted this with the discomfort that she felt when asked to complete creative writing tasks, stating, "I can fully relate to children who sit in an English lesson going 'but I can't write a story'…If someone told me to sit down and write a poem I'd just freeze." She therefore empathised with children who had difficulty in learning mathematics, drawing similarities to her own difficulty and 'fear' around creative writing. Through this contrast between literacy and numeracy, Teacher A appeared to categorise 'mathematics people' and 'literacy people' as fundamentally different, noting "some people are just more mathematically minded aren't they."

Teacher A's juxtaposition of mathematics against literacy ability is not uncommon. The internal/external frame of reference model (IE model), summarised by Marsh (2007) and subsequently applied in research (Parker et al., 2013) illustrates this point. The IE model suggests that while Teacher A's mathematical achievement has had a positive impact upon her mathematics self-concept, it has also reduced her English self-concept (at least in creative writing) by comparison. Research around the IE model suggests that this effect would be salient regardless of objective attainment in these subject areas (Parker, Marsh, Ciarrochi, et al., 2013), although negative self-concept in an academic area may further impact interest, motivation and subsequent performance (Seaton et al., 2014).

Although Teacher A viewed herself as a ‘mathematics person’ she mentioned on several occasions her own mathematics ‘limit’. She observed, “I did A-level mathematics but there's no way I could have done it at degree level. I just don't have that ability.” This was an interesting assertion when considered alongside other conversations I had with Teacher A around the approaches of her school mathematics teachers. These indicated that her GCSE and A-level teachers had distinct teaching styles and varied in how they prepared Teacher A for her final assessments. Describing her secondary school mathematics teacher (who I have named Mr X to protect anonymity), Teacher A said, “Mr X his name was…He was very direct, very straight, very logical, very precise, which I really responded to. I had him for a few years at high school.” This contrasted with her memories of her A-level mathematics teacher:

> At sixth form I had a teacher who gave me a great interest in the abstract nature of mathematics and looking at Bach and Escher and things like that, and Fibonacci and all that interesting stuff ... Doesn't help you pass your A-level though. Because it’s not on the paper.”

It is not only pertinent that Teacher A continues to see a dilemma between presenting ‘the wonder of mathematics’ to students while also teaching ‘the mathematics skills they need’; it is also curious that she continues to associate her lower A-level performance to her own ability, despite acknowledging her lack of preparation by her teacher.

Teacher A was highly aware and herself reinforced that there is no ‘one type’ of autistic person and the mathematics skills of the autistic members of her class were highly variable. This matches with research in this area that suggest that while a fifth of autistic children may be ‘hypercalculic’ (very high achieving in mathematics) around a third may have low mathematics performance relative to peers, with lower achieving hypercalculics more likely to be from lower socio-economic backgrounds. Teacher A’s experiences of having neuro-diverse family and friends may also contribute to her ideas of ‘brain difference’ and rejection of a neurotypical norm. Teacher A identified particular autistic traits that she perceived to be supportive in relation to mathematics development, noting for example:

> There's quite a huge dollop of autism in our family as well! Not that they always go hand in hand… but it's high functioning autism. Very logical, I think there is an aspect of that isn't there … and how you compartmentalise stuff in your head and visualise stuff.

Viewing autism as a learning difference rather than a learning difficulty (Kapp, Gillespie-Lynch, Sherman & Hutman, 2012) may strengthen Teacher A’s desire to focus on children’s personal strengths over attainment difficulties, but need not exclude the amelioration of the difficulties in mathematics that they experience (Kapp et al., 2012).

Teacher A’s background working with children who have severe, profound or multiple learning disabilities is also a likely influence, alongside her teaching role within a specialist PMLD setting. Having viewed the impact of the daily struggles these children have, and the vast differences there might be between normative success and a success for each child (Ng, 2018) it is likely difficult for Teacher A to see the relevance of normalised standards of mathematics performance. For her, to expect that the system is able to change enough to accommodate these vast differences appeared to seem unrealistic at best (Norwich, 2014). Teacher A may therefore be more motivated to avoid a generalised low-value characterisation of the students in her class, instead accepting a view of low ability in mathematics as a necessary sacrifice. By doing so she appeared to hope to increase the chances of these children succeeding in leading a level of independent life that might not be afforded to them without identifying such a strength (Björnsdóttir & Traustadóttir, 2010; Tilly, 2019). Pursuing curriculum expectations over functional numeracy skills is therefore likely to be seen by Teacher A as too high a risk to take.

In summary, Teacher A's bioecology, particularly her experiences in working with children with complex needs, the autistic traits of family members and her own fixed perceptions of her abilities since childhood all appear to correlate highly with her conceptualisations of mathematics attainment differences. These interactions are summarised in Table 10.

Table 10
The impact of Teacher A's bioecological influences on her views around mathematics attainment differences

Conceptualisation of Mathematics Attainment Differences	Bioecological Influences
Broad ceiling/limit to learning	Own difficulties with creative writing. Experience working with children with PMLD throughout her life. Perceived inability to progress beyond A-level in mathematics.
Makes sense to some more than others	Sees own brain and those of her family as 'logical', visualising and compartmentalising differently based on the autistic traits within the family. Own difficulties with creative writing including when at school but persisting now.
Intrinsic motivation/ enjoyment/ wonder is important part of mathematics	Enjoyed mathematics herself and the 'wonder' behind it. Finds frequent repetition of the same skill frustrating and 'boring' at times.
Persistent task failure causes anxiety	Own anxiety around creative writing tasks. Observations of anxiety of children in her class related solely to the word 'mathematics' having had previous negative experiences
Unrealistic expectations of the curriculum for some children Mathematics over-prioritised (relative to other potential strengths children may have)	Experience working with children with PMLD . Values and accepts difference (related to autistic traits of family members and children she has taught). Wants children to feel comfortable in their own skin and not feel they need to be good at everything – something she felt unable to do at school and beyond in certain curriculum areas.
Different/ functional skills curriculum needed	Observed increase in self-esteem and independence where those with learning disabilities have functional skills, and the impact if people do not.

Teacher B

"I didn't feel I was being invested in."

Teacher B frequently drew upon her own experiences of learning mathematics in our discussions. She contrasted her mathematics experiences at secondary school with those during her PGCE teaching qualification. However, even with the strength of this personal narrative, the way that she conceptualised and operationalised "learning in different ways" showed variability and complexity..

Teacher B was open about her own struggles with confidence in mathematics in the past. She noted, "It was always something I'd have to work at; it wasn't something I was like I do that and that's the answer, I'd always be like having to really think about it and unpick it all for a while." Teacher B shared with me her journey to improved mathematics self-concept from her school years to becoming a teacher, reiterating this during multiple sessions and highlighting how transformational her experiences had been. While she identified that she had "never found mathematics easy," she pinpointed secondary education as a particularly difficult time in relation to her mathematics self-concept and sense of belonging.

> I got a very negative feeling at school, and I remember being put in the middle set for mathematics and all my friends were in the top set; and then that kind of feeling of like 'Oooh [frown]'. Whereas you know I could do it. I got my B at GCSE in mathematics so … I did what I needed to do but it was something that I had to work at. I didn't kind of feel that I was getting support from school to work for it, it was more me thinking 'I need to do this because I want to go on and to do that' … I'm lucky in that sense that I've got that mindset … I'm like 'well no! you're wrong!' [laughs]

Teacher B noted that she felt her level of worth was reduced within the context of grammar school, as she was not meeting the valued criteria of being highly skilled in mathematics. As a result, Teacher B felt a sense of rejection and a lack of belonging within secondary school, considering herself to be less valued by teachers as a consequence. Her perception of this lack of investment matches trends in primary education where those who are most likely to achieve the expected standard in end of key stage assessments are more highly supported in their mathematics development during these times than those who are not (Marks, 2014), although this of course varies depending on the culture of the school. All of these factors are likely to have contributed to a reduced mathematics self-concept and lower interest for Teacher B both during and after this time (Lazarides et al., 2018).

Teacher B reported, “In terms of the grammar school I was kind of middle of the road. I was kind of like …. Unimportant… Ignored… [That’s] the kind of feeling that you got given.” She compared this to how she may have been perceived in other secondary school settings, noting “I feel like maybe if I’d been at the comprehensive I might have been completely different.” Research around teacher judgements of mathematics ability suggest that higher ability cohorts can lead to deflated perceptions of ability of those who are not the higher attainers in class (Kikas et al., 2018). This perception may be particularly strong in mathematics, where ‘average’ skills are perceived by people to indicate they do not have strong mathematics skills. For example, research by Perry and Dockett (2018) highlighted that where parents viewed their mathematics skills to be average, they self-described as not being good at mathematics. Like Teacher B, these attitudes were more likely to develop at secondary school than primary, but remained prevalent into adulthood (Perry & Dockett, 2018).

Teacher B emphasised the importance of her determined mindset and approach to learning in her success at GCSE. She noted that where other adults she knew had not had this mindset, they continued to have a low mathematics self-concept, reporting for example, “He was very much well I can't do it and I'm rubbish and so he very rarely tried with mathematics then, because he just kind of told himself...I'm rubbish at this. I can't do it.” She also described the reaction of a family member: “If someone says you can't do that she says, ‘Oh Okay’. You know. She's accepting of that whereas I'm like well no! You’re wrong! [laughs]” Teacher B directly linked the mindset she viewed to underlie her mathematics success to her own teaching practice, identifying. “So I need to kind of be ‘this is amazing’. And I would say to the children you know; ‘I didn't find this particularly easy at school…But if you keep trying you will get there.’”

Teacher B’s experience of learning mathematics dramatically changed during her teacher training course, transforming her views around her mathematics abilities and understanding. She recalled:

> I remember being on the PGCE, and I signed up to do the extra input on mathematics. And that was literally the best experience of mathematics teaching that I'd ever come across, because I was sat there and it was like a lightbulb moment. And it was like <u>*that makes total sense to me*</u>… that little 6-week course … I was just like wow! I can do this!

Teacher B particularly credited this to the availability of multiple methods and ways to understand a concept, rather than ‘just one way’ which she had found confusing. This perhaps explains her strength of frustration with parental persistence with formal written methods over more varied approaches to calculation. However, Teacher B’s description of her feelings around mathematics even after this positive experience highlight the length of time and level of positive feedback required to improve mathematics self-concept, even where mathematics achievement has improved (Sewasew et al., 2018). She described her persistent self-doubt in mathematics despite improved confidence over the course of her teaching career. This had resolved somewhat as she became subject lead for mathematics, noting “I've become more adventurous and yeah I feel I enjoy teaching mathematics. Yeah, it's good! [celebrates]”. However she still described feelings of “pressure” at “being put on the spot” in mathematics in subject lead meetings.

Teacher B reported explicitly sharing her own struggles with mathematics as a child with children in her class to demonstrate the possibility for progress and skill development. She reported, “I would say to the children, you know, I didn't find this particularly easy at school…But if you keep trying you will get there… You’ve just got to keep practicing.” In being overt with her own mathematics difficulties, Teacher B models and reinforces to the children in her class that success in mathematics is attainable through perseverance and practice, and getting the wrong answer initially “doesn’t matter” (Dweck, 2008; Haimovitz & Dweck, 2017). She observed:

> It's kind of getting them to see that ok, you might be finding it tricky at the moment, but that doesn't mean you're always going to find it tricky, you just need to take a different path and it just might...to show them that they are moving forward, just at a different pace. And that *that's ok*.

In summary, Teacher B’s contrasting experiences of learning mathematics over her life-course have strongly influence her perceptions of mathematics attainment differences and children’s potential for progress and development. Her acknowledgement of this was explicit and influenced her emphasis on flexible approaches and promotion of resilience in her class. A summary of these interactions is provided in Table 11.

