Experiences of Teaching and Learning Mathematics in Setted and Mixed Settings

by

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Abstract

An investigation of the effect of grouping practices on pupils' mindsets, teachers' mindsets and teachers' beliefs and practices. This study compares mathematics in School A (mixed-ability groupings) and School B (sets). Questionnaire data was collected from 286 pupils and twelve teachers and triangulated with lesson observations and interviews. This study offers some evidence to support the notion that grouping practices could indeed influence pupils' mindsets, teachers' mindsets and teachers' beliefs and practices when teaching mathematics. School A pupils had stronger growth-mindsets than School B pupils. School A teachers had stronger growth-mindsets than School B teachers. Mathematics teachers in School A were found to hold more 'connectionist' beliefs. Most pupils in School A perceive typical mathematics lessons as involving a substantial problem or challenge that is worked on collaboratively in pairs or small groups and has several entry points. Mistakes are encouraged, learnt from and pupils develop understanding through discussion. Teachers and pupils in School B tended to have a more traditional experience. This has implications for further research as mixed-ability groupings may be a catalyst for improving pupils' experiences of learning mathematics.

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1 Introduction

1.1 Beginnings

Teaching mathematics to mixed-ability groups is not common practice in secondary schools. As a new teacher I never considered any other way of grouping pupils other than in ability sets. However once I became a head of mathematics I became increasingly concerned pupils were limited by the group they were placed in. Teachers looked forward to teaching 'top-groups' because they got to teach interesting things to willing pupils and dreaded bottom-groups where they would drill 'the basics'. In my opinion, there were too many pupils who didn't enjoy mathematics either because it was boring and repetitive or because they were overwhelmed by the pace of lessons. I began to research the situation and found my experiences were common and work by Boaler, Wiliam and Brown (2000) confirmed a less procedural, time pressured curriculum and heterogeneous grouping could help.

Six years ago I resolved to change the way mathematics was taught in the school where I was head of mathematics. I wanted a scheme of work with space for pupils to explore and work on their own mathematics whilst developing a deeper understanding of content. I wanted a five year curriculum where no pupils were limited by prior attainment. Some were resistant, but there was enough support to work together to redesign the curriculum.

I wanted more pupils to enjoy mathematics, feel it was useful and feel they could succeed in the subject. I hoped that this could be achieved without a detrimental effect on results. I was influenced by Boaler's 'The Elephant in the Classroom' (2009) and Coles's session at the Birmingham branch of Assosciation of Teachers of Mathematics.

If the focus is on 'becoming a mathematician' (Brown and Coles, 2008) as opposed to 'learning mathematics', for me, many obstacles are removed and it guides a clear way of working for teachers. Everyone can develop as a mathematician; everyone is capable of thinking hard and asking questions and being organised and systematic.

The mathematics staff were uneasy about moving to mixed groups so we began this gradually by having two 'top groups', three 'mixed groups' and one 'support group'. We trialled the new grouping alongside a new scheme of work based on one large topic per half term and using 'low threshold/high ceiling' tasks so everyone could start and there was plenty of opportunity for extension. At the end of the year feedback was overwhelmingly positive. It was said the ability range in the 'top groups' was so wide they may as well all be mixed. We moved to mixed groups the following year.

Changing anything in teaching can present difficulties for teachers. Changing big things like the curriculum and groupings presents many issues. Whilst there is evidence from over thirty years of research setting has a detrimental effect on attainment overall (see Kulik & Kulik ,1982; Slavin, 1990) this could be a reason why so few schools teach mathematics to mixed groupings. In the summer of 2013 I took an online course from Stanford run by Boaler called 'How to learn Math'. This is where I first became aware of the concept of mindset (Dweck, 2006). I was interested in how pupils felt about mathematics in my school and also whether the changes had influenced teachers' beliefs about mathematics, about pupils and what teachers did in the classroom. Several studies consider the effect of ability grouping on self-esteem, attainment or both but there have been few studies of mixed-ability mathematics teaching in the UK in recent years.

These experiences led me to be interested in this research area. I now present a brief outline of the structure of this dissertation.

1.2 Overview

This research begins with a review of literature surrounding ability-grouping and mathematics. Notions of 'ability' and different ways of grouping pupils, attainment, attitudes and equity are key issues. Teachers' beliefs about mathematics, pupils and teaching mathematics are discussed following an exploration of pupils' beliefs particularly regarding motivation and 'mindset' (Dweck, 1999). The literature informs the research questions given at the end of this chapter.

The methodology gives background on interviews, questionnaires and observations, explaining how they are used in this study. This research compares two schools (School A and School B) with different grouping practices. The majority of data comes from pupil questionnaires supported by teacher questionnaires, lesson observations and brief follow-up interviews. Ethical considerations are stated and a timeline is offered for clarity.

Results are presented under three themes. Firstly, 'teaching styles', which draws on teachers' professed beliefs triangulated with pupils' perceptions of teachers' practices, and observations. School A teachers have a more 'connectionist' teaching style compared to School B teachers who are more 'transmission'. Secondly, 'mindsets' are analysed. Pupils and teachers in School A are found to have a stronger 'growth orientation' than those in School B. Thirdly views on ability-grouping are analysed. Results are then summarised.

The research ends with overall conclusions. Key results are synthesised to answer the research questions and tentative conclusions are drawn that grouping practices influence pupils' mindsets, teachers' mindsets and teachers' beliefs and practices when teaching mathematics. Limitations of the study are considered along with implications for future research. Reflection on the research process completes the dissertation.

The next section explores literature around teaching and learning mathematics in setted and mixed settings.

2   Literature Review

2.1   Introduction

I begin by considering notions of ability, grouping practices and the issues around these. I focus on three key areas: attainment, attitudes and equity. There is evidence grouping practices impact on teacher beliefs (see Boaler et al., 2000; Ireson et al. 2002b). The main points discussed here are in relation to: teachers' beliefs about the nature of mathematics, beliefs about pupils and beliefs about the most effective ways to teach pupils mathematics. This is followed by consideration of pupil beliefs and perceptions of how they are taught mathematics. I conclude this chapter by identifying my research questions in light of the literature.

2.2   Ability and Types of grouping

In the UK, it is widely believed people have an innate, measurable 'ability' that is the main determining factor in educational performance (Sukhnandan and Lee, 1998). This belief continues in spite of evidence achievement is influenced more by social and cultural status (Nash, 2006), and evidence from international comparisons which indicates focussing on effort rather than ability improves attainment (Askew et al., 2010 and Dweck, 1999). Slavin (1996, p.168) defines ability-grouping as 'any school or classroom organization plan that is intended to reduce the heterogeneity of instructional groups'. Pupils can be grouped according to some notion of 'ability' by *Streaming* – where pupils are taught in the same 'ability' groups for all lessons or *Setting* – where pupils are allocated to 'ability' groups for each subject. The alternative is *Mixed-ability* – where classes contain a range of attainment levels (Hodgen, 2010).

Streamed classes were common in the UK until the 70s and 80s when mixed-ability became more common as 'more people wanted an equitable experience for students' (Boaler et al., 2000). More recently, pressure from OFSTED, the government's introduction of a national curriculum and a desire to raise standards has seen many schools increase the level of setting (Ireson, 2002a) although Boaler et al.(2000) argue few mathematics departments 'have needed to change *back* to ability-grouping' as most had kept sets even if other subjects did not. An OFSTED survey suggested 96% of schools had sets for mathematics (Guardian, 1996). OFSTED recently admitted they would be unable to report current figures (Stewart, 2013).

There are several issues regarding grouping arrangements for mathematics. The main argument for ability-grouping is that it will be possible to teach more effectively with a narrower attainment range in classes (Higgins et al., 2014). The main argument against ability grouping is that it damages self-concepts of pupils, exaggerates socio-economic differences, impoverishes the curriculum and causes underachievement (Boaler, 2008; Ireson et al., 2002a; Gillborn and Youdell, 2000).

Oakes (1986) points out ability grouping depends on some underlying assumptions; pupils have different abilities, these can be known, and pupils will learn most effectively with others of similar ability. It is also assumed self-concepts of low-attainers will be damaged by working with high-attainers and that teaching homogenous groups is easier.

I now consider key issues regarding attainment, attitudes and equity.

2.2.1 Attainment

Kulik and Kulik (1982, 1984, 1987, 1992) conducted several meta-analyses into secondary school setting. They find small positive effects for higher attainers and minimal effects for average and below-average pupils. This contrasts Gutiérrez and Slavin (1992) and Linchevski and Kutscher (1998) who find the effect of ability-grouping to be essentially zero and Boaler (2008) and Hallam, and Parsons (2013) who find high attaining pupils working in mixed-ability groups accelerate progress more than anyone else. Higgins et al. (2013) found low negative effects for setting alone. Kulik and Kulik (1987) found special within-class programs designed for 'talented' pupils result in 'high' positive effects. Vaughn et al. (1991) showed improvement in achievement of 'gifted and talented' pupils with additional 'pull-out' classes. These types of intervention are included in some meta-analyses, which may explain some of the differing conclusions. Terwel (2005) argues overall effect of ability-grouping on attainment is limited, and any gains for higher-attainers are at the expense of lower-attainers. This is supported by Boaler et al. (2000) and Ireson et al. (2002a) who find 'extent of setting' experienced by a pupil impacts on progress in mathematics. Ireson et al. (2002b) also find the set a pupil is allocated can have a significant impact on later achievement. The same pupil will do better if placed in a higher set than if placed in a lower set, Barker-Lunn (1970) and Linchevski and Kutscher (1998) corroborate this.

This finding presents an issue of equity and consequently some researchers have considered how pupils are placed in sets. Whilst teacher judgements and social factors were sometimes considered, the majority of mathematics departments set using one assessment (Ireson et al., 2002b). Black and William (2006) conservatively estimate even using an excellent test, 50% of pupils would be placed in the wrong set and this

could influence pupils' attainment. If pupils are placed in the 'wrong set' they are unlikely to move (Ireson et al., 2002b; Peak & Morrison, 1988; Dentzer & Wheelock, 1990). Frequency of set changes varies from fortnightly to annually (Ireson et al., 2002a). Some curriculum managers cited capacity to move sets as 'an important motivational factor' although opportunities for movement appear inconsistent. Knowing pupils well is seen as desirable in successful countries like Finland (OFSTED, 2010). Changing groups reduces opportunities for this. Oakes (1995), supported by Macintyre & Ireson (2002), found setting did not significantly reduce the attainment range within a class despite this being a key argument for setting.

Hodgen (2010, p.214) recognises, 'the notion that high-attainers are significantly disadvantaged in mixed-ability groups is very persistent' despite the evidence to the contrary. Investigations by Burris et al. (2006) concluded differences in performance of the highest-attaining pupils was not the result of grouping pupils but of the higher expectations and better teaching experienced.

2.2.2 Attitudes

A key argument against ability-grouping is it damages pupils' self-esteem, self-concepts and attitudes to schoolwork (Gamoran & Berends, 1987; Lacey, 1974; Oakes, 1986). Kulik and Kulik (1992) found self-esteem reduced for higher-attainers and slightly increased for lower-attainers. This contrasts with Gamoran and Berends (1987) who suggest a negative impact on self-esteem and motivation for pupils placed in low groups. This corroborates the findings of Oakes (1986) who found lower-attaining pupils' self-concept becomes increasingly negative over the years. This may be due to the content of lessons 'High-track classes focused primarily on mathematical concepts;

low-track classes stressed basic computational skills and math facts' (Oakes, 1986, p.15).

Boaler et al. (2000) found pupils in both lower and higher sets significantly disadvantaged by setting. 'The students reported that teaching practices emanating from setting arrangements had negatively affected both their learning of mathematics and their attitudes towards mathematics' (Boaler et al., 2000, p.635). High-set pupils were taught in a high pressure environment where at least a third of those pupils felt the pace limited their opportunity to understand. Dweck (1999) has shown that pupils' 'theories of intelligence' can have significant effects motivation. Pupils who have a 'fixed' view of intelligence are more likely to give up when work becomes challenging and less inclined to learn from feedback. Setting pupils has been shown to put pupils into this 'fixed mindset' (Boaler, 2009). Blackwell et al. (2007) showed even simple messages could put pupils into a fixed mindset. This is discussed in more detail later.

Teachers also change their attitudes. Teachers who used a variety of teaching methods with mixed-ability groups, expected pupils in sets to follow procedures, without detailed help or thinking time in an environment where mistakes are not encouraged so cannot be learned from (Boaler et al., 2000). This has consequences for equity in classrooms.

2.2.3 Equity

Gutiérrez (2002, p.9) defines equity as 'Erasure of the ability to predict students' mathematics achievement and participation based solely on characteristics such as race, class, ethnicity, sex, beliefs and creeds, and proficiency in the dominant language'. Girls can be disadvantaged by setting. In one longitudinal study, Meece et al. (1982) found a

decline in girls' mathematics self-concepts despite higher achievement than boys. This decline led to reduced attainment later. Minority groups and poor pupils are over represented in low sets (Ireson et al., 1999).

Oakes (1986) notes inequities as teachers of high sets spend longer on learning activities, have higher expectations of work, and spend less time addressing indiscipline. These teachers were also more enthusiastic and gave clearer explanations. They also used less 'strong criticism or ridicule' (Oakes, 1986, p.16) than their lower-set colleagues. Oakes' (1986) found pupils with the most difficulty learning tend to be taught by the least effective teachers. This is supported by recent reports that less-experienced, temporary and non-specialist teachers were more likely to teach mathematics to lower-sets. 'Learning and progress were good or outstanding in nearly two thirds of lessons in Key Stage 4 higher-sets, double the proportion observed in lower-sets where around one in seven lessons was inadequate' (OFSTED, 2012, p.9). These claims are supported by Sukhnandan and Lee (1998) who found higher-sets get the best qualified and most experienced teachers.

The claim teachers changed their behaviour dependent on the set they teach is substantiated by Hallam and Ireson (2005). They found pupils taught in mixed-ability groups have similar access to the curriculum and are taught in a variety of equitable ways. However, when low-attainers are grouped together they have less access, more repetition and less discussion (Ireson et al., 2002b, p.313). Harlen and Malcolm (1999) cite considerable evidence to support this assertion. Boaler et al. (2000) note much research has been conducted into inequities of grouping arrangements for pupils in 'low' groups. Pupils disadvantaged by the school system because of their 'race', class or

gender are more likely to be placed in 'low' groups (Hargreaves, 1967; Lacey, 1970; Ball, 1981; Tomlinson, 1987; Abraham, 1989).

Boaler (2008), supported by Bernstein, (2000) and Bourdieu, (1986) suggests 'hidden' pedagogical practices, not curriculum materials, are what support equitable learning. Making equitable aims more visible to pupils is one way of improving outcomes for pupils when teaching mixed groups, with notably the highest-attainers making the most progress (Boaler, 2008). International comparisons show the most equitable countries are most successful (OECD, 2010).

In summary, 'ability' grouping has been shown to have negative effects on attainment, attitudes and equity. Despite recent political consensus that 'ability' grouping is a mechanism for driving up standards it seems unlikely to raise attainment for the majority of pupils. The government have quietly dropped their commitment to setting, 'It is for schools to decide how best to organise teaching - including whether to group and set pupils by ability - as they know exactly what their students need' (Stewart, 2013). This view now aligns with findings from the Education Endowment Trust (Higgins, 2014). It appears likely that variation is caused by teachers' beliefs and pupils' beliefs. I now consider these in more detail.

2.3 Pupils' Beliefs and Perceptions

Pupils' experiences of mathematics are influenced by many factors. Social factors including grouping arrangements, whether they work individually or collaboratively and pupils' perception of mathematics lessons can shape experiences. As can self-theories, motivation, attributional style, and affective states. Cobb, Yackel and Wood (1989) recognise studies on affective issues in mathematics are scarce.

Dweck and Elliot (1983) found pupils were motivated differently when completing tasks. For some pupils, the goal is to impress others, or as Dweck (1999, p.15) puts it, 'to avoid looking dumb'. This is termed '*performance* orientation' and contrasts with '*mastery* orientation' where the goal is to learn as much as possible. Prawat and Anderson (1994) recognised pupils sometimes attribute academic failure to internal, constant factors outside of their control, for example lack of ability. The same pupils also attribute success to external factors such as luck or tasks being 'easy'. This 'attributional bias' can be a barrier to success in mathematics (Eccles, 1986). 'Attribution retraining' (Dweck & Bempechat, 1983) was suggested as one solution.

Later research by Dweck (1999) and others suggested motivation and attributional style are both influenced by self-theories. Dweck (1999) contrasted two 'theories of intelligence'. An 'entity theory' or *'fixed-mindset'* is the belief qualities like intelligence or mathematical ability are permanent traits that cannot be developed. These pupils are driven by performance goals, devaluing effort, 'if you're good at something, you shouldn't need effort' (Dweck 1999, p.40). An 'incremental theory' or '*growth-mindset'* views intelligence as malleable and increasable through effort (Bandura and Dweck, 1985). Growth-mindset pupils seek out challenging tasks they can learn from. Blackwell et al. (2007) found growth-mindset pupils improved in mathematics following challenges and they were significantly more orientated towards learning goals. Following setbacks, fixed-mindset pupils were less persistent and found work less enjoyable, Blackwell et al. (2007, p.250) reported these fixed-mindset pupils would "try to avoid the subject in the future" or "try to cheat on the next test". This supports earlier work by Butler (1987), who found learning goals fostered greater intrinsic motivation.