Table 11
The impact of Teacher B's bioecological influences on her views around mathematics attainment differences

Conceptualisation of Mathematics Attainment Differences	Bioecological Influences
Being 'mathematically minded' or not	Not finding mathematics 'easy'
Accessing a 'different path' i.e. a different pace or variety of approaches to understanding mathematical concepts. Parental focus upon traditional / formal methods and 'finding the answer'	Transformational experience during PGCE where short mathematics course made her realise 'I can do this' Found multiple approaches and 'not just one way' as key to improving her own mathematics understanding
Children deciding they 'can't do it' and difficulty shifting this view Parents disengaging from mathematics home learning due to perceived inability to support.	Difficulty in improving mathematics self-concept even after her understanding increased (before becoming mathematics subject lead).
Being pigeon-holed by teachers as low ability Difficulty accessing the same learning as peers (age related)	Negative school mathematics experiences of not being 'invested in and being seen as unlikely to succeed
Viewing themselves as slower or less able than their peers Perceiving themselves to be 'low ability'	Saw self as undervalued due to comparison with higher ability peers
Parents having negative perceptions / assigning low value of mathematics	Necessity for determination to succeed at GCSE mathematics

Teacher C

"I make it my mission to make them love it by the end."

Teacher C frequently noted the barriers faced by children in her class relative to their background of social deprivation and the inequalities of attainment standards. Her length of experience within the school allowed her to develop strategies to reduce this gap wherever possible; however it also served as a reminder of the consistent disadvantage children from her catchment experience in attaining in mathematics (and school generally). Her background of study in psychology and her awareness of social inequalities were also important elements. Most of all, Teacher C's determination to ensure children left the school 'less disadvantaged' and more interested in mathematics than when they had started was clear throughout, even where 'expected standards' were likely out of reach.

Teacher C's central focus was that children would have reduced levels of disadvantage as a result of their education, both in their approach to learning and their skills. She acknowledged that mathematics was a skill "that they just really need for life," and reported "striving all the time to make sure that those children that are disadvantaged, that doesn't show when they leave us." She stated that this was part of the school culture noting "I think everyone's aiming for that." The challenge for Teacher C is to convince the children in her class that becoming a 'mathematics person' is both achievable and valuable. Identity-based motivation theory suggests that although identity is changeable depending on the context, it is the motivation to change and the value attributed to this change that determine whether a person successfully adapts their behaviour to an identity congruent with the situation (Oyserman, 2015; Oyserman & James, 2011). For example, if a person sees attainment of an identity as impossible, they may decide that the identity is not relevant to them and instead shift their attention to a more attainable identity (Onu et al., 2015; Oyserman et al., 2017). That Teacher C emphasises regularly to children that they can achieve and enjoy mathematics reinforces their mathematics self-concept and interest (Liu et al., 2018). Her understanding of the particular barriers that children in her school face, reinforced by ten years of working within the school and her previous studies in psychology was clear throughout my interviews with her.

Teacher C wanted children to have an awareness of the relevance of mathematics to them as individuals, justifying why they should invest their time and effort into gaining these skills. This has been positively highlighted in studies related to cultural differences (Ramirez & Mccollough, 2016), but is equally relevant to social class discussions. Studies have indeed found that children from lower socio-economic backgrounds rarely connect their mathematical home practices to school-based learning (Rittle-Johnson, Fyfe, Hofer & Farran, 2017; Taylor, 2009). Teacher C herself noted that she found mathematics more engaging and easier to understand during her undergraduate degree as it was purposeful learning. As a consequence, she used comparative language in the classroom such as "so this is like when…" to successfully support children to make links between current learning and previous experience. The importance of creating "that experience that they remember" or providing a practical context was iterated as important for retention. In addition to aiding memory and understanding, there was an element of personal independence to Teacher C's focus upon application of knowledge, noting for example, "You want to work out if you can afford it. You need to be able to do it."

Teacher C expressed sadness that some of the children in her school did not have the same positive view of school and mathematics that she did growing up and was keen to ameliorate this. She reported, "My experience of school was very positive.

So I know that’s not true for some of the children who come here. They don't feel the same.” She talked particularly of a girl who had a strong almost phobic dislike for subtraction; her disappointment that she was unable to shift this child’s perspective consistently to a positive outlook upon mathematics was evident, despite levels of success at times. Teacher C appeared to judge her success in improving this child’s mathematics to be as much related to a change in perception or increased enjoyment as improved attainment:

> X, who is on the spectrum, she doesn't think she can subtract; therefore she just won't do it, and then other areas of mathematics it could be really quite challenging and she'll give it a go because it's not subtraction. But subtraction in her brain is like a mental block and ‘I'm not doing that’. And then we can't move beyond that, and that's really difficult to get her round to do that. Have been successful on occasion, but it's hard to get her to do that.

Although child X’s anxious response to subtraction is likely to require more persistent and gradual support (Hill et al., 2016; Timmerman, Toll & Luit, 2017; Villavicencio & Bernardo, 2016), Teacher C’s focus upon engagement and enjoyment is likely to support child X in approaching this task over time (Villavicencio & Bernardo, 2016).

Teacher C observed that although it could be deflating to achieve negative gradings from Ofsted inspections, this did afford additional focus and funding for professional development opportunities that may not exist in other settings. Through this consistent CPD and teaching experience, Teacher C was confident in her mathematics teaching skills and in her ability to explain ideas effectively to her students in different ways. Increased professional self-efficacy has been linked to higher student mathematics attainment (Katz & Stupel, 2016) and a reduction in ‘teacher as expert’ approaches (Ren & Smith, 2018). Teacher C appeared to embody this, valuing understanding of children's approaches rather than focussing upon knowledge transmission. She observed for example, "Often things that do have more than one answer depending how you look at it, I think that involves everybody better." She proposed, "It's what they take on from it isn't it as opposed to what you taught them about it." Teacher C also explicitly focussed on metacognitive strategies such as 'being more resilient' and used mastery-based goals to judge success. Both of these approaches are strongly supported in relation to improving mathematics self-concept and attainment in mathematics (Bonnett et al., 2017; Boyd & Ash, 2018; Katz & Stupel, 2016; Luo et al., 2014).

Teacher C herself modelled perseverance and determination in her efforts to support mathematics learning of all children in her class. It was observable that she was keenly aware of barriers to attainment whilst continuing to perceive the possibility of positive change, and she maintained a similar approach to discussing barriers with her class. Teacher C reported, "I think I maybe give them the impression that there is no sort of 'can't do' so you know you *will* find a way, there'll be a way, something will help you." However, at times, Teacher C expressed concern for those who had mathematical difficulties, wondering, "Don't you think sometimes the children are there in class and they never get it quite right in mathematics, they're *nearly there* all the time, but it must be so like...every time it's not quite right, you know?" This suggests that Teacher C is also mindful of the impact of persistent task difficulty upon the mathematics self-concept of children in her class (Jõgi et al., 2015; Sewasew et al., 2018), despite her focus upon resilience.

In summary, Teacher C's own positive experience of mathematics at school and schooling generally motivated her to seek the same positive reactions from her class. She had a strong awareness of the barriers that children in her school face due to socio-economic disadvantage developed over her ten years within the school, but also a high level of training related to mathematics as a consequence of additional funding support from previous low Ofsted grades. These influences are summarised in Table 12.

Table 12
The impact of Teacher C's bioecological influences on her views around mathematics attainment differences

Conceptualisation of Mathematics Attainment Differences	Bioecological Influences
Curriculum assumptions that children have relevant experiences and vocabulary	Needing to explain vocabulary that she expected children would have understood at their age (e.g. bought and sold) Identifying how children's experience differ from her own.
Vocational curriculum more matched to their mathematics needs (for life) Practical applications of mathematics valued.	Found it easier to understand mathematics herself when it was purposeful (e.g. during psychology degree) Not wanting children to leave disadvantaged in terms of their ability to function in society as well as their attainment. Viewing the effects of disadvantage on attainment.
Attainment measures not accurate – doesn't show progress of children.	Sees multiple influences on mathematics that are not specific to mathematics skills (e.g. reading, processing speed). Looks for shifts in classroom practice that benefit all as there are so many influences that they can't all be tackled simultaneously
Intergenerational low mathematics attainment and attitudes	Enjoyed and succeeded in mathematics at school. Sees this is not the case for some of the children she teaches. Wants to shift children's perceptions of their abilities and show that mathematics can be fun. This is as important to her as attainment improvements.

Teacher D

"You know your cohort"

Teacher D was keen to emphasise the importance of responding to children as individuals. It was important to her that children who needed "nurturing" were able to access this support. She often empathised with students' difficulties or low interest, relating it to either her own experience or that of family members. Teacher D was aware of the motivators of children within her class such as "food" and parents being "their idol" and had a high level of knowledge of children's family backgrounds and personal interests.

Having an accepting and empathetic approach to working with the students in her class appeared particularly important to Teacher D, and is equally viewed as important in psychological literature, including related to mathematics attainment (Hughes, Golding & Hudson, 2015; Martin & Rimm-Kaufman, 2015; Ponitz et al., 2019). In our initial discussions, Teacher D talked about her journey to becoming a teacher, and the positive impact that her first primary teacher had after Teacher D experienced a family bereavement.

> She was just really caring … and I remember that time as a whole in that she really understood what was going on in my life. And like she… made sure I was happy when I was there you know, was just really supportive of what was going on in the here and now, and I just remember her being that way, more than I remember anybody else in my school life.

Teacher D noted, "I think it'd improve everything wouldn't it; If you're feeling happy." Teacher D is likely right in this assumption, as mathematics self-concept is indeed positively influenced by subjective wellbeing (Yao et al., 2018). Perhaps as a consequence, Teacher D showed particular concern that children gained enjoyment from mathematics activities, even where this interest was not related to the mathematics itself. She illustrated this point by identifying areas of mathematics that she herself disliked:

> You have to teach things that they're not interested in and they're not going to get, just like I hate shape, some of them probably hate ...number. And therefore aren't as bothered about it, whereas they really enjoyed doing about shape all the time sort of thing. And I do think they do need to know all of it but it does affect how much they want to do it.

Teacher D also appeared to perceive that both her interest and ability related to mathematical shape knowledge was unlikely to change over time and applied this assumption to the children in her class. This fixed mindset may affect how both she and her students perceive their ability to make progress in different areas of mathematics; while her empathetic response may be comforting to children, it does nothing to improve their mathematics self-concept or interest in areas that they find challenging (Boyd & Ash, 2018; Dweck, 2008; Haimovitz & Dweck, 2017; Sun, 2019). It may be more difficult for children to build intrinsic motivation (where they enjoy the learning itself), if external motivators and performance-related feedback is more prevalent (Boyd & Ash, 2018; Haimovitz & Dweck, 2017), although low intrinsic motivation is not necessarily detrimental to mathematics attainment (Garon-Carrier et al., 2016; Weidinger, Steinmayr & Spinath, 2017).

When discussing her family member's experience with an additional need, Teacher D noted a hierarchy of difficulty where 'basic mathematics' was less of a difficulty, but 'reasoning probably for him would be a no go to have to explain it." Teacher D noted that the language of mathematics could be a particular barrier for her family member, as "some of the language in mathematics, it's hard to break it down to make it simpler than what it is". Teacher D therefore had personal experiences that supported her concerns around the impact that complex mathematics vocabulary may have upon the access of mathematics to those with additional needs. Further reinforcing this notion, Teacher D saw little purpose in the range and technicality of the vocabulary used, stating “I’m one hundred percent sure I was not taught a lot of this language and I got by in life without it”. She stated that even for herself as a qualified teacher the level of language could be “overwhelming” because “you’re never trained to use it”. She noted, “Sometimes I say the same sentence four different times with a different word for add, just in case they might not call it that, they might call it this or they might call it... It is tricky.”

Teacher D identified the constant push for progression and improvement as a challenge both for herself as a teacher and for the children in her class, not least because expectations and ‘best practice’ were constantly changing. She reported:

> Sometimes there's so much going on that … I wish one person was like, ‘This is what we're doing. This is the way forward’, because like we worked really hard at working on our problem-solving skills and teaching it to the children and it's like yep, just about got my head around that and it's like ‘No now we're going to do this,’ and it's like... And it's <u>*all the time*</u>. And sometimes I do really feel for the kids because you just get them on to one thing and then as you do it you gain confidence and then it's ....something else and something else.

Consequently, when presented with another new approach, Teacher D was keen to identify whether it was “really needed” and questioned its efficacy and value. She was a proponent of “stripping it back” in terms of both content and “how we teach” to simplify and clarify things. This appeared to lead to Teacher D being a highly critical evaluator of research and new models of practice (Cain, 2015a, 2015b), questioning their applicability and validity. If an approach was not initially successful, particularly where Teacher D had anticipated that it would be unsuccessful, her perseverance with it was more limited as these initial difficulties further confirmed her negative assumptions (Scopelliti, Min, McCormick, Kassam & Morewedge, 2017). She reported, for example:

> We were trying to do problem solving Friday where they all had a problem that they had to do. For my lower attainers it was more like meltdown Friday. And it was getting to the point where it was like lowering their self-esteem towards mathematics. So we kind of pushed that to the side … Quite often if they've finished an activity they might have a problem-solving reasoning thing to move on to…

In summary, Teacher D's positive experience of teacher support at a difficult time in her life led to her pursuing her teaching career; this responsive approach is something she appears to have adopted herself, with engagement, enjoyment and realistic expectations of children all important to her. Where she could see a purpose and legitimacy in an approach, she was much more likely to accept and engage with it. Her experience of having a family member with an additional need appeared to underpin her understanding of the potential barriers or negative feelings associated with technical mathematics vocabulary and problem-solving approaches. A summary of these interactions is provided in Table 13.

Table 13
The impact of Teacher D's bioecological influences on her views around mathematics attainment differences

Conceptualisation of Mathematics Attainment Differences	Bioecological Influences
Lower expectations of children with learning disabilities / 'lower ability'	Family member with an additional learning need. Curriculum not seen to match the needs of all children in her class, particularly low ability groups. Happiness and responsiveness of teacher deemed as particularly important as a result of own experiences at school.
Problem-solving approaches seen as higher ability activities that can alienate lower ability learners Elicitation tasks seen to lower 'self-esteem' of some learners	Family member with an additional learning need. Observations within the classroom of children experiencing difficulties in accessing these activities. External advisor not someone Teacher D knows well and her concerns not felt to be addressed.
When children see themselves as low ability they are not motivated to try	Own experiences of staff training: when not supportive environment, less likely that she will adopt the approach. Observations in the classroom of children struggling to access problem-solving activities.
Technical vocabulary unnecessary or a barrier to understanding	Likes to understand the reasoning behind approaches and see the purpose. Family member with additional learning need. Not needing to use this vocabulary herself during school learning.
Task engagement and enjoyment is most important for motivation. Needs to be matched to what individuals like for best success.	Own experiences of school being a positive place at a difficult time Need to see the purpose of activities and feel motivated to invest time in this. Observations of external motivation of students in her class. Some activities that she doesn't like in mathematics (e.g. shape) mean she can relate to these feelings.

Summary

In this chapter I have compared each teacher's conceptualisations of mathematics attainment with their bioecological influences as identified by themselves over the course of their interviews. The interaction between teachers' views and their characteristics, contexts and experiences could be strongly observed within each case study. Multiple elements and sub-categories from the bioecological model could be seen to influence how teachers formed their views around mathematics attainment differences.

The impact of the chronosystem, particularly teachers' own experiences of schooling appeared consistently connected to how they viewed mathematics attainment differences. The impact of universal attainment expectations and frequent national assessments was also a common theme within teacher narratives. However, the way in which these factors influenced teachers' conceptualisations varied significantly depending on the individual; It was clear that multiple factors from various elements of the bioecological model were interacting to produce highly individual views and responses. For example, the teachers in this study identified personal or contextual factors that influenced their school experiences such as their own resilience, interest or personal circumstances around this time. The implications of the interaction between teachers' mathematics attainment views and bioecological influences for the work of educational psychologists is further explored in the next chapter.

Chapter Seven: Tailoring Educational Psychology Approaches

Through this exploratory research I have been able to present the complexity and diversity in the perspectives of teachers related to the mathematics attainment gap. The findings and discussion within chapter five and six highlight that individual circumstances have a considerable impact upon the way in which teachers conceptualise the attainment gap and their responses to strategies and approaches that aim to reduce mathematics attainment differences. It is the role of an educational psychologist to challenge or develop narratives that may negatively impact upon children and young people using psychological skills and knowledge (BPS, 2002, 2018; Fallon, Woods & Rooney, 2010; HCPC, 2016). Consequently, it was important for me to consider how detailed knowledge of teachers' views and influences might be utilised during educational psychology practice.

In this chapter I explore how educational psychologists might tailor their approaches when working with each of the teachers within this study around reducing the attainment gap in mathematics. It was beyond the scope or purpose of this study to attempt to modify the conceptualisations held by each teacher; in fact both my literature review and research findings suggest that no one way of conceptualising the attainment gap is unproblematic. While suggestions are made in this chapter to develop or challenge some of the conceptualisations of teachers around mathematics attainment differences, this is not designed as a criticism of these teachers and their views. Indeed many of the dilemmas that they face and views that they hold are rooted in an education system and wider culture that they have little power to change. This chapter instead illustrates how psychological knowledge and approaches might be individually tailored to support teachers in addressing mathematics attainment differences.

Psychological knowledge and approaches such as consultation, supervision, and psychoeducation (e.g. around topics such as adverse childhood experiences and internal working models) are among some of the intervention suggestions in this chapter. However this is not an exhaustive list of actions which may challenge or develop each teacher's conceptualisations, but an illustration of how tailored approaches may be beneficial. Further illustration of the bioecological factors that support and maintain the constructions of each teacher as well as those that challenge or further develop them is presented in Appendix 8. Towards the end of this chapter, I consider general implications for educational psychology practice that emerged in this research, including the value of the bioecological model both for elicitation of views and for professional self-reflection.

Teacher A

Teacher A sought acceptance and recognition of children who experience significant difficulties in acquiring mathematics skills. She was a strong proponent of valuing practical mathematics skills and focussing upon non-academic strengths that increased the likelihood of young people in her class achieving higher levels of independence and participation within their community in adulthood. She sought to motivate children to have an interest and enjoyment in mathematics and reduce the anxiety that some children in her class experienced related to mathematics.

Challenging fixed ability narratives.

Teacher A's own experiences of difficulty in creative writing appeared to underlie her perspectives around valuing differences rather than reducing the attainment gap. She was clear that there were some characteristics or difficulties people may have that you 'can't change'. She sought acceptance of these differences and greater value for practical life skills and non-academic strengths. It seems likely that her experience of working with those with PMLD throughout her life, her family experiences of autism and her current role within a specialist setting had further strengthened these narratives. While this perspective provides acceptance and a person-centred strength-based model, it may cause some mathematical experiences, qualifications and skills to be dismissed as unattainable. This will impact upon how Teacher A interacts with any training, casework or consultation undertaken with an educational psychologist around children's mathematics attainment.

Presenting Teacher A with scaffolded creative writing activities to reduce her negative comparison of her literacy ability relative to her mathematics ability is one approach which may begin to shift her fixed perceptions of learning ability (Marsh, 2007; Parker et al., 2013). In addition, highlighting to Teacher A the inconsistencies in her personal narratives around her own mathematics potential at A-level may cause her to critically reflect on her assumptions around fixed ability (Hébert, 2015). Due to the strength of Teacher A's fixed narratives, focussing upon building a 'limited mindset' (Li & Bates, 2019) rather than a growth mindset with Teacher A may enable a gradual shift in her views. A limited mindset posits that while ability may be limited in some way, goals and progress can still be achieved through hard work. By using this conceptualisation, Teacher A may not experience such a high level of dissonance between acceptance of difference and self-improvement, allowing for these to be mutually acceptable goals (Kapp et al., 2012).

Challenging alternative curriculum narratives.

Teacher A's frustration with the unrepresentative nature of the mathematics curriculum may need to be acknowledged explicitly to reduce her perceptions that progress is unattainable (Croizet et al., 2020). Teacher A would need to be persuaded that a focus upon academic standards in combination with functional skills is both possible and beneficial to the children with which she works, as suggested by Courtade et al. (2012) and Graham (2015) among others. This could be achieved by drawing Teacher A's attention to personal examples within her setting, but if these examples are few, her assumptions are unlikely to be changed (Croizet et al., 2020). Perhaps a more successful approach may be to suggest related professional books to Teacher A, as she highlighted her interest in this type of professional development throughout our interviews. For example, she reported:

> I've been buying so many books [about] PMLD and SLD… and what we teach them in mathematics …. Money was really challenging for me … It really turned it on its head for me …Where do you buy stuff for pennies and twos and 5s? You don't. So why are we teaching them it? I thought it was really interesting research. I thought, 'yes I can see that.'

This suggests that where Teacher A was able to see the logic in an approach, she enthusiastically adopted it. Indeed, logic was a frequently repeated term in Teacher A's discussions of mathematics. While some teachers may look for a simple, easy to apply protocol or intervention (Cain, 2015a, 2015b; Laski et al., 2007; Vanderlinde & van Braak, 2010), Teacher A would be more likely to change her perceptions when presented with academic and diverse reading material around the subject (Cain, 2015a, 2015b). This would be a key consideration when providing training to Teacher A or in consultation work which required her to consider alternative perspectives.

Teacher B

Teacher B demonstrated strong views that all children are able to achieve when provided with the right opportunities to do so. She was committed to ensuring that the children in her class did not have the negative experiences of mathematics that she experienced at school. She identified ways in which children could be supported to understand mathematics, and the importance of emotional as well as academic support for children within her class.

Developing views around learning in different ways.

A number of Teacher B's practices could be viewed as positive in reducing mathematics attainment differences. These included a 'growth mindset' related to mathematics attainment (Dweck, 2008) where all learners have the potential to achieve with the right approach, pace and support. However, Teacher B's strength of feeling around avoiding early use of traditional procedural methods is likely to require sensitive challenge as it may affect how Teacher B approaches parental engagement. For example, consultations with Teacher B and a parent may be impacted by Teacher B's belief that parents are not being effortful or are contradicting her approaches.

Tailoring approaches to the needs of specific parents has been found to be essential to successful engagement of parents in mathematics learning (NCSL, 2011). Indeed, when relationships between home and school are viewed as equal, with sharing of contexts and applications being bi-directional rather than purely school-led, a mastery-based school intervention was seen to be particularly successful (Perry & Dockett, 2018). Through her passion to reduce the likelihood that children will share her negative experience related to mathematics understanding, Teacher B may inadvertently reduce parental involvement and support of mathematics at home or reduce contact with parents altogether. As general positive contact (unrelated to mathematics or attainment) is more likely to improve parental involvement and consequent student mathematics motivation (Fan & Williams, 2010), these relationships may be more important to preserve than continuity of methods in the initial stages of involvement. Teacher B may therefore need support to critically reflect on the unintentional impacts of her views on relationships between home and school.

Developing views around accessing learning despite barriers.