Table 2.1: Comparison of academic mindsets
(adapted from Yeager and Dweck (2012, p.303) and Blackwell et al. (2007))

	Fixed Mindset	Growth Mindset
Goals	Avoid looking 'dumb'	Learn as much as possible
Effort	If you have ability, you shouldn't need effort	Effort is key to success
Challenges	Tendency to give up	Work harder and smarter
Setbacks	Hide mistakes and deficienceis	Learn from mistakes and confront deficiencies
Response to a low test score	"Spend less time on the subject from now on" "Try to cheat on the next test"	"I would work harder in this class from now on" "I would spend more time studying for the tests"
Change in grades during times of adversity	Decrease or remain low	Increase

A pupil's mindset can have a significant influence on their learning experiences, particularly in mathematics (Dweck, 2008). Differences are summarised in Table 2.1. Studies (Blackwell, et al., 2007; Good, Aronson & Inzlicht, 2003) found when pupils were taught about growth-mindsets the trend for declining grades reversed. Furthermore, this made more difference for girls than boys, reducing the gender gap.

The way pupils are perceived by teachers impacts pupils' view of themselves as learners (Allen, 2004). Mason and Johnston-Wilder (2004, p.218) explain 'how parents and teachers perceive individuals and groups of learners exerts tremendous influence on those learners'. Pollard et al. (2001) suggest a focus on raising standards in mathematics is actually preventing pupils from becoming self-motivated problem solvers. This is corroborated by Duffield, Allan, Turner and Morris (2000). Allen (2004) finds the considerable emphasis placed on summative assessment of performance, setting and position within a set by pupils and teachers has a significant effect on pupils' self image

and whether pupils view themselves as successful or unsuccessful learners. This is supported by research on mindset (Dweck, 1999; Blackwell et al. 2007; Yeager and Dweck, 2012).

2.4   Teacher beliefs

Teachers' experiences of teaching mathematics are influenced by government policies, national curricula, and the culture and school context in which they teach. Askew et al. (1997) suggest teachers' beliefs influence their teaching, and these beliefs are influenced by three things: beliefs about what mathematics is; beliefs about pupils; and beliefs about the most effective ways to teach mathematics. This in turn is influenced by a teacher's pedagogic subject knowledge. Ernest (1991, p.249) agrees with this, asserting beliefs are dependent on 'the teacher's conception of the nature of mathematics and mental models of teaching and learning mathematics'. I will consider these aspects in more detail.

2.4.1   Beliefs about the nature of mathematics

Thom (1973, p. 203) suggests 'all mathematical pedagogy, even if scarcely coherent, rests on a philosophy of mathematics'. Lakatos (1978) suggests there are two dominant views: firstly mathematics as a body of knowledge built on universal foundations; secondly that mathematics develops out of conjecturing, then proving or refuting conjectures. Lerman (1990, p.55) identifies this second view as evident in all stages from school problem-solving to cutting-edge mathematical research, 'It is not a matter of teaching a certain amount of content, deemed necessary by some group in control of the curriculum, which children will then be able to apply when required'. The first view implies teachers are in possession of mathematical knowledge pupils must access.

Ernest (1991, p.249) calls this an *instrumentalist* view of mathematics as 'a set of unrelated but utilitarian rules and facts'. Ernest (1991) explains this can be seen as part of a hierarchy. Instrumentalism is the lowest level followed by the *Platonist* view of mathematics as a unified but unchanging body of certain knowledge to be discovered, not created. Finally, there is the *problem-solving* view of mathematics as a dynamic, continually expanding field of human creation and invention. (Ernest, 1991).

Ernest (1991) defines three roles for a mathematics teacher: *Instructor* – concerned with skills and mastery; *Explainer* – for conceptual understanding; and *Facilitator* – for confident problem solving. Swan (2006) notes there may be considerable differences between professed beliefs and observable practices, and considerable overlap of the three roles.

Beliefs about the nature of mathematics have a strong influence on how teachers work with children in classrooms. Studies (Kerry, 1980; Reid et al., 1982) suggest if teachers perceive mathematics as abstract and requiring correct answers then they view it as less suitable for mixed-ability teaching (Ireson and Hallam, 1999).

2.4.2   Beliefs about pupils

Rosenthal & Jacobson (1968) investigated the influence of teachers' beliefs about pupils. A number of pupils were highlighted at the beginning of the school year as 'academic spurters', those expected to make exceptional progress during the year. This group did indeed show increased intellectual gains, despite the fact they were actually chosen at random. Raudenbush (1984) found if teachers had limited prior knowledge of pupils the results were replicated. This suggests teachers' beliefs about pupils have significant consequences.

Educators have attempted to boost self-esteem in mathematics (Dweck, 2008). Praising ability is often thought to increase motivation (Briggs, 1970). Mueller and Dweck (1998) found people believed praising ability to be motivational because it increases self-esteem by making pupils feel intelligent and this feeling motivates future learning. Research (Blackwell et al., 2007; Mueller and Dweck, 1998; Heine et al., 2001) shows praising intelligence puts pupils into a fixed-mindset: making them avoid challenging tasks; lose confidence and motivation when work becomes hard; and impairing performance on and after difficult mathematics problems. Rattan et al. (2011, p.731) found teachers with fixed-mindsets comforted and demotivated pupils with consoling statements such as 'it's ok, not everyone can be good at math'.

Another well-intentioned teacher action described by Dweck (1999) is simplifying tasks to give pupils success and boost self-esteem. This has parallels with 'funnelling' (Bauersfeld, 1988, 1995; Holt, 1964; Wood, 1998) where teachers repeatedly reduce the demand of questions until pupils can easily answer. This can result in 'learned helplessness' (Watson, de Geest & Prestage, 2003).

Researchers (Cimpian et al., 2007; Kamins and Dweck, 1999; Mueller & Dweck, 1998) found praising efforts and strategies made pupils more inclined to seek out and learn from challenging tasks and mistakes. Stevenson and Stigler (1992) found parents and teachers in Japan place more emphasis on effort than Americans. More recently it was shown by Rattan et al. (2012, p.787) 'In Western societies, intelligence is often conceptualized as an individual difference with a significant genetic component' whereas, South Asian Indians tended to believe most people have the potential to become highly intelligent.

Boaler et al. (2000) and Ireson et al. (2002b) found teachers change their practices when teaching mixed and setted groups. Setting practices created fixed mindsets (Boaler, 2009; 2013; Dweck, 2006) and teachers tend to possess fixed-mindsets, believing for example 'top-set' pupils ought to understand methods given without explanations, "You should be able to, you're in the top set" (Boaler et al., 2000, p.640). These statements send fixed-mindset messages to pupils and also suggest the teacher's view of pupils' intelligence is fixed. This is even more damaging for low-attaining pupils (see Slavin, 1991; Linchevski and Kutscher, 1998 for examples). As Dweck (2006, p.108) notes, teachers with a fixed-mindset 'don't believe in improvement, so they don't try to create it'.

Ireson and Hallam (1999) find teachers stereotype and label pupils based on their group allocation. This is supported by others (Hargreaves, 1967; Lacey, 1970; Keddie, 1971; Ball, 1981; Burgess, 1983). Schwartz (1981) reported teachers stereotyped pupils as thick, bright, slow, difficult, etc. indicating fixed-mindset views of pupils.

Teacher beliefs about pupils have been shown to influence teachers teaching mathematics. I will now consider teachers' beliefs about how pupils learn mathematics.

2.4.3 Beliefs about effective ways to teach children mathematics

'A person's understanding of the nature of mathematics predicates that person's view of how teaching should take place in the classroom' (Hersh, 1986, p. 13). The 'traditional' conception of mathematics as a body of knowledge, skills and techniques for pupils to acquire is prevalent in western society. Swan (2006, p.41) contrasts more 'progressive' approaches where learners 'construct concepts and strategies through exploration or creativity and discussion'. US and German mathematics teachers wanted to teach pupils

a particular skill (Stigler, 1999). In Japan, the aim was that pupils 'understand a new concept or think in a new way' (Swan, 2006, p.43).

Swan (2006,) contrasts several theories for learning mathematics. In particular: behaviourism – learning as acquiring responses to stimuli; learning as individual construction; and learning as social construction. Askew et al. (1997) identify three orientations which align well with the three theories discussed by Swan (2006). . They suggest these orientations 'shape rather than directly control [teacher] behaviour' (Askew et al., 1997, p.29). Askew et al. (1997) call the three approaches 'transmission', 'discovery' and 'connectionist'. They emerged initially from a large study of primary teachers (Askew et al., 1997), but were later used extensively by Swan (2006) in a very large study of FE teachers suggesting the characterisations may be useful at all levels of mathematics teaching. I will consider each of these orientations in turn.