Teacher B's identification of the importance of foundational mathematics skills and emotional support is important for her awareness and understanding of the challenges that students in her class may be facing. However, the assumption that progress cannot be made before these foundations are in place can also be limiting, reducing children's exposure to a variety of forms of mathematics and to higher level cognitive challenges as well as reducing attainment expectations (APPG, 2012; Graham, 2015). By focussing on the skills or abilities that a child does not yet have, Teacher B may be unwittingly engaging in 'failure narratives' with pupils and staff around the potential of children to succeed in challenging academic or emotional circumstances (DeLiema, 2017). Teacher B's strength of belief in the ability of all to succeed in mathematics suggests that this is not Teacher B's intention, and therefore the challenge of this narrative would need to be conducted with sensitivity. Highlighting to Teacher B the practices she can adopt within the classroom to address gaps in skills or security, such as trauma-informed approaches, pre-teaching or scaffolding may reduce her perception that the attainment of these children relies on prior resolution of these difficulties ahead of participation. It appeared that Teacher B had already initiated some of these approaches in the classroom and should be encouraged to continue.

Teacher C

Teacher C was clearly committed to reducing the levels of future disadvantage that children within her class may face. She was determined that children would leave her class with a love of mathematics and would gain the mathematical skills that would be valuable to them throughout their lives. She highlighted inequalities of experience and skills in her school catchment and was keen to identify general cross-curricular practices that would assist children to achieve their potential.

Supporting reduction of disadvantage.

A potential support to Teacher C's goal of increasing student motivation and reducing disadvantage may involve being more overt about the disadvantages that children face with both children and their parents. Where students are made aware of the potential sources of their disadvantage relative to their more affluent peers, performance differences can disappear (Croizet et al., 2017, 2020). Through these shared narratives, collective action can emerge (Sweetman, Spears, Livingstone & Manstead, 2013) that combats the perception of mathematics by children and their families as 'not for them' (Croizet et al., 2020). Teacher C was keen to identify generalised approaches that could be adopted across the curriculum for the benefit of the children in her class and this would represent one such approach.

Challenging exclusively environmental attributions for low vocabulary.

A further area of potential development for Teacher C would relate to her assumption of environmental causes of vocabulary differences in the children she teaches. While a speech and language therapist may be concerned about the potentially supportive interventions missed through this assumption (Sedgwick & Stothard, 2019; Vivash et al., 2018), environmental explanations would perhaps be less problematic for an educational psychologist, who may suggest classroom-based support approaches and environmental remedies for such vocabulary difficulties (Vivash et al., 2018). This would of course likely be dependent upon the particular outlook and constructions of individual psychologists and indeed speech and language therapists. Whether Teacher C's environmental assumptions around causation are wholly accurate is unclear, her assumption potentially reduces the level to which Teacher C accesses the support of other professionals such as speech and language therapists and educational psychologists, despite a clear underlying need. Undoubtedly Teacher C's schools used interventions and training to address the low language skills of children in the school. However, by discussing language difficulties with Teacher C as a continued unfair disadvantage that may be ameliorated through support, this may increase her engagement with these external support services on a more consistent basis.

Teacher D

It was important to Teacher D that the children in her class were happy and enjoyed their mathematics sessions. She went to great lengths to motivate children using knowledge of their interests and practical activities. Teacher D identified that where children are aware of their ability relative to others this can negatively affect them; she was particularly concerned that some activities suggested by external advisors would have a detrimental impact upon the self-concept and self-efficacy of her pupils and lead them 'not to try' due to assumptions of inadequacy.

Challenging views around appropriateness of activities and approaches.

Teacher D appeared protective of the wellbeing of the children in her class. She was keen to emphasise their age and maturity and voiced concerns when she believed expectations were beyond children's abilities. While this was an empathetic response from Teacher D, it is possible that this approach will limit the challenge and reduce the expectations that both Teacher D has for the children in her class, and that children have for themselves (Dweck, 2008; Haimovitz & Dweck, 2017). Teacher D was particularly reluctant to ask children to use more complex thinking skills such as reasoning or problem-solving without fluency in the underlying knowledge that might be required. Teacher D is a highly critical evaluator of models of practice (Cain, 2015a, 2015b), questioning their applicability and validity in "real life". Therefore it is likely that presenting her with solely the evidence base for an approach would not be enough to change her perspectives around mathematics teaching practices (Francis et al., 2017). It is similarly unlikely that observing universal problem-solving approaches being successfully implemented in another class or setting would be enough to convince Teacher D that this will work for her cohort (Scopelliti et al., 2017); observation and reflection opportunities have been shown to have only short-term influences on teaching mathematics reasoning approaches (Yook-Kin Loong, Vale, Herbert, Bragg & Widjaja, 2017). In addition, Teacher D is keenly aware of the individuality of both her class and its members and has limited trust of external advice. Teacher D's confidence in implementing or trialling new approaches is therefore likely to be more successful if presented by staff members that she knows and respects in a supportive environment.

Another possible alternative may be for Teacher D to use mindfulness approaches while observing another teacher working with her class; mindfulness approaches have been shown to significantly reduce confirmation bias in some studies over and above that of attention to detail approaches (Hopthrow et al., 2017). By allowing Teacher D to observe "in the moment" the strategies and approaches of her lower attaining children without the demand for input or outcomes, she may become aware of their more successful approaches to problem-solving and reasoning tasks (Moscardini, 2014). Working with Teacher D alongside her staff team and validating her concerns related to self-concept and motivation, an educational psychologist may shift Teacher D's perceptions of what her pupils are able to manage, both cognitively and emotionally.

General Implications for Practice

As well as specific strategies and interventions that may be supported for each teacher within this research, there are also a number of practical implications that might be applied within educational psychology practice with teachers more generally:

1. **Using the bioecological model in teacher consultations.** Teachers' perspectives related to mathematics attainment differences in this research were complex and appeared to be highly influenced by their own bioecological influences. Through conversations structured around the bioecological model, I was able to better understand the influences underpinning the perspectives of teachers that would not be routinely explored in casework or consultation, such as teachers' own experiences of mathematics at school. As such, it would be beneficial for educational psychologists to consider areas of the bioecological model for which they have limited or no information during their work with teachers around mathematics attainment differences. Providing teachers with a safe space to explore and reflect upon these ideas would allow valuable insight into their thinking and how this may be developed.
2. **Empathising with systemic difficulties.** As Moir (2018) notes, educational psychology practice is developing to promote more systemic ways of working over individual casework responses, although this change is partial and somewhat gradual (Boyle & Lauchlan, 2009; Fallon et al., 2010). While working systemically at a whole school level, individual differences of teachers remain important in managing acceptance and implementation of new ways of working and thinking (Moir, 2018). It is likely that educational psychologists will need to be overt in their acknowledgement of difficulties and concerns related to implementation, particularly around 'tragic choices' of inclusion (Norwich, 2014)

environmental barriers (Augostinos & Callaghan, 2020), and the types of activities children with low mathematics skills can access without adjustment (Clarke & Faragher, 2015; Meier, 2020). However, they will also need to challenge the stability of these influences and therefore the inevitability of low access, shallow understanding and poor attainment in mathematics (Batruch et al., 2020; Easterbrook et al., 2020; Peach, 2015). Having a clear understanding of teachers' perspectives and assumptions allows educational psychologists to both acknowledge and challenge these perceptions more effectively.

3. **Engaging in critical self-reflection.** The process of exploring influences upon teachers' views can adjust educational psychologists' own perceptions of educators whose beliefs and constructions around mathematics attainment differences may differ significantly from their own. For example, teacher narratives around acceptance of students with learning differences and the different mathematics skills they value broadened my thinking around how growth mindset and strength-based approaches might be experienced by teachers. In addition, this exploration can challenge the assumptions and narratives of educational psychologists themselves and assist critical reflection around how they came to develop their own professional standpoints. For example, my own experiences of achieving in mathematics despite areas of significant weakness (e.g. visuo-spatial skills) influence my perceptions around the importance of specific foundational skills. Through engaging with alternative viewpoints, educational psychologists can become more aware of the assumptions and gaps in their own perspectives (Habermas, 1987; Kincheloe, 2008; Moon, 2004; Olafson et al., 2010).

4. **Advocating for children and young people.** While this research did not look directly at the impact of teachers' views around mathematics attainment differences on the students they teach, it reinforced the lack of power and choice that both children and their parents may have in how low mathematics attainment is supported. For example, while teachers were aware of the importance of mathematics self-concept and perceptions of low ability, children were often not involved in discussion or decision making around these experiences and how they might be tackled, such as support outside of the classroom or the connections made between the mathematics they engage in at home and at school (Alderton & Gifford, 2018; Peach, 2015; Rittle-Johnson, Fyfe, Hofer, & Farran, 2017). Educational psychologists are well placed to provide this voice for children and their families (DfE, 2014; Fox, 2015) supporting them to share the mathematics they know and value and the type of support they prefer with their teachers (Walshaw, 2014).

Summary

Knowledge of the influences and views of individual teachers related to mathematics attainment differences allows for greater tailoring of psychological approaches and knowledge to support teachers in addressing the mathematics attainment gap. A full exploration of these views and influences will often not be possible within the time constraints of educational psychologists' work, but consideration of under-represented influences such as teachers' experiences of learning mathematics at school may broaden educational psychologists understanding of teachers' views and teaching approaches. Acknowledgement of systemic constraints and 'tragic choices' faced by teachers in equalising attainment is also likely to strongly influence professional trust between educational psychologists and teachers. Exploration of teachers' views is beneficial both for the self-reflective practice of teachers and of educational psychologists. Both of these professionals may be unaware of the implicit assumptions they are making within their approaches to mathematics attainment differences until they engage with alternative narratives and perspectives. It is also important to maintain awareness of the relative low power and voice of children and their parents in reducing the mathematics attainment gap and facilitate their inclusion in teacher conceptualisations and wider practice.

Chapter Eight: Conclusion

I set out in this research with the aim of exploring teachers' views around mathematics attainment differences. In this thesis I have presented four case studies, exploring teachers' conceptualisations of mathematics attainment differences and how these conceptualisations might be influenced by their experiences, personal characteristics and wider context (their bioecology). Through detailed analysis of each case study, I was able to identify critical themes related to their views on mathematics attainment differences and consider ways in which educational psychologists might positively influence their views through tailored individual approaches.

How do primary school teachers conceptualise mathematics attainment differences?

Each of the teachers in this research varied in their constructions of mathematics attainment differences:

- Teacher A saw national curriculum expectations as wholly unrealistic for the children in her class and emphasised the importance of recognising children's limits in their learning potential (Ng, 2018). She viewed differences in attainment as expected, and saw value in differentiating the mathematics that children learn to make it representative of the mathematics they would need for life and the mathematics they could succeed in (Ayres et al., 2011; NUT, 2015).
- Teacher B viewed mathematics as a skill that was more difficult for some learners to acquire but believed all learners could achieve in mathematics given a different pace and approach (Dweck, 2008, Haimovitz & Dweck, 2013). She identified skills, concepts and feelings of security and safety that she viewed as essential foundations to mathematics learning and progress (Parhiala, Torppa, Vasalampi, Eklund & Poikkeus, 2018; Public Health England, 2015; Yao et al., 2018). She

also highlighted the impact of parental involvement, which may support but could also confuse children in their mathematics learning (Fan & Williams, 2010; Kocayörük, 2016).