The transmission orientation links to the view of mathematics as 'a given body of knowledge and standard procedures to be 'covered'' (Swan 2006, p. 133). In the transmission orientation, teachers believe pupils learn best through watching, listening and imitating. The teacher typically explains a method and pupils practise the procedure until fluency is attained. The teachers' goal is to explain clearly and logically in order to avoid misconceptions (Swan, 2006). Askew et al. (1997) suggest this stems from beliefs pupils vary in ability and failure to learn results from lack of aptitude if methods are logically explained. Reinforcement and practice of methods is perceived as the remedy for pupils' failure to 'grasp' what is taught. Effective teaching is through structuring a linear curriculum and understanding is checked through practice of similar problems (Swan, 2006).

The transmission approach encourages what Skemp (1976, p.21) describes as an 'instrumental understanding' of mathematics. Boaler (1997, p.183) cites this approach as the cause of 'most of the problems experienced by students'. The approach has much in common with what Wigley (1992, p.4) calls the 'path-smoothing model' and is criticised by Ahmed (1987) as restricting mathematical development. Spencer (1878, pp.56-57, cited in Mason and Johnston-Wilder, 2004) describes the teaching of rules as 'producing an appearance of understanding without the reality'.

A second belief system is the *discovery* orientation, where mathematics is made up of separate elements and pupils create their own methods to solve problems. Learning mathematics is 'an individual activity derived from actions on objects' (Askew et al., 1997, p.34). Pupils' own strategies are most important and pupils must be 'ready' to learn particular mathematical ideas. This viewpoint has commonalities with Piaget's stage theory, that mastery must be achieved before embarking on the next stage in learning. (Swan, 2006). Discovery teaching also parallels Piaget's 'to understand is to discover, or to reconstruct by rediscovery' (Piaget, 1975, p.20). Ahmed (1987) amongst others (for example: Banwell et al., 1972; more recently Piggot, 2007) suggests accessible 'rich' tasks allowing further challenges are important to promote decision-making and conjectures, explaining and proving, discussion, questioning and invention.

As Swan (2006, p.65) notes discovery teaching 'places more emphasis on learning than teaching' in contrast to the transmission approach. This aligns with Gattegno's (1971) view that teaching should take a 'subordinate role' to learning. Learning is viewed as an individual activity based on practical exploration and reflection (Swan, 2006). Teachers also tend to believe learning should be introduced in 'discrete packages' and application through 'practical problems' (Askew et al., 1997). Some oppose discovery learning

because learners cannot be expected to rediscover everything known (Swan, 2006). As Mason and Johnson-Wilder (2004) point out, some things one must be told and there are time limitations. However, Freudenthal (1991, p.49) argued '…the learner should reinvent mathematising rather than mathematics'. Hewitt (1999) suggests mathematics can be divided into *arbitrary* – something one could only know by being informed, and *necessary* – things one can deduce. This distinction addresses some issues around discovery teaching.

The third viewpoint proposed by Askew et al. (1997) is the *connectionist* orientation of mathematics as an interconnected web of ideas and processes. This resonates with Thompson's (1984, p.109) 'coherent collection of interrelated concepts and procedures'. A connectionist teacher believes pupils have ideas and conceptions that can be worked on via discussion to arrive at understanding. It is believed the teacher's role is to make links between different aspects of mathematics explicit and support pupils in exploring efficient strategies to solve problems. Connectionists believe the most effective ways to teach children mathematics requires a non-linear dialogue, working on problems before explanations and learning from mistakes (Swan, 2005).

Much research investigates pupil errors and misconceptions in mathematics (Hart, 1980; Küchemann, 1981; Bell et al. 1983; Hodgens et al., 2009). Sierpinska (1994, p.32) describes understanding a concept as requiring four mental operations: *identification* – to name, notice and describe a concept ; *discrimination* – to see similarities and differences between the concept and others; *generalisation* – to see general properties in particular instantiations; and *synthesis* – to perceive a unifying principle. Misconceptions can be viewed as concepts which have not yet fully formed (Swan, 2006). Cobb (1988, p.92) suggests pupils 'have no reason to build new conceptual

structures unless their current knowledge results in obstacles, contradictions or surprises'. Connectionist teachers believe these 'cognitive conflicts' can be utilised to help pupils learn. Swan (2006) describes conflict-teaching as pupils working intuitively to begin with, then a conflict is created, so pupils reflect on and recognise the need to revise concepts and methods; the conflict is resolved through discussion and later consolidated through practice and application. Swan (2006) compared this with guided discovery and exposition and found conflict discussion produced more lasting effects.

Askew et al. (1997) found teachers with strong connectionist orientations had classes making greater gains than discovery or transmission teachers. They state connectionist teachers believe 'teaching mathematics is based on dialogue between teacher and pupils, so that teachers better understand the pupils' thinking and pupils' can gain access to the teachers' mathematical knowledge'(Askew et al., 1997, p.32). International comparisons, found mathematics teachers in the most successful nations tended to focus on connections, relationships and complexities (Stigler et al., 2009).

The three orientations described are ideal types and no teacher is likely to perfectly fit one of the orientations. Teachers may hold 'clusters of beliefs' in certain situations (Wilson and Cooney, 2002). As Swan (2006, p.173) notes 'a teacher may believe that skills are best taught through demonstration and practice (a transmission view), while simultaneously believing that students have to construct concepts for themselves (a constructivist view)'. However, they do provide a useful framework for characterising teacher beliefs.

2.5 Summary

The literature included in this review has concerned setting arrangements and their impact on teachers and pupils. There has been some interesting research into the impact of setting in mathematics on pupil experiences (see Boaler et al., 2000; Boaler, 1997, 2008; Ireson and Hallam, 2002a), and fruitful study into mathematics teachers' beliefs and practices, and some useful categorisations (see Askew et al., 1997; Swan, 2006). Furthermore there has been significant work in the area of mindset and motivation (see Dweck, 1999; Blackwell et al., 2007). I am interested in investigating the following questions:

- To what extent do grouping practices influence mindsets of pupils learning mathematics?
- To what extent do grouping practices influence mindsets of teachers teaching mathematics?
- To what extent do grouping practices influence beliefs of teachers teaching mathematics?
- To what extent do grouping practices influence practices of teachers teaching mathematics?

3 Methodology

3.1 Introduction

I am investigating effects of grouping on mathematics teachers and pupils. In particular, I am interested in whether setting influences: mindsets of pupils learning mathematics; mindsets of teachers teaching mathematics; beliefs of teachers teaching mathematics; and practices of teachers teaching mathematics. I first look at three methods of data collection and consider the issues. I begin by considering the interview, then questionnaires and finally observation. I then make ethical considerations and conclude this chapter with a timeline outlining the data collection.

I chose to collect data from teachers and pupils in two different schools. The schools were chosen for two primary reasons. Firstly, when the schools were selected, the teaching of mathematics had some commonalities. Both schools taught the mathematics curriculum in half-term blocks with the aim of 'deep progress' (Watson, de Geest, & Prestage, 2003) in contrast to the standard practice of changing topics frequently and repeating similar work each year. However there have been some moves away from this curriculum as a new head of mathematics started this year. Any tentative conclusions drawn from this study must be seen within this context.

The schools differ in their grouping practices. School B groups pupils predominantly by 'ability' whereas School A teaches predominantly mixed groups. There are other potentially significant differences, School B is coeducational, School A is an all-girls school. The schools have comparable examination results and OFSTED gradings but there are countless known and unknown variables unfeasible to account for in this research. The second reason for comparing these two schools is access. I am head of

mathematics in School A and have done previous research with a colleague in School B and people seemed willing to be part of the research upon initial inquiries.

I now discuss some of the issues concerning interviews in social research.

3.2 Interviews

As Denscombe (2010, p. 172) recognises, 'interviews are an attractive proposition for project researchers'. Interviews provide flexibility and despite the time-consuming nature of interviewing, transcribing and analysing, they can be accommodated into researchers' lives (Bryman, 2001). Arguments for using interviews to collect straightforward factual information include increased reliability over self-completion questionnaires, but they are more valuable when exploring complex and subtle phenomena (Denscombe, 2010).

Interviews can be categorised by level of structure (Robson, 1993; Bryman, 2001). A structured interview has the goal of reliability. Each respondent should receive the same 'interview stimulus' (Bryman, 2001, p.107) this has commonalities with a self-completion questionnaire. The other end of the continuum is the unstructured interview. Robson (2011, p.280) suggests these may be 'completely informal' with conversation allowed to develop around a general theme with Denscombe (2010, p.175) adding the interviewer should be 'as unobtrusive as possible'. There is, however, much more freedom for interviewers to ask follow-up questions and be guided by the interviewee. The goal is to 'discover' by allowing participants to speak their mind (Denscombe, 2010). Unsurprisingly, the semi-structured interview is somewhere in between. The interviewer is likely to have a schedule but can vary the sequence of questions and ask follow-up questions or seek clarification on points of interest. Newby (2010, p.341)

suggests the advantage of the semi-structured interview is collection of rich data on 'indicators' used to answer the research questions. However, in comparison to questionnaires, they can be costly in terms of time, training and money, and require a 'need for scepticism' to avoid undue interviewer effects (Newby, 2010, p.342).

A major disadvantage of interviews in social research is that unlike observation, the data is based on what participants *say* rather than what they actually *do*. These things may differ for a number of reasons. Interviewer attributes such as age, gender, socio-economic status or ethnicity may influence responses (Bryman, 2001). Denscombe (2010) suggests interviewees may supply answers they feel tally with the researcher's expectations or tailor their responses to please the researcher. Interviewer effects can be minimised by being aware of the types of questions asked, maintaining a neutral stance and attempting to remain non-committal to responses given. This does present issues for the interviewer as nods and 'yes?' are commonly used both conversationally and as prompts in interviews. Probing when conducting an interview can be 'highly problematic for researchers' (Bryman, 2001, p.118). Probes may be required when participants do not understand questions, provide insufficient or ambiguous detail for coding or for more detail on an open-ended question. When probing however, interviewers must be careful not to exert undue influence (Newby, 2010).

Webb et al. (1966, p.19) also describe 'response sets' as a potential source of bias. These can take the form of 'acquiescence' or the tendency to respond consistently to questions, particularly Likert scale questions, in a manner irrelevant to concepts being measured. Acquiescence can be 'weeded out' to some extent by deliberately utilising questions implying opposite stances (Bryman, 2001, p.123). This is also relevant to questionnaires. The other prominent response set is the social desirability effect:

providing answers perceived as more socially desirable. Denscombe (2010, p.186 his emphasis) encourages interviewers to look for 'clues about whether the informant's answers involve an element of *boasting* or are answers intended to *please the interviewer'* whilst Bryman (2001, p.124) suggests the effects can be minimised by 'not becoming overly friendly with respondents and by not being judgemental about their replies'. However, Kitwood (1977) cautions against being too detached, suggesting the more detached the interviewer is the more calculated the responses and arguing the increased reliability leads to decreased validity.

3.2.1 Interviews and this study

Interviews could be utilised in this study because the area of interest *is* the attitudes and beliefs of teachers and learners of mathematics. Hoyles (1982) finds learning mathematics elicits the strongest of feelings. It could appear the aims of this research are best achieved by interviewing teachers and pupils however there are several reasons why this may not be the case. Interviews are 'time-consuming' (Denscombe, 2010), this means data would be collected from a smaller number of participants than, say, a questionnaire. Reliability is likely to be adversely affected given the relationships in play in my school. I will now discuss these relationships in more detail.

As Newby (2010, p.358) notes regarding interviews, '…people try hard to give us what we want'. As head of mathematics in a school where pupils are taught in mixed-ability groups it is clear I will have some strong opinions on how pupils are grouped and taught. It is also highly likely teachers in my department, and to a lesser extent pupils within the school, will have an awareness of these opinions. It is possible teachers, particularly within my school, may supply answers they believe align with my expectations (Denscombe, 2010), teachers may not feel they can speak freely given

potential power relationships in play. Given my professional role it may be difficult to hide my feelings and remain impartial when teachers talk about their beliefs. Few of these 'interviewer effects' would be in place in School B meaning interviewing is likely to introduce bias thus having an adverse effect on reliability. This will need to be borne in mind during analysis of any interview data and 'warranting' any claims from interview evidence (Gorard, 2013).

Given the issues outlined, I do not intend to use interviews as my primary source of data collection. I will, however, utilise brief, follow-up interviews after lesson observations for 'triangulation' which Newby (2010, p.122), supported by Robson (2011) suggests can 'demonstrate reliability and validity'. There are precedents for belief data to be gathered using questionnaires (Boaler et al., 2000; Blackwell, et al., 2007; Swan, 2006). I now consider collecting data using questionnaires.

3.3 Questionnaires

Like interviews, questionnaires take advantage of the fact humans can tell you things about themselves and the social world (Robson, 1993). Unlike interviews, self-completion questionnaires can obtain data from large numbers in a cost and time efficient manner. In order to investigate the research questions two questionnaires were devised. The design of the questionnaires was informed by the literature review, in particular questions used by previous researchers. The process raised several issues I will now address.

As Gillham (2008, p.5) notes, 'In research we have to balance the gains and losses of anything we choose to do'. An advantage of questionnaires acknowledged by Denscombe (2010, p.169) and supported by Newby (2010), Gillham (2008) and Robson

(2011) is 'Questionnaires are economical'. This is in terms of cost, materials and time. Gillham (2008, pp.5-6) describes this as 'the overwhelming argument' particularly for someone like myself 'doing research in addition to a full-time job.'

Gillham (2008, p.5) states, 'open questions are only occasionally used in questionnaires because they are difficult to analyse'. Hence, closed questions can be preferable with a small number of more-open questions to serve Newby's (2010, p.299) purpose of giving 'personality to a written report'. The number and type of open questions must be 'restricted to justify the [time] 'cost'' (Gillham, 2008, p.5). There are several ways to ask closed questions; dichotomous, multiple response, rank ordering, and rating style questions amongst others and Denscombe (2010, p.165) suggests researchers should consider reducing risks of boredom and 'pattern answering' by using a variety of questions or maintaining a consistent type for ease of answering and to allow comparisons between questions.

The *summated rating* approach developed by Likert (1932) is commonly used in questionnaires. Robson (1993) notes, these items appeal to respondents and 'if they are interested they are likely to give considered rather than perfunctory answers'. Interest also aids completion and response rates (Bryman, 2001). Gillham (2008, p.39), however warns against using too many of the same type of questions: 'it is extremely boring, for example, to answer a series of scaled-response questions; and people stop thinking about what they are doing.' However, the use of scales does increase internal consistency (Robson 1993). An advantage of closed questions is responses are 'pre-coded' improving reliability as coding is completed beforehand however coding decisions may be influenced by personal opinions and bias at the time of questionnaire creation. Pre-coded responses are one of several advantages of an internet based data

collection tool. Respondents can complete a questionnaire at a time convenient to them although as Gillham (2008, p.5) notes this is a 'mixed blessing' as in an interview the researcher can prompt and probe and a response is expected (Bryman, 2001) and teachers may feel they have insufficient time to complete questionnaires (Newby, 2010). When participants submit their responses online, data collection is quick and accurate (Denscombe, 2010) and researcher bias at this stage is reduced.

As Gillham (2008, p.1) makes clear, 'good research cannot be built upon poorly collected data'. Question content and phraseology need careful consideration. For practical and ethical reasons, questions must be relevant to participants and participants need the information, experience or opinions that allow them to answer (Denscombe, 2010). Robson (1993) suggests questions should be specific to reduce misinterpretation. Robson (1993, p.249) points out '…the meaning of almost any question can be altered by a preceding question'. Denscombe (2010), suggests moving from straightforward towards more complicated or sensitive questions later on is good practice, but any respondent can vary the order when answering questions or 'read ahead' (Gillham, 2008, p.12).

3.3.1 Questionnaires in this study

The purpose of this study is to describe the experiences of learners and teachers of mathematics. As Robson notes (2011, p.242), 'It is possible to go beyond the descriptive to the interpretive; to provide explanations of the phenomena studied and the patterns of results obtained'. It is my intention to view the descriptive results through the lens of grouping practices, and to compare the similarities and differences.

Two questionnaires were devised for this purpose; for teachers and pupils. The first (appendix 2) administered electronically to teachers in two schools received six responses from School A and six from School B. The questions asked were heavily influenced by the literature review. In particular, I made use of the theoretical frameworks adapted from Blackwell et al. (2007), Boaler et al. (2000) and, in particular, Swan (2006) to uncover teacher beliefs.

The study of teacher beliefs resurged in the 1970s following a focus on behaviourism (Furinghetti and Pehkonen, 2002). There are several difficulties with accessing teacher beliefs. As Kyriakides, Creemers and Antoniou (2009) note, some researchers have been concerned with observable teacher behaviours whereas others believe teacher beliefs underpin their actions (Pajares, 1992). Pehkonen and Pietilä (2003) note several issues with concepts related to beliefs. Researchers differ over whether beliefs are related to knowledge (Pajares, 1992; Furinghetti, 1996), attitudes (Grigutsch, 1998), or conceptions (Thompson, 1992). Pehkonen and Pietilä (2003) also note people may use the same terminology to refer to different concepts making comparisons difficult. Swan (2006) draws on the work of Askew et al. (1997) and Ernest (1989; 1991) in the design of his research instruments and I in turn draw on his work.