- Teacher C conceptualised mathematics attainment differences to be related to unquestioned curriculum assumptions of experience (Croziet et al., 2020, Batruch et al., 2020), subsidiary skill and uniform starting points that did not represent the children in her school. The importance of interest and motivation, as well as mathematics being viewed by children as relevant and achievable was key to Teacher C's approach to teaching mathematics (Browman & Destin, 2016; Croizet et al., 2020). This included children's own learning behaviours such as resilience.
- For Teacher D, negative effects of having special educational needs on attainment were viewed as inevitable and she questioned the reasoning of teaching all children the same content in the same way (Ng, 2018). She identified the curriculum and some approaches to mathematics as problematic in that they promoted skills that would benefit some in the class but serve to exclude those with learning difficulties (Ayres et al., 2011; Ng, 2007). She saw motivation and interest as key to improving mathematics attainment (Browman & Destin, 2016; Garon-Carrier et al., 2016; Lazarides et al., 2018).

The participating teachers showed stable conceptualisations across the four interviews, even where they had adapted elements of their practice in response to reflections or research from these sessions. While there were some common narratives that emerged such as the impact of universal expectations on attainment and self-concept, teachers varied in their conceptualisation of causes of mathematics attainment differences and of how realistic it might be to eliminate this gap. It therefore appeared that individual differences between the cases had a strong influence upon the way in which teachers formed, developed and operationalised their ideas around mathematics attainment differences.

How are primary school teachers' conceptualisations of mathematics attainment differences influenced by their personal characteristics, wider context and historical experiences?

Each of the teachers in this study showed strong interactions between their views on mathematics attainment differences and their own characteristics, contexts and experiences. The degree of influence of each factor varied even within this small sample, and factors could be seen to interact to produce individuals' views.

- Teacher A's conceptualisations of mathematics attainment differences appeared most strongly influenced by her view of her own abilities as being limited and unchangeable over time, her experience working with children with PMLD and other learning difficulties, and additional needs and autistic traits of family members. The internal/external frame of reference model (Marsh, 2007; Parker et al., 2013) was also particularly relevant to her thinking.
- Teacher B's experiences of learning mathematics at school were clearly highly influential upon her conceptualisations of differences in mathematics attainment. A number of overlaps between these experiences and her constructions of 'learning in a different way' were observable, and often Teacher B made these associations for herself. Growth mindset narratives (Dweck, 2008; Haimovitz & Dweck 2013) were strongly favoured by this teacher.
- Having had positive experience of mathematics at school and particularly in higher education where these skills were purposeful, Teacher C made it a personal mission to ensure that all children in her class enjoyed mathematics

sessions by the end of the year. Her length of service in an area of deprivation made her highly responsive to social inequalities and the psychological and academic barriers this might create (Batruch, 2020; Croizet, 2020).

- Teacher D had positive memories of her own primary school teacher who had showed attunement to her needs at a time of difficulty and made learning enjoyable. She sought to make activities engaging for children who may not be motivated by mathematics and to remove extraneous content such as technical vocabulary that might prove a barrier to some. She identified the importance of both external and internal motivation for mathematical attainment , particularly in early years of schooling (Garon-Carrier et al., 2016; Weidinger, Steinmayr & Spinath, 2017).

There was high variation in the bioecology identified in each case study, despite all participants being female and working within the same local authority area. Connections between teachers' conceptualisations and their bioecology were often explicitly highlighted by teachers themselves as they reflected on their most salient memories or thoughts during the research process. One area that appeared to be particularly relevant to teachers' conceptualisations was their own experiences of learning mathematics at school, although the influence of this was both highly variable and interconnected with other areas such as temperament and wider family experiences.

Contribution to the Literature

This research adds to existing literature exploring teachers' views and assumptions related to attainment differences in mathematics. It supports the findings of Campbell (2015) that individual differences impact upon the views of these teachers around the attainment gap. The case studies I have shared here illustrate the breadth and variability of factors that may influence teachers' views on mathematics attainment differences. This research also adds further depth and detail to existing research knowledge related to the longevity and stability of these views over time. Furthermore, the findings highlight a novel theme around the potential impact of primary teachers' own experiences of learning mathematics during their schooling on their perceptions of attainment difference reduction.

Implications for Educational Psychology Practice

This research highlights the importance of educational psychologists exploring individual differences and background information not just of individual learners, but also their teachers. Through a greater understanding of teachers' views around mathematics attainment differences and how these interact with their personal experiences and contexts over time, educational psychology approaches can be presented to teachers in ways that they are most likely to engage with. Knowledge of the influences that shape teachers' views allows these experiences to be acknowledged while gently challenged rather than overlooked or pushed aside. This exploration process can also be seen as a professional development opportunity both for teachers and educational psychologists in increasing their awareness of their own perspectives and assumptions around mathematics attainment differences. The general implications for educational psychology practice of this research were therefore as follows:

1. Using the bioecological model in teacher consultations
2. Empathising with systemic difficulties
3. Engaging in critical self-reflection
4. Advocating for children and young people

Limitations and Future Research

One potential criticism of my research design may be the use of a single type of evidence rather than a variety of data sources within each case study. Traditionally, case study designs would use a variety of information sources such as observations, secondary evidence sources and interviews to achieve this aim and triangulate their findings (Creswell, 2007; Yin, 2012). However, the depth of information gathered through multiple individual interviews provided a high level of detail to answer my research questions (Driessen et al., 2005); Other sources of information such as observations or samples of student work would not have been relevant to my study aims nor compatible with the critical constructivist nature of the research. Future research might combine the views of teachers, pupils and parents in their exploration of views and influences to further broaden perspectives and allow comparison between individuals in each case study.

A further sampling limitation was that all participants were female and white-British. Given the predominance of women within the primary teaching profession and the lower levels of ethnic diversity in South West England this is likely to be largely representative of the population within which I was studying, but the impact of race and gender may have been more prominent in a more varied sample. A sample of teachers within the same school may also have provided an interesting comparison of the perceptions of a single staff group, particularly as 'in-house' training and staff development is now more commonplace. Overall the sample was fit for the purpose of an initial exploration of the diversity of teachers' experiences, particularly given that proximal processes (i.e. teaching itself) are central to the bioecological model (Bronfenbrenner & Morris, 2007). Future research may seek to vary the type of sample used to explore specific subgroups of teachers or those working within a single setting.

Finally, while this study illustrates the impact of different areas of the bioecological model upon each teacher's conceptualisations, there may have been additional influences that teachers did not mention or had little memory or awareness of that were equally influential to their thinking and ideas. For example the views of their own family and community around mathematics attainment differences or representations in popular culture may not have been considered. The study therefore provides an illustration of some of the possible influences and interactions related to teachers' views, rather than an exhaustive map of each teacher's conceptual development. My analyses did not suggest that the proximal processes were the main influence upon the development of teachers' views in this study: chronosystemic influences and wider contextual factors appeared to be more influential to their perspectives. Further research might therefore consider how the impact of these chronological and contextual influences might change or be changed over time. Consequently, while this research supports the utility of the bioecological model in exploring wider influences upon development, it did not confirm Bronfenbrenner and Morris's (2007) first proposition that proximal processes lead this development process. However it did support the use of the model as a tool to explore influential factors upon teachers' conceptualisations, and future research may beneficially use the model to scaffold their exploration. It also supported proposition two, that the power and direction of bioecological influences is an important consideration.

Reflections on the Research Process

This research caused me to question my own professional assumptions more than any other piece of casework I have completed. For example, I had not previously acknowledged the tension between succeeding in maths and succeeding in life, as identified by Teacher A. I noted that my reaction to Teacher A's success story of a young adult finding work at a hairdressers was different to that of Teacher A. While she felt elated, I felt frustration that the young adult had been deemed unable to achieve the skill of ‘doing the till’ over time. This was an important realisation, as in a casework situation I may not have had the time or depth of knowledge to consider why Teacher A may have come to this fixed ability narrative.

I had also not previously considered the longevity of the impact of school experiences well into teachers’ adult and professional lives. By structuring my discussion very deliberately within a research process, I stumbled upon emotive and salient factors that I may otherwise never have broached in a casework discussion. It also caused me to questions some of my own assumptions around the fixed nature of attainment and what I might have assumed was ‘realistic’ for a young person to achieve. The research process was therefore also a professional reflective process for me that altered both my practice and perspectives.

Final Thoughts

This thesis is written in the midst of the coronavirus pandemic at a time when schools are closed to most pupils and fears of an ever-growing attainment gap fill the media. The uptake of school places by vulnerable children remains low. While little has changed to reduce barriers to mathematics learning of those from vulnerable groups, school closures have highlighted the multitude of inequalities that mean mathematics attainment cannot be solely attributed to ability and effort. Schools may find that during this time they have increased contact and better relationships with parents of vulnerable children, increasing their engagement with school and learning. Whether policy or practice will be adjusted to ameliorate some of the systemic barriers to reducing the mathematics attainment gap as a result of the pandemic remains to be seen.

The findings of this research suggest that teachers will have differing assumptions around the impact that school closures will have around maths attainment differences. These assumptions may have been confirmed or reinforced during children's absence and return to schools. However they may also have had opportunities to reflect upon their assumptions, as I did over the course of this research. My research findings suggest that teachers' reactions to growing maths attainment differences will be complex and highly individual, but their own school experiences will remain salient to their responses to the growing attainment gap.

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Appendices

Appendix 1: Handout extract for session 1

Session 1: Cognitive Factors

Q: Tell me a bit about yourself/this school/your class
Q: How would you rate your mathematics skills?
Q: What do you remember about learning mathematics when you were at school?
Q: What cognitive barriers do you observe in your classroom?
Q: Do you have any personal experiences of cognitive factors that have affected learning (through yourself, family or friends)?

Introduction: Cognitive abilities consistently contribute to mathematics development, and mathematics development also impacts on cognitive development. Progress is often not linear, fluctuating across terms, and increasing more rapidly at particular age points: for example, lower attaining learners often show more rapid growth between age 8 and 11 than their higher achieving peers. Many different cognitive profiles have been found in studies of mathematics learning difficulties.

Research findings

1. *Visuo-spatial skills*

- Visuo-spatial working memory (VSWM) is lower in some children with low mathematics attainment and affects place value, counting and number order, fluency and complex calculations. Differences in VSWM reduce over time between those with difficulty in mathematics and those without.
- The spatial skills–mathematics link might be related to factors that affect them both e.g. self-regulation
- Mental rotation and visual coordination both link to number-line development. Symbolic comparison of numbers (e.g. which is bigger, 14 or 29?) is linked to this number-line development too. Mental rotation and spatial visualisation both relate to mathematics performance. Understanding order and sequence also improves mathematics abilities.
- Time processing improves with age but is lower in those with mathematics learning difficulties.

2. *Self-regulation and meta-cognition*

- Self-regulation - controlling attention, ignoring distracting information and reducing impulsivity – directly predicts early mathematics attainment and is linked to most mathematics skills in a number of studies.
- Ignoring (inhibiting) previously learnt rules is important for mathematics development, although its importance may fade over time. Spontaneously focussing on amount (rather than colour for example) predicts mathematics performance 6 years later.
- Attention impacts on mathematics in the early years of primary. Inattention can also highlight a lack of understanding by a child if it differs when in whole class/small group settings: it might suggest more intensive support is required.
- Metacognition improves problem solving performance and reduces hopelessness after poor mathematics performance.

3. *Cognitive flexibility and updating*

- Cognitive flexibility (e.g. moving between different types of sorting) is related to abstract skills and understanding of concepts as well as quantity-number associations and can

predict mathematics attainment. Transcoding fractions, decimals and percentages is also particularly difficult for struggling mathematics learners.
- Updating (working out where you are in a planned sequence and moving forward/back within it) is also linked to mathematics performance, particularly with learning counting sequences.

4. *Fluid reasoning, knowledge and long-term memory*
- Fluid reasoning links with calculation and problem-solving and is more important in early mathematics learning than 'facts'. However, knowing formal reasoning methods supports mathematics development
- Factual knowledge predicts problem solving ability. Some children with low mathematics attainment have difficulty recalling number facts. Mastery of mathematics concepts deepens over time. Distributed practice of mathematics facts throughout the day is more effective than a block of practice, improving fluency.
- Long -term memory is important for complex calculations. No long-term memory differences have been found between those with mathematics difficulties and those with mathematics and reading difficulties combined.

5. *Processing speed*
- Processing speed links with calculation and problem-solving and is important in mathematics achievement. It increases fluency of calculation and improves problem solving. Speed when comparing number symbols takes longer for those with mathematics difficulties than those without, although their accuracy was the same.

6. *Verbal working memory, phonetic coding and reading*
- Phonetic coding, phonological awareness and rapid naming predict calculation fluency and number skills.
- Verbal working memory remains consistently below average for those with mathematics difficulties.
- It has been suggested that those with specific mathematics difficulties have higher problem-solving skills than those with mathematics and reading difficulties combined. Comprehension knowledge links with calculation and problem-solving. Mathematics problem-solving skills and verbal reasoning have also been linked to reading level and reading reduces the effect of low working memory and inhibition on mathematics attainment. However, generally, those with reading/writing and mathematics difficulties combined do not have specific cognitive differences compared to those with just mathematics difficulties.

7. *Short-term memory and working memory*
- There's lots of evidence both for and against the approximate number system, with some suggesting short term and working memory differences could be behind it. Estimating numbers on a number line is a particular difficulty for those with mathematics learning difficulties.
- Visual processing short-term memory is linked to lower mathematics performance.
- Some studies say that working memory is more important for older children (over 11) but effects complex calculations and problem-solving. Others link working memory to mathematics performance in early primary and say a higher working memory capacity leads to higher mathematics growth and is linked to comparing and combining numbers and quantities. No working memory differences have been found between those with mathematics difficulties and those with reading and mathematics difficulties combined.

Teacher related
- Teachers' own strategies for self-regulation and the ones they use to improve student self-regulation can be predicted by their beliefs in their own mathematics abilities, how much they value mathematics and their professional investment. This isn't linked to enjoyment.

- Teaching problem-solving by building on children's existing strategies improves teachers' awareness of their own mathematics thinking.
- Teachers become more aware of the impact of 'executive functions' (e.g. inhibition) with experience, but don't always know the terms to describe them.
- Teachers can accurately identify Gifted and Talented mathematics students in their classes better than cognitive tests alone would predict, as they consider other characteristics (e.g. temperament). However, they are more likely to identify children with high language and academic skills and lower avoidance as higher ability and can see lower ability children as lower in skill than they really are if levels of attainment in the class generally are high. Using lots of independent work and perceiving children's calculation to be superior negatively affects performance.
- Working memory and spatial ability (as well as mathematics anxiety) are high predictors of mathematics performance in teachers.
- Attendance of mathematics training (in initial teacher training) improves teachers' mathematics grades at end-point assessments. Teachers hold a number of misconceptions in mathematics both before and after initial teacher training. Increased teacher subject knowledge and conceptual understanding improves the mathematics performance of their students.

Interventions

- Work on self-regulation in early primary rather than behaviour.
- Providing feedback is positive for low knowledge learners but can be negative for high knowledge learners, particularly relating to procedures.
- Consider block play interventions for new school starters with low numeracy, cognitive flexibility or executive functioning (memory, planning etc).
- Self-graphing and self-cuing improve self-regulation skills and subsequent mathematics productivity.
- Target executive functions (memory, processing, updating), attention problems and number skills to improve mathematics skills
- It is possible that visuo-spatial working memory training can improve mathematics attainment, but other studies have found this isn't the case. Using spatial visualisation/mental rotation practice in early education should be used where required, especially as these skills develop rapidly with age.
- Brief experimental analysis shows that different interventions are effective for different children, but that there is usually one that they respond well to, both immediately and over time. For persistent difficulties, test a number of different interventions to find 'what works'.
- Direct children's attention to mathematics rules and examples that are exceptions – be explicit. If using mnemonics for reasoning, focus on why you do something as well as how.
- Use observation of worked examples to improve meta-cognition.
- Comparing quantities can 'prime' mathematics performance
- Provide training to increase teachers' subject knowledge, including using demonstration lessons and collaborative reflection opportunities.
- Formal teaching of alternative fraction notations is required for struggling mathematics learners. Using rulers to teach fractions confuses children – a blank number line is better.
- Use modelling of estimation and checking procedures as well as appropriately complex tasks to promote higher attainment in problem-solving.
- Teachers should use their own knowledge of a student to assess what they do understand, but their previous answers when assessing what part of a problem they don't understand.

Appendix 2a: Email to headteachers for expression of study interest

FREE MATHS CPD!

Please find attached a flyer detailing some free maths CPD for teachers. The subject is "the psychology of maths teaching and learning". It consists of 4 one-to-one sessions of 90 mins each and includes psychological research evidence and opportunities for professional self-reflection.

CPD sessions will be audio recorded for use as part of my doctoral research.

If a member of your teaching staff is interested in participating or would like further information, please contact me by **Friday 5th April**.

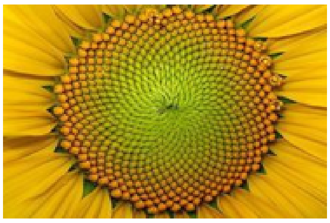
Best wishes,

Valerie Marshall

Trainee Educational Psychologist, University of Exeter

Appendix 2b: Research flyer

UNIVERSITY OF EXETER



LOOKING FOR FREE MATHS CPD?

Participants required for new research project

THE PSYCHOLOGY OF MATHS TEACHING AND LEARNING

What's in it for us?

6 hours of free one-to-one professional development, led by a Trainee Educational Psychologist

Up-to-date summary of the psychological knowledge base around mathematics teaching and learning.

Opportunities for professional reflection

What's the commitment?

4x 90-minute sessions with the researcher at fortnightly intervals.

1 x follow-up session to review the research.

Who can participate?

Primary teachers who teach maths at least twice a week

INTERESTED?

For further information, contact Valerie Marshall (Researcher)

EMAIL: xxxx

Appendix 3: Participant Information Sheet

Title of Project: Sharing psychology related to maths teaching and learning.

Researcher name: Valerie Marshall (Trainee Educational Psychologist)

Thank you for your interest in this research project. This sheet provides information about what this project will involve, things to consider, and your rights should you choose to participate. Please take some time to carefully consider the information provided. You may wish to discuss your participation with family, friends, colleagues or senior leaders. If you have any outstanding queries, please ask the researcher for further details or clarification.

What is the study and why is it important?
There is a stubborn attainment gap in maths between socially advantaged and disadvantaged children in England, but there is no 'best' intervention that has been identified that might reduce this gap. This might be because there are many factors that impact upon maths development, and no single intervention could cater for all strengths and needs.

In this project I will look at how individual teachers interact with psychological knowledge around maths teaching and learning. By conducting this research, I hope to find out how teachers view maths attainment differences and how this differs depending on their individual characteristics, contexts and experiences.

What would taking part involve?
If you choose to participate you will take part in 4 one-to-one sessions with the researcher. These would take place once a fortnight for 90 minutes per session. Where possible, these sessions will be arranged to take place within your school, to avoid the need for travel. In each session, you will be provided with recent psychological research knowledge related to maths teaching and learning.

Sessions will be audio recorded and transcribed. All recordings and transcripts will be identifiable only by a single letter and stored securely. I will use these recordings to look for themes. You will be able to comment on, correct, or question these themes, and any feedback will be incorporated into my analysis. Any details that I have reported that you think will make you identifiable can be discussed and removed.

What if I require adjustments to take part?
Wherever possible, I will make adjustments within this research to ensure it is accessible to all potential participants. If you require adjustments to ensure you can participate fully in this research (e.g. larger font materials, dietary requirements, a need for frequent breaks, timings that fit around caring responsibilities), please inform me when you express your interest in participating, so that we can discuss how best to accommodate your needs.

What are the possible benefits of taking part?
You will receive 6 hours of free one-to-one professional development, led by a Trainee Educational Psychologist. While I can't promise specific benefits from the sessions, they will offer psychological knowledge and opportunities to critically reflect on how these ideas apply to you and your class. There should be no expectation of a direct impact from this project on pupil attainment.

What are the possible disadvantages and risks of taking part?

The risk and likelihood of personal or professional disadvantage in this research is low. However, the following measures have been taken to reduce this further:

- Working within a school, you will likely have many demands on your time. I have made sure that the sessions are as short as is practical and are spread fortnightly to reduce the demands on your schedule. I have also approached school leaders/SLT first to make sure that you are supported in your attendance of the research sessions.

- This research is not linked to measures of teacher ability, pupil progress or teacher performance. If you feel at any point that this is expected of you as a participant, I can support you in clarifying this with your school.

- Some people can find self-reflective activities mildly uncomfortable. However, the study sessions are designed to provide a safe space to complete these tasks (individually, in a familiar but private setting and confidentially). You can also take a break or stop the activity at any time.

- You might be worried that some of the details you have discussed about maths teaching and learning might not be seen positively by your school. Your responses will be reported anonymously, but if you think anything in the transcripts or themes makes you or your school identifiable, I can edit or remove it.

What will happen if I don't want to carry on with the study?
You can stop taking part in this study at any time (without needing a reason) by contacting the researcher in person, by telephone or by email. If you have already completed some sessions, you can choose for this information to either be included or withdrawn. If you choose to withdraw from the study, all transcripts and audio recordings will be destroyed.

You will have the right to withdraw your data up until the end of the research process when a final thesis is submitted.

How will my information be kept confidential?
The University of Exeter processes personal data for the purposes of carrying out research in the public interest. The University will endeavour to be transparent about its processing of your personal data and this information sheet should provide a clear explanation of this. If you do have any queries about the University's processing of your personal data that cannot be resolved by the research team, further information may be obtained from the University's Data Protection Officer by emailing dataprotection@exeter.ac.uk or at www.exeter.ac.uk/dataprotection

Information gathered during this research will be kept confidential unless safeguarding concerns arise. In this case, safeguarding procedures will be followed and information reported to the designated safeguarding officer for the school. Where safeguarding protocol allows, I will inform you that I am raising an issue.

Audio recordings and transcripts of the sessions will be uploaded to the University U drive (which is password protected) at the earliest opportunity. A back-up copy will be stored in an encrypted zip file on a password protected laptop. Each file will be saved using only the participant number as an identifier. The contents of transcripts will be anonymised, removing names of people or locations.

The information collected within this research will be used to produce a PhD Thesis. Your information will only be used for other purposes where you have given specific permission for this to happen. Possible additional purposes are noted on the consent form. There is no obligation to consent to these alternative uses of your information, and declining to tick them will in no way affect your eligibility to participate in the study. Information gathered during this research will be permanently deleted once I have completed my thesis.

Will I receive any payment for taking part?
You will not be paid for participation in this study but will receive the 4 sessions as a free professional development opportunity. Any travel costs reimbursed.

What will happen to the results of this study?
The results of this study will be used in the writing of my doctoral thesis. This will be openly accessible in the thesis repository of the University of Exeter Website using the following link: https://ore.exeter.ac.uk/repository/. Where consent has been agreed, results may also be shared with participants and schools through summary reports, and with other professionals through academic publications, conferences and presentations.

Who has reviewed this study?
This project has been reviewed by the Research Ethics Committee at the University of Exeter.

Further information and contact details

For further information or to request to take part in this study, please use the following contact details:**XXXXX**

If you are unhappy with any aspect of this research or would like to make a complaint, please contact my lead project supervisor:**XXXXXXX**

Thank you for your interest in this project. Please keep this copy for your own records.