I adapted items for my questionnaire from Swan (2006). Teachers recorded the perceived frequency of different practices and gave percentage weightings to three different belief statements. The purpose of this was to avoid the 'false dichotomy' described by Fang (1996) when teachers are forced to choose between options. It was used as Swan (2006, p.194) describes as 'a crude measure of teachers' relative orientations towards transmission, discovery and connectionist belief systems.' Previous observational work by Swan (2006) highlighted a number of 'teacher centred' and

'student centred' behaviours. 28 statements were devised to offer 'insights indirectly, through low inference statements concerning practices' (Swan, 2006, p.198). I utilised these statements in my teacher questionnaire to allow for direct comparison and also to reduce the need for participants to interpret 'jargon' (Fang, 1996). Fang (1996) also notes inconsistencies between what teachers say they believe and what they do in practice, by asking about practices I hoped to gain access to beliefs. For ease of completion and analysis, each statement on the practices section of the teacher questionnaire was rated as follows:

1 = almost never, 2 = occasionally, 3 = half the time, 4= most of the time, 5 = almost always

The next section of the teacher questionnaire was designed to access beliefs related to mindset. Blackwell et al. (2007) reported on US data collected during a four-year longitudinal study. They designed a scale to measure motivational variables. I adapted seven of these items for the teacher questionnaire. Participants were required to rate these items on a 6-point Likert-type scale from 1 (Strongly Agree) to 6 (Strongly Disagree).

The six item scale, omitting a middle category was chosen. Robson (1993) notes, around 20% of respondents use this middle category and it does allow an extra degree of gradation. However the middle was omitted to get information on which way people lean in line with Newby's (2010, p.318) suggestion neutral can be a 'lazy option' and is more appropriate for larger sample sizes. Also, the scale used by Blackwell et al. (2007, p.249) had good internal reliability and test-retest reliability.

The final section of the teacher questionnaire allowed space for some more detailed responses on teachers' opinions on setting by ability, and aims when planning for and teaching mathematics lessons. I had a few more open questions on the teacher questionnaire because I knew I would have fewer teachers than pupils and wanted some rich data. I also wanted to give people an opportunity to mention anything they felt had been omitted and minimise the common problem of 'channelling' their perceptions to fit with available responses (Denscombe, 2010).

3.3.2 Pupil Questionnaire

The pupil questionnaire (appendix 3) was constructed in three parts adapted again from Swan (2006), Blackwell et al. (2007) and Boaler et al. (2000). Data was collected from year seven in School A (129 pupils) and School B (157 pupils). These pupils were selected for two reasons: I conjectured the effect of setting might be noticeable to pupils moving from primary to secondary school and these pupils do not have external examination pressures. Furthermore, I had access to year seven form groups in School B as all the tutors were mathematics teachers and they had agreed in principle to cooperate. I collected data from teachers on their practices but in line with Swan (2006), pupils' views of teacher practices were also collected for comparison. Pupils' perceptions of teachers' practices rather than pupils' own learning strategies were collected as it was felt these would be less constrained by conditions imposed by the teacher. For example, it is difficult for pupils to discuss ideas with a group if the teacher imposes work in silence; this issue was noted by Swan (2006). Swan (2006, p.193) found pupils 'do not tend to respond in depth to open questions' and as such this questionnaire mainly used scale responses for efficient data collection and analysis.

To access pupil mindsets I used questions devised by Blackwell et al. (2007). Four items on 'theories of intelligence' were adapted by replacing 'intelligence' with 'maths' e.g. '*You can learn new things in maths, but you can't really change your basic maths ability'*. This was due to their high reliability. Four items on 'learning goals' and two on 'effort beliefs' were used (Blackwell et al. 2007). Learning goals items are designed to measure whether a pupil is motivated by learning even when work is challenging or 'conflicts with short-term performance' (Blackwell et al., 2007, p.250). Effort beliefs items test beliefs increased effort leads to positive outcomes. I used a mixture of positively and negatively phrased items throughout both questionnaires to avoid pattern answering (Denscombe, 2010).

The final section of the questionnaire used items from Boaler et al (2000). These questions were obtained via correspondence with Dylan Wiliam and included items regarding enjoyment, pace and identity as a mathematician. Dichotomous responses were included to allow for chi-squared analysis later (Gillham, 2008). There were also two longer response sections to allow for some pupil voice (Rudduck, Chaplain and Wallace, 1996).

The questionnaire was piloted in two stages as suggested by Gillham (2008). Firstly, the questionnaire was administered to a small group of year eight pupils to see if they had any difficulties and some revisions to wording were implemented. The second stage involved getting a small group of pupils to complete the questionnaire without anyone present to assist. The 100% response rate implied the majority of significant issues in the questionnaire design had been resolved.

When questionnaires were trialled they took around ten minutes to complete. However, when the questionnaires were administered during a fifteen minute form period, some pupils struggled to complete the entire questionnaire within the time allowed so some later questions were not completed. In School B, this was not the case as the longer form period proved ample time.

I now consider observation as a data collection tool.

3.4 Observation

Despite the arguments for using questionnaires as the main data collection tool 'questionnaires are rarely sufficient as a research method on their own' (Gillham, 2008, p.99). As Newby (2010, p.286) notes, 'direct observation of people's actions, behaviour and attitude is an alternative to asking them about it.' Observation, although clearly more time-consuming is a way of corroborating to what extent what participants do what they say.

A key advantage of observation is its directness (Denscombe, 2010). In particular observation has the potential to overcome the tendency to portray oneself in the best light during interviews and questionnaires (Hanington, 2003). Another major advantage is that it can take place in 'real' settings. As Coolican (1996, pp.75-76) notes of laboratory settings 'behaviour can be artificial and does not occur in its normal social context'. Observations, like interviews, can be categorised by level of structure (Robson, 2011). Casual observation may be recording things that seem interesting whereas structured observation is likely to be more systematic in order to reduce bias (Denscombe, 2010). Differing levels of structure are associated with different types of data. 'Structured observers tend to take a detached, 'pure observer' stance' (Robson,

2011, p.329) and as such generate quantitative data. Less structured observations produce a more qualitative narrative although Newby (2010, p.360) stresses 'observation comes a weak second to talk-based investigations when we see what is published'.

Newby (2010, p.362) proposes categorising observations according to 'ways of being an observer'. This has consequences for how data is generated and whether observers influence the situations observed. Robson (2011) draws a distinction between being a 'participant' or a 'pure observer'. Newby (2010, p.365) adds another factor, whether the observer is ''obtrusive or overt' if [observers] are known to those observing or 'unobtrusive or covert' if [observers] are not known'. These combinations produce four different types of observation (Table 3.1) although it could be argued that setting, whether naturalistic or contrived (Guba and Lincoln, 1981) adds a third dimension, although, Newby (2010, p.364) classifies any situation without 'conditions or variables that are not usually present which could influence or disrupt what is being observed' as naturalistic.

Table 3.1: Types of observation.
Adapted from Newby (2010, p.365)

	Obtrusive	Unobtrusive
Participatory	Active and known	Active and not known
Non-participatory	Inactive and known	Inactive and not known

However observations are conducted, 'the process is far from straightforward' (Denscombe, 2010, p.197), an observers perception of any situation may be influenced by factors which reduce the data's reliability.

There is much research on the shortcomings of human memory. Eyewitness testimonies provide a good example of the extent of errors in recall (Wells and Olson, 2003).

Denscombe (2010, p.198) identifies three problems; selective recall, selective perception and accentuated perception. Selective recall suggests there is a pattern to what we forget and recall. Selective perception is how the mind 'filters' information, allowing some things to be experienced and others disregarded, reminiscent of 'stressing and ignoring', (Gattegno, 1971, p.11) without which 'we cannot see anything'. Accentuated perception is how our emotional and physical state and past experiences influence our perception.

Systematic or structured observation is one way of attempting to address some of these issues (see Bakeman, 1997; Sackett, 1978). Robson (2011) suggests the development of a coding scheme. Common observation schedules are based on: frequency of particular events, recording what occurs at time intervals, timing particular events or observing individuals at predetermined times. Denscombe (2010, p.201) suggests that to be included in schedules, the observed must be overt, obvious, context independent, relevant, complete, precise and easy to record.

Structured observation has some disadvantages as it focuses on observed behaviours without the 'intentions that motivated the behaviour' (Denscombe, 2010, p.204), they can have 'in-built potential to oversimplify' and lose context. Observers can also affect the naturalistic setting because of the observer effect – you cannot observe something without changing it (Wickström & Bendix, 2000).

The alternative to structured observation is participant observation. Robson (2011, p.319) stresses participant observation is 'by no means independent of the formality/structure dimension'. The 'complete participant' as referred to by Robson (2011), is what Newby (2010) would call 'active and unknown'. There are serious

ethical issues (see below) associated with this type of research, particularly in an educational setting. What many researchers might do is what Robson (2011, p.323) calls 'observer-as-participant', i.e. the observer is known to participants but has no part in the activities. Robson (2011) questions whether 'anyone who is known to be a researcher can be said to not take part in the activity'. A more likely role is what Robson (2011) calls a 'participant as observer' – a known observer who attempts to establish a rapport with the group observed and is able to ask for explanations of events whilst they occur.

Disadvantages of participant observation include over-familiarity in 'native settings' and difficulty gaining access to unfamiliar settings, reliability of the data and representativeness. As Robson (2011) notes, in a native setting one may have extensive knowledge of the group being observed but this can reduce objectivity. Existing relationships are useful for gaining trust but it can be difficult for participants to view researchers in a different role. As Denscombe (2010, p.214) notes there is a lack of verifiable data because observation relies on the 'self'. This makes generalisability difficult although arguably, generalisation is not the aim.

3.4.2 Observation in this study

Observation was utilised to 'triangulate' findings rather than relying solely on 'what people *say* they do, or what they *say* they think' (Denscombe, 2010, p.196, his emphasis). To minimise some potential issues of bias and problems with perception I chose to conduct structured observations using an observation schedule. The type of dialogue that occurred and the type of pupil activity was recorded at minute intervals. These coding had to be observable (Denscombe, 2010), so I coded whether pupils worked alone or collaboratively, whether they were answering exercise type questions or discussing ideas, whether the task was routine, getting progressively harder or a

substantial task accessible at different levels. I also recorded whether pupils were following a routine they had been taught or were discussing alternative methods. These categories were selected to link with the questionnaire data and were influenced by Swan (2006).

Newby (2010) suggests a 'framework' for recording can be generated by either designing one specifically for the research and trialling it or adapting a pre-existing framework. The coding of speech was adapted from the 'Flanders Interaction Category' framework (Flanders, 1961). This was specifically designed to code interactions between pupil and teacher in a teaching and learning setting. The coding framework was trialled by watching a video lesson and attempting to code the interactions. No changes were made following the trial. However, during the first observation it became apparent a category between 4 'asks a question' and 5 'explaining method' was required for the 'funnelling' style questioning during explanation of a method to keep pupils engaged (see Leahy and Wiliam, 2010 for more details), this was coded as 4.5.

Newby (2010, p.371) notes even when coding, observers should record 'descriptions and comments not covered by the recording schedule'. I made allowance to make a brief note of what was happening and highlight times I felt something significant might be happening. The observed lessons were tape-recorded so I could listen again to these significant points and take any quotations verbatim.

A mixture of methods generally provides more convincing data than a single source of data collection (Gorard, 2013). Whilst some commentators (such as Sale, Lohfeld and Brazil, 2002) believe qualitative and quantitative paradigms do not investigate the same phenomena and hence the methods cannot be combined, others (Bryman, 2006; Robson,

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2011) suggest a more 'pragmatic approach'. Symonds and Gorard (2010) suggest traditional quantitative/qualitative distinctions may not be as helpful as selecting methods fit for the purpose of answering the research question. 'The key underlying principle which guides the choice of methods is fitness for purpose' (Gorard, 2002, p.345).

The research design used here is what Robson (2011) would call a 'sequential explanatory design'. A large amount of mainly quantitative data was collected and then enriched with observation and brief interviews producing more qualitative data. 'The qualitative data function to help explain and interpret the findings of a primarily quantitative study' (Robson, 2011, p.165). Bryman (2006) outlines some potential benefits of combining methods in this way: validity is enhanced by triangulation of data; a more comprehensive picture of the situation is obtained and complex real-world settings can be dealt with. The intention was see to what extent teachers acted out their beliefs about teaching. Here in line with Gorard's (2003) 'seven samurai' principle that research is improved by researchers pointing out potential defects when warranting their claims.

There is clear potential for observer bias and distortion as a subject leader with my own beliefs about teaching mathematics. Also, when observing, I had already analysed data concerning what the participants say these experiences are. My observation will almost certainly have been coloured by my expectations and my perceptions. As well as the issues outlined previously, I was susceptible to the tendency to 'interpret things according to frequent past experiences', and to 'exaggerate desirable things' such as results confirming previous data (Denscombe, 2010, p.198).

Both pupils and teachers are used to being observed in schools as observation is widely used as a professional development tool and to monitor teaching. It is unlikely observing lessons would disturb the naturalistic setting although it may to differing extents in the two schools. In School A, pupils and teachers know me and are used to seeing me both in and out of lessons. In School B, I am not known to the same extent so pupils and teachers may behave differently. Pupils may try to act in a way they think will show them or their teacher in a certain light. I know from personal experience that pupils are sometimes reluctant to engage in discussions when being observed by an outsider as they want to be perceived as 'quiet and well-behaved'. This has some parallels with Bennett et al. (1984), who noted children learn very early in their schooling that working cheerfully and industriously is a central goal. Teachers may also wish to act in a way they think conforms to my expectations. My influence will be discussed in more detail as I consider the ethical considerations of my research design.

3.5   Ethical considerations

Denscombe (2002, p.175) describes ethics as 'what ought to be done and ought not to be done' and requiring a 'moral perspective' rather than simply a practical one. It is not just a case of choosing the method most practical for answering a research question. Researchers have a responsibility to participants, sponsors and the wider research community (BERA, 2011).

Teachers from both schools were invited to be part of research and the focus of the research was made clear. As adults they were able to provide voluntary informed consent. They were made aware their responses would be used anonymously and they could withdraw at any time. With pupils, I explained the nature of the research on the questionnaire and assured confidentiality. I also explained taking part was voluntary and

they could contact me in the future if they no longer wanted their data used. It would have been easier and less time consuming to have pupils submit their questionnaire responses online, however, for ethical reasons, pupils completed the questionnaires by hand so they could sign to give permission to use their data.

I ensured the confidentiality and anonymity by using pseudonyms for teachers, pupils and school names. The research is ethical because there are few possible detrimental effects of the study on pupils but there is potential for pupils' and teachers' views to enhance mathematics teaching when the findings are shared. This is in line with BERA guidance (2011).

Teachers are busy people and it was felt necessary to adhere to the guidance to:

> 'recognize concerns relating to the 'bureaucratic burden' of much research, especially survey research, and must seek to minimize the impact of their research on the normal working and workloads of participants' (BERA, 2011, p.7).

With this in mind, it was important to ensure no items on the questionnaire were redundant so time was not wasted by participants. This was achieved through trialling and analysing questionnaire responses. 'analysing even four responses in the way that you will during the full study forces you to design this stage early on' (Gorard, 2003, p.114). Some ethical concerns related to relationships in School A were discussed previously in relation to interviews. I am in a position where I have to make decisions about them that could affect pay progression etc. I hoped to put participants at ease but the potential stress for participants from my school cannot be underestimated. It is hoped these concerns are addressed and minimised using anonymous questionnaires.

I have discussed three methods of data collection and their appropriateness. Below is a summary and timeline of the data collection process.

3.6   Timeline

WB 24/02/14 - Trial pupil questionnaire

WB 03/03/14 - Trial modified pupil questionnaire / Trial observation schedule

WB 10/03/14 - Administer pupil questionnaire School A and School B

WB 24/03/14 - Observe lessons in School B

Conduct follow-up interviews in School B (same day as observation)

WB 31/03/14 - Observe lessons in School A

Conduct follow-up interviews in School A (same day as observation)

WB 31/03/14 - Administer teacher questionnaire

 I have outlined the methods deemed most appropriate for answering the questions and considered the ethical issues related to this study. I now analyse the results of this research.

4 Results

4.1 Introduction

In this chapter I will present an analysis of the data collected from two schools. Data was collected from year 7 (age 11/12) pupils, 129 from School A and 157 from School B. Data from teachers was collected via questionnaires, lesson observations and interviews. I organise the results analysis into themes and identify relevant data to support assertions about teaching styles and mindsets.

Teaching styles will be analysed first. I will recap some definitions and offer some notation to assist the reader. I then present analyses of teachers' beliefs; what teachers say about their practice. As Fang (1996) notes, there is much inconsistency between what teachers say they believe and what they do in practice. To illuminate any differences, I offer analysis of pupil questionnaires where they report on their perceptions of teachers' practices. I then consider teaching styles witnessed during lesson observations.