Appendix 4: Literature synthesis procedure for content of interview sessions

I completed a research synthesis of the past five years (2014-2019) of literature related to the psychology of mathematics education and summarised key findings to present to participating teachers. To identify these studies I carried out a search using the EBSCOhost academic database including British Education Index, Education Research Complete and Psychology and Behavioural Sciences Collection using the search terms math* (title) AND psychology* (subject terms). 859 articles were identified within this search. I then applied the following exclusion criteria:

- Studies without full text and/or without peer review
- Studies related solely to secondary school-aged young people (over 11 years)
- Longitudinal studies where Year 6 pupils (age 10-11) were the baseline measure for the study.
- Studies concerning the development or evaluation of assessment tools
- Studies evaluating research methodology.
- Studies exploring teachers' views of international policy changes where previous policies were not described.
- Descriptive illustrations of the success of particular methods without forms of evaluation
- Theoretical discussions without study findings

This left 219 studies for summary and inclusion. The findings from these studies were synthesised and organised into four categories: cognitive, biological, affective and environmental. These categories were further divided into subcategories of child-related, teacher-related and intervention-related for ease of presentation.

Appendix 5: Certificate of ethical approval

GRADUATE SCHOOL OF EDUCATION

St Luke's Campus
Heavitree Road
Exeter UK EX1 2LU

http://socialsciences.exeter.ac.uk/education/

CERTIFICATE OF ETHICAL APPROVAL

Title of Project: Teachers' reflections on the psychology of mathematics teaching and learning: themes of experience and change

Researcher(s) name: Valerie Marshall

Supervisor(s): Dr Andrew Richards,
Dr Chris Boyle,
Elizabeth Hampton

This project has been approved for the period

From: 17/01/2019
To: 01/07/2020

Ethics Committee approval reference: D1819-024

Signature: Date: 17/01/2019
(Professor Dongbo Zhang, Graduate School of Education Ethics Officer)

Appendix 6: Exploration of my own bioecological influences

Element	Sub-category	Examples
Process	Form	Through observation in the classroom, individual assessment of mathematics or related skills, or in consultation meetings with teachers
	Content	Discussion, observation and questioning, individual assessment, considering approaches to learning, identifying barriers.
	Power	Able to make suggestions that are included in statutory advice or report recommendations, can be seen as gatekeeper to resources.
	Direction	Referrals made by school to service, although needs could be highlighted by me if observed/in discussion about mathematics generally.
Person	Demand characteristics	Low skills in spatial aspects of mathematics.
	Resource characteristics	Past experience as a teacher, mathematics qualifications up to GCSE, good access to research knowledge.
	Force characteristics	Interest in social inequality, strong sense of fairness, self-motivated, prone to catastrophising.
Context	Microsystem	Young family at home, completing placement in a large Educational Psychology Service with some Educational Psychologists specialising in mathematics. Variety of schools worked with, some regularly and some less so. Supportive and knowledgeable supervisors and trainee cohort.
	Mesosystem	Work-family balance, interacting with schools with different expectations and ways of working around mathematics teaching and learning. Different intakes and concerns.
	Exosystem	Impact of changes in curriculum e.g. mastery focus, academy-based changes. Potentially different views around mathematics teaching relative to advisory teachers – different perspectives.
	Macrosystem	Can be seen as gatekeeper to resources or completing mostly cognitive-based work with pupils – this can limit pupils who may be referred to me to those with solely learning differences. Being good at mathematics is valued by society and seen as a marker of intelligence alongside literacy.
Time	Micro-time	Singular observations, casework or interactions with schools and teachers.
	Meso-time	It can be difficult to be involved consistently over time due to cost of Educational Psychologist time, either with one individual or teacher. Can be more consistent if delivered through a course of training, but often not seen as an area for Educational Psychology – viewed as an advisory teacher role.
	Macro-time/ Chronosystem	Experience of being a teacher, succeeding at mathematics during GCSE despite low skills in some key areas. Previously qualified as a Social Worker and worked as a SENDCo. Observed children to struggle at mathematics and unsure how best to support them.

Appendix 7: Coded extract from interview session 2 for Teacher B

Coding Key

Biocecological influences

They can learn but in a different way

Foundational knowledge and skills required

(00:00-13:53 of 55:21)

R: So how have things been since 2 weeks ago?

TEACHER B: Yeh yeh yeh yeh Its good so as I say coz my job share she's not, she's not been back since after Easter she's been off for quite a while. [ok has she] um so kind of had to kind of think about the whole week. Rather than just You know even though I'm only in three days [yeh] still keeping that sort of breadth of the whole week.

R: Yeah [um] Has that felt really different? To …

TEACHER B: A bit different. Yeah [yeah]. Um but.. But you know it's fine. And um yeah I've been really thinking about my lowers particularly with Mathematics. And um we were doing the number line today um with our subtraction and It's really interesting that um two out of the three coped with it really well but that boy that I was telling you about last week again was just like. We were doing um subtraction and we're doing it really slowly like you know 8 takeaway two so where's 8 on the numberline and mark it on the number line. Right now I'm gonna do some jumps we're going to count back 2 and we're doing it together and we did a couple of examples and those two were then like "oh yeah I've got" this and went off . Whereas he was then still because the number line was to 10, each time started going back to 10 [really] even though [yeh] it wasn't the number in the question [yeh]. He started [starting right back] ...Yeah which was. He's really struggling with that concept of the number line.

R: Yeah yeah. and Being able to go up and down

TEACHER B: Yeah so there's lots of unpicking needs to happen with him [yeh] because there's a real sort of lack of understanding there.

R: Yeah yeah of what's going on

TEACHER B: Yeah. Because as I said you know normally the three of them kind of work on a similar level but those two kinda once they'd had a few modelled examples they're like oh I can do this now and they were you know counting their jumps and everything but he was just every time. It's like no no, what's the number in the question. All right. Okay. Find it.. and he can tell you which is the larger number. So he's got that sort of you know basic understanding but the actual process is no

R: The actual thing…that's what he's really struggling with or….[its bizarre] it is isn't it and they are So yeah So different even though they're working at a similar level. Yeah. Just the difference. He might be good. I was gonna go back quickly just to see where things were but he might be a good example to go through actually. [Yeah]. And Just see where it is that we think or what it is we think he's struggling with in that cognitive bit and then we carry on [yeah yeah] and see if there's other bits as well. [yeah absolutely] Sometimes it helps make it a bit more concrete. Doesn't it [mmm] when you're using …when we're thinking of the person when we're thinking of it. [Yeah. Definitely] So how is he generally with those kind of spatial skills being able to repeat a pattern and those kind of things.

TEACHER B: Er I think he'd struggle. He struggles to hold a sentence in his head. [OK yeah] So sort of he'll say the sentence when it comes to writing it down. He's kind of got halfway through or he'll just write down the subject of the sentence rather than you know. So I'm like writing it so today it was it was raining. So the first thing he writes down is raining.

R: Yeah Oh I see so he's got that last word and that's the one that sticks in his head and the rest

TEACHER B: Yeh. is it's just a blur. So it's like okay what was the sentence and then you talk it back and he can tell you the sentence but when it comes to record again you have to almost sort of keep repeating back his words to him because he just can't, can't hold it

R: Hold it in mind so actually his, that verbal working memory is really what he's really struggling with actually isn't it, that he's trying to hold something in mind then it's just gone [laugh] or he's got a bit but not the whole thing. Yeah okay. And visuo spatial as well. How about his ability to sort of regulate himself and sort of pay attention to things.

TEACHER B: oh yeah [yeh] that's a struggle.[that's quite a struggle] yeh He's um he's very active. He loves his sport he's really good at P.E. but he's had a disruptive home they've his parents have split up and I think there's been a bit of a custody battle. So I'm not sure how much of that he's aware of, But so . You know that's going to have had an impact. [yeah yeah] so he started having social and emotional support so we can. He's going to like a X group as well. Doing some sort of you know making him feel a bit special those kinda things so he's having that kind of personal impact intervention. Which I think to be honest. There's not much point doing the learning stuff until we know that he's feeling a bit more secure. and settled

R: Yeah. Yeah. In what he's doing. Yeah. [**4:35]**

TEACHER B: But it's interesting what you were saying last week about them being almost lost on the carpet. He is just that child. That [really] yeah is not really there . But then when he's the one that almost needs just the small group to learn.

R: Yeah yeah. So he kind of gets lost in amongst others. [Yeah]. And blends [Yeah]. Oh bless him, sounds lovely

TEACHER B: Oh he's a lovely little boy yeah [laughs]

R: and like how is he at retaining facts and things like that? Is he quite good at retaining?

TEACHER B: No, no And again he struggles with his reading [ok]. So yeah that was another thing that we talked about didn't we.

R: Yeah. It was wasn't it. About how that, All of those kind of verbal skills as well will link and yeah.

TEACHER B: So we've been doing his like high frequency words um each day. And it's really interesting it's the same words that um continue to be a barrier like… Continues to be a struggle [mm mm]. So he always reads no as on and go and got he muddles those up and not and No. It gets muddled by those kind of ones.

R: Yeah. And kind of moves them round and [yeah] oh OK. And how is he when he's just doing .... like if he's like If it's words he's sounding out or like…

TEACHER B: Yeah. Well when we've been doing sort of like um almost drilling the children because we've got the phonics screening coming up [ahaa yep]. So almost doing reading drills this morning just to try and build up their fluency, like segment and blend. And again my turn your turn (both laugh) and again. And he's been trying to join in with those and been sort of most of the time trying to keep up. [good] So it's really interesting that you know those sorts of words. He's still. [yeh] You know. Like. We'll go over it and I'll say you remember what that word is again? on.

R: Yeah - [both laugh]. And it's funny cause for some children it'll be the other way round and they'll find it really hard to do that segmenting and blending. [Yeah] But I spose because those visual skills are something that he found not so easy. It might be that remembering the order. [Yeah. Yeah] and the sequence is where he's finding it a bit more difficult. Hmmm [yeah] [**6:55**] And is he, would he be able to move if he's got a task like if he'd managed to do one more than, would he be able to move on to something else like move say for example if he did one more than would he be able to do two more than?

TEACHER B: I probably would say No. [mm] I think he'd get stuck in that pattern. [Yeah] like I said this morning the whole starting at 10 he gets kinda caught in a... because the question before was ten take away something. So obviously I need to start with 10 again. and it's like No. you'd.. yknow [yeh yeh]

R: So he's following sort of the actions he's learnt from the last time but not [yeh] not really thinking about how it [no] all fits together. [No.] Okay.

TEACHER B: Because I guess he hasn't got the.. he's not secure enough in it and confident enough so he he can't just see it and do it he needs that extra input.

R: Yeah that extra bit. And is that what really works for him? What works sort of teaching wise for him that you've found?

TEACHER B: I definitely, Well it definitely has to be small groups. [mmhm] Yeah. Definitely. Because as I say whole class it's just like you were describing he's kind of sort of… left

R: Yeah Just like always looking. Hard to focus, ok. **8:03**

TEACHER B: Yeah. [yeah ok] Yeah he does. So again I don't know partly whether that's possibly to do with the whole visual and memory and everything. And also his what's going on at home wondering if it's like a combination [yeah combinational] of the two. [and it often is] Its just too much going on that he just can't then sit and focus. And like you said it's is too hard so I can't I'm not going to I'm going to switch off..So

R: Yeah yeah absolutely. Sounds like an interesting one. [laughs] so we can come back to him as [yeh yeh] we go[yehyeh] anyway because it's quite a useful one to come back to because he is a little bit different to the others as Well and sometimes that can help just to think about [oh] how does it compare. [yeah] and things like that [yeah]. So the bits today are about sort of biological factors so developmental conditions and language disorders and those kind of things have you had a lot of children with different sort of developmental needs in your class before?

TEACHER B: Umm I Had a child. She left err I think she left last year. I think they moved up to X. Um She was held back a year. And she had she had a lot of massive developmental delays. She was working well when she was with me in year two. She was working at like Foundation/Year one level. I think she was still. Very much at a year one level when she was going into year three and then she was quite quite significantly behind and she had a one to one. [mmhmm] So I'd plan separately for her and she'd do sort of it was five minute tasks and then stop and then do something else. it was very sort of short focused. And then [and then something else] let's go for a run around the playground let's do this because that was kind of her that's as much as she could cope with. **9:52**

R: And how about some people will and some people won't sort of within your own family or friends or people that you know that might have had sort of conditions that had effect had an effect or didn't have an effect on their learning.

TEACHER B: Erm No. I mean thankfully in our family everyone's..... There's not been anything particular. I mean. There's things like hearing my X struggled a lot with his hearing. [Yeah]. Um He couldn't. His speech was massively delayed [mm] And he had really poor vision as well. And Neither of them were properly picked up 'til he was kind of pre-school age. And I remember I remember Because he used to confuse me and my X. [Oh really]. Cause we've got a similar sounding names X and X. [Yeah]. Um He it was almost like he thought we were the same person [yeah] because his vision and his hearing was it wasn't great. So um as soon as kind of he got his grommets and his glasses and everything his speech and everything improved and My X is the same she wears and she's got hearing aids and her reading's fine now but her again her speech was was delayed because of hearing [yehyeh] but that's the only thing personally.

R: Yeah. Yeah. Um So the other bit I was going to…no I'll do this bit first. So when it comes to biological factors there's. There's always a debate about whether there is a specific mathematics difficulty like a biological thing. [Yeah] but it's problematic. They've never managed to pinpoint one particular thing it's always been there's kind of there's lots of different factors going on. But do you think there's that there's like mathematics people and literacy people. What do you you think?

TEACHER B: I don't know, I think some people. Haven't. I don't think it's that they're naturally...good at mathematics. I think it's that they've got an interest and so therefore they build more on that interest. Like my X for example is like definitely mathematicsy sciency. [mm] But that's what he's interested in so I think he absorbs all those facts because that's what he wants to know more about. [Yeah yeh] but I mean at the same time he loves books and everything. But I think and I think like I said before you get that perception. Don't you and it kind of those labels kind of stick and then it's hard to shift them. [Yeah yeh true] and I remember my X growing up he was very much well I can't do it and I'm rubbish and so he very rarely tried with mathematics then because he just kind of told himself...I'm rubbish at this. I can't do it. [mmm] But I don't know. I wouldn't. I don't know, am I wrong? (laughs) [no no]. **12:48** Is it true? Does it have certain…?

R: I think it's an opinion again really and I think completely like you say like different people will have different interests and different perspectives and it feeds into each other doesn't it if you're good at something then you like it [yeh] and if you've struggled with something you avoid it. [mm] and then You don't like it even more because.. Yeh so I think its it is a real balance. And Some people have really quite strong opinions on it and think well there must be something. Yeh you know there must be something in particular that's [yeh] affecting people. That would mean that they can't do mathematics. [Yeah] and Yeah. So I don't think there's a right or wrong [no] It completely make sense what you're saying [laugh] about different ones. So what I thought I'd do next is have a look at the sort of conditions that they have you know and there's not loads which for me was surprising although I don't know. Maybe it's just that [mm] you know it's more of a general thing with mathematics but it'd be interesting to see just what you might expect people's mathematics abilities to be. [yep] With different conditions [ok] so again there's no right or wrong and there's not very much information afterwards to corroborate bits but it's just interesting to see where you sort of place things. So number one on the list is ADHD. What you might expect.

TEACHER B: Well I've only experienced it once when I was um when I was a supply teacher. And um the boy in question just it was just struggling with concentration more than anything else. Yeah. [Yeah].

R: Rather than Something in particular but that attention Yeah. Yeah. Um autism, autistic spectrum condition, however you like to uh…

TEACHER B: Well they all say don't they that they they're good with mathematics and they're good with numbers but that can't always be the case surely [yeah]

R: There is a variety isn't there And. Learning disabilities We talked a little bit about with. Your. [Yeah].girl with Developmental delay but what would you sort of expect mathematics learning to look like for.

TEACHER B: Well I would expect them to be struggling across the board I wouldn't expect it to just be mathematics. I'd expect that there's going to be difficulties in lots of different areas. [Mhm yeah Yeah]. And that It's just going to be a lot slower [yeh] and a lot more gradual and learning would take place in a slightly different way. [Yeah]. To the other children learning in a slightly different manner. Smaller groups or one to one. [Yeah.Yeah.] **13:53**

Appendix 8: Support, maintenance, challenge and development of teachers' constructions of mathematics attainment differences

Teacher A: Fixed Learning Potential Construction

Element	Sub-category	Support / maintenance of construction	Challenge / development of construction
Process	Form	Children showing fear of 'mathematics' due to previous difficulty	Children's increased confidence when explored mathematics independently
	Content	Repetition leading to boredom and low self-esteem	Children's increased confidence and progress after familiarization.
	Power		Pressure to justify changes to teaching and coverage
	Direction	Choosing to 'stop' when potential deemed to be reached	Letting children work independently challenged fixed views
Person	Demand Characteristics	Brain having 'limits' and neuro-diversity unchangeable	
	Resource Characteristics	Experience of supporting neuro-diverse children at work and at home	New thinking about labelling and working memory caused her to question fixed narrative
	Force Characteristics	Connects positive learning experiences with enjoyment and success	Wants children to experience 'wonder' of learning mathematics and have mathematics skills for life
Context	Microsystem	Observing children's personal strengths (non-curriculum based)	Increasing independent activities in class and seeing progress
	Mesosystem	Experiences of learning differences within the home.	Own reading for CPD at home changed approach.
	Exosystem	'unrealistic' parental expectations leading to feelings of sadness	
	Macrosystem	Push for pupil progress. Lack of value for diverse skills/strengths	
Time	Micro-time		
	Meso-time		Seeing children succeed over time and make progress
	Macro-time/ Chronosystem	Persistence of creative writing difficulties	

Teacher B: Different approaches needed to learn effectively

Element	Sub-category	Support/ maintenance of construction	Challenge/ development of construction
Process	Form	not 'one way of doing things'	Needing to follow progression of models Teaching different or shorter inputs to children to meet their needs.
	Content	High achievers struggle with some areas compared to the mid-attainers.	Needing to have the basics before being able to progress, needing to teach particular things for formal assessments
	Power		Wants to avoid formal methods at early ages, Lack of availability of teaching assistant support.
	Direction	Children sharing their methods.	
Person	Demand Characteristics	12 years teaching experience.	More 'inclined' towards English than mathematics. Previous experience of anxiety.
	Resource Characteristics	Had supportive parents, now more confident in mathematics skills, is mathematics lead within school.	Experience of visual and hearing impairment in family that required intervention to improve performance.
	Force Characteristics	Doesn't expect others to find mathematics easy, determined attitude to learning.	Previously felt was not good at mathematics, prioritises security, wellbeing and safety of children.
Context	Microsystem	Small class size, pupils described as 'lovely'	3 learners identified as low attaining.
	Mesosystem	Supportive mathematics lead meetings and supportive head.	
	Exosystem	Own child good at mathematics due to interest.	Parents confusing children using different methods, parents not engaging with school mathematics.
	Macrosystem		Government focus on formal assessments. Knowing some children will not reach the expected standard.
Time	Micro-time	Teaching different inputs or shorter inputs to particular children to meet their needs.	
	Meso-time	Including all abilities in problem-solving activities, different methods work for different children.	
	Macro-time/ Chronosystem	Experience of struggling at mathematics before succeeding through different methods	Own difficulties in mathematics at school, residual doubts of own ability when on the spot.

Teacher C: Barriers to Attainment for Socially Disadvantaged

Element	Sub-Category	Support/maintenance of construction	Challenge/development of construction
Process	Form		Uses problem-solving models which value variety of answers and making mistakes (with positive outcomes)
	Content	Too much content in curriculum to consolidate it effectively.	
	Power	Restricted by what the government measure	Independent problem-solving activities promoted in class.
	Direction	Encouragement of peer learning, teacher learning from pupils different approaches	
Person	Demand Characteristics	Teaching for 10 years in the same setting	Rules person
	Resource Characteristics	Lots of CPD opportunities due to low performance of pupils in mathematics. Has a psychology degree	Lots of CPD opportunities due to low performance of pupils in mathematics. Has a psychology degree
	Force Characteristics	Frustration at trying to cater for wide range of ability in class without adult support.	Wants children to enjoy mathematics – makes this her mission. Determined that children make progress despite starting points. Good at explaining things in different ways.
Context	Microsystem	Has young children at home who can be a form of comparison	Connectionist model used to help children 'pull in' knowledge to a problem
	Mesosystem	Lack of parental engagement and limited maths activities at home. School has high levels of free school meal uptake	
	Exosystem	Has observed family and friends to have difficulties with dyslexia and low self-belief	
	Macrosystem	Expectations of everyone being at age related standards seen as impossible despite progress and hard work. Affects Ofsted grading. Assessment appears to be full of barriers unrelated to mathematics.	Good assessment results this term when using problem-solving approaches.
Time	Micro-time		Opportunities to share ideas and experience success. Resilience and perseverance encouraged. Important how children complete a task as much as the right answer.
	Meso-time		Showing children their progress over time
	Macro-time / Chronosystem	Previous initiative related to learning behaviours had lasting positive impact. Has seen many changes in teaching approach and education initiatives.	Enjoyed mathematics at school and school generally. Recalled mathematics being more rigid and less practical but all moving along at the same pace.

Teacher D: Different Attainment Inevitable

Element	Sub-Category	Support /maintenance of construction	Challenge/development of construction
Process	Form	Elicitation and open-ended tasks seen as difficult for students less confident in mathematics and problematic for self-esteem.	Children perceiving ability groups as fixed and unchangeable
	Content	finds complicated/ varied maths terminology unhelpful.	Sees need for children to have exposure to number breadth
	Power		Pressure from maths advisors and systemically to use certain methods (e.g. problem-solving for all at start) and language.
	Direction		Values other class members verbalising what they know to support other children.
Person	Demand Characteristics	Close family bereavement at same age as her students. Memories of 'best teacher' are from this time as they made things fun and a positive distraction. Enjoys teaching maths that's practical.	Younger than other teachers so remembers her school days more vividly.
	Resource Characteristics		Supportive mathematics lead who she can access to ask questions. Lots of advice around teaching mathematics
	Force Characteristics		Comfortable to take advice from trusted colleagues. Questions reasoning of what she teaches.
Context	Microsystem	Making each task fun or practical.	Lesson structure suggestions from phase advisor (although seen as oversimplistic).
	Mesosystem		Many parents 'relatively old' and so are less aware of current maths approaches. Own family member had additional need which impacted upon his maths abilities.
	Exosystem	People running CPD that puts you on the spot disliked.	
	Macrosystem	Contradictory advice in CPD. Questions remaining about supporting those on SEN register and the impact on their confidence of some approaches.	
Time	Micro-time	Children more engaged if the mathematics is physical, practical, outside, matched to interests.	
	Meso-time	Sees elicitation or problem-solving at start of sessions as a 'waste of time' or negative impact.	
	Macro-time / Chronosystem	Remembered mathematics teacher not being very engaging in secondary. Doesn't recall there being so much technical mathematics language at school and got by without it	Awareness of children perceiving ability groups as fixed and unchangeable