I present analysis of teachers' mindsets comparing questionnaire responses from the two schools, supported by interview evidence. I then analyse pupil data regarding mindsets, discussing differences and commonalities.

Results analysis finishes with a discussion of pupils' and teachers' views on ability grouping. The two settings are compared mainly using teachers' own words as collected from open-ended items on the questionnaire. Some data is offered in pupils' own words. This chapter concludes with a brief summary of the findings of this research.

As previously discussed, pseudonyms for schools, teachers and pupils will be used throughout for ethical reasons. The schools are referred to as 'School A', the mixed-

ability school, and 'School B', the setted school. For ease of comparison, teachers will be referred to as, for example 'Teacher A1'. This allows the reader to see, at a glance, which school the teacher is from and the number is used to consistently refer to that teacher so other data from the same teacher may be identified.

Apart from the grouping practices in the two schools there is another major difference: School A is an all-girls school whereas School B is coeducational. Given this, I am not going to look at gender as a factor. Calculating the Spearman's rank correlation coefficient for the responses to the first 32 items on the questionnaire shows boys' and girls' responses in School B are highly correlated (r = 0.939). This suggests it is valid to compare the two school cohorts without taking gender into account.

4.2 Teaching Styles

Teachers' beliefs and practices can be characterised into three orientations; transmission, discovery or connectionist (Askew et al., 1997). An understanding of teacher's beliefs and practices in School A and School B was created using data from four sources: teacher questionnaires, pupil questionnaires, lesson observations and brief teacher interviews following lesson observations.

Firstly, I label the key characteristics of each style to assist the reader when reading the analysis (Table 4.1).

Table 4.1**: Key characteristics of teachers' practices** (Adapted from Askew et al. 1997; Swan, 2005)

Label	Transmission orientation
[T1]	Mathematics is viewed as a given body of knowledge and standard procedures to be 'covered'.
[T2]	Explanations of methods are given before problems. Pupils imitate methods.
[T3]	Pupils attain fluency through repeated practise via exercises .
[T4]	Teacher corrects misunderstandings when pupils fail to 'grasp' what is taught.

Label	Discovery Orientation
[D1]	Pupils create their own concepts and methods.
[D2]	Learning is an individual activity based on practical exploration and reflection.
[D3]	Assessing when a pupil is ready to learn and providing a stimulating environment to facilitate exploration.
[D4]	Avoiding misunderstandings by the careful sequencing of experiences.

Label	Connectionist Orientation
[C1]	Using misconceptions by making misunderstandings explicit and learning from them.
[C2]	Pupils are challenged and arrive at understanding through discussion.
[C3]	Exploring meaning and connections through non-linear dialogue between teacher and pupils.
[C4]	Collaborative groupwork on substantial tasks.

It is not expected any one teacher should perfectly match any of the three orientations. However, I use this framework to compare beliefs and practices between the two schools. Swan (2006, pp.265-266), found '…the discovery position does not appear to have distinctive practices associated with it but rather it seems to serve as a middle position between the transmission and connectionist positions'. I follow this convention although it should be noted the terms use may differ slightly from its original meaning. I begin analysing results from teacher questionnaires.

4.2.1   Teachers' professed beliefs about teaching mathematics

Teachers were asked to give weightings to different belief statements and these were combined to give a 'belief score' for each teacher (Figure 4.1)

Figure 4.1: **Triangular plots showing the overall professed beliefs of each teacher.**
Points in the top third, bottom right and bottom left represent a predominantly transmission, discovery or connectionist approach respectively.
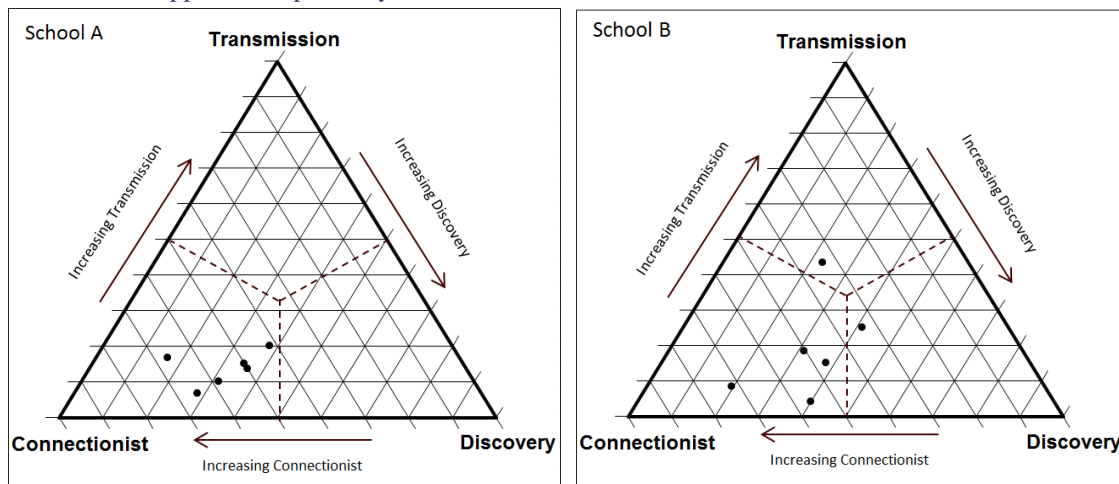
Most of the teachers surveyed in the two schools professed beliefs consistent with the connectionist orientation. School A teachers professed beliefs placing them on the continuum from discovery to connectionist with all teachers having very low transmission scores (a mean of 13%) and very high connectionist scores (mean = 55%). The teachers from School B tended to profess slightly more of a discovery orientation (33%) and a higher degree of transmission beliefs (20%) with one teacher stating significantly more transmission beliefs. These results have similarities but may not be representative of teachers at School B. At School A, all mathematics teachers (excluding myself) completed the questionnaire. At School B, six out of eighteen completed the questionnaire. The following (Table 4.1) shows teachers' practices statements for each of the schools.

Table 4.2: **Teachers descriptions of practices**.

Teachers were asked to say how often each practice occurred on the following scale:

1 = Almost Never   2 = Occasionally   3 = Half the time   4 = Most of the time   5 = Almost always

Statements are ordered by most common practices (number of occurrences of 4 and 5). Statements prefaced T (and shaded) are 'teacher-centred'; S are 'student-centred'.

School A - STATEMENTS	School A COMMON PRACTICES
S Students learn through discussing their ideas [C2]	6
S Students work collaboratively in pairs or small groups [C2]	6
S I encourage students to make & discuss mistakes [C1]	5
S Students compare different methods for doing questions [C2]	4
S Students work on substantial tasks that can be worked on at different levels [C2]	4
S I find out which parts students already understand and don't teach those parts [C3]	4
T I teach the whole class at once [T1]	4
T I know exactly what maths the lesson will contain [T1]	4
S Students choose which questions they tackle. [D2]	3
S I draw links between topics and move back and forth between topics [C3]	3
S I teach each student differently according to individual needs [C3]	3
T I teach each topic from the beginning, assuming they know nothing [T2]	3
S I am surprised by the ideas that come up in a lesson [C3]	2
T Students start with easy questions and work up to harder questions. [T3]	2
T I tend to teach each topic separately [T1]	2
T I try to cover everything in a topic [T1]	2
S I jump between topics as the need arises [C3]	1
T Students use only the methods I teach them [T2]	1
S I encourage students to work more slowly [D2]	0
T Students learn through doing exercises [T3]	0
T Students work on their own, consulting a neighbour from time to time. [T2]	0
S Students invent their own methods [D1]	0
T I tend to follow the textbook or worksheets closely [T1]	0
T I only go through one method for doing each question [T2]	0
S I only cover important ideas in a topic [C1]	0
T I tell students which questions to tackle [T1]	0
T I avoid students making mistakes by explaining things carefully first [T2]	0

School B - STATEMENTS	School B COMMON PRACTICES
T I teach the whole class at once [T1]	5
T I know exactly what maths the lesson will contain [T1]	4
S Students choose which questions they tackle. [D2]	4
S I draw links between topics and move back and forth between topics [C3]	4
S Students learn through discussing their ideas [C2]	4
S Students work collaboratively in pairs or small groups [C2]	4
S I find out which parts students already understand and don't teach those parts [C3]	4
T Students start with easy questions and work up to harder questions. [T3]	3
S Students work on substantial tasks that can be worked on at different levels [C2]	3
S I encourage students to make & discuss mistakes [C1]	3
T Students learn through doing exercises [T3]	2
T I try to cover everything in a topic [T1]	2
T I only go through one method for doing each question [T2]	2
S I jump between topics as the need arises [C3]	2
T Students work on their own, consulting a neighbour from time to time. [T2]	1
S I encourage students to work more slowly [D2]	1
S Students compare different methods for doing questions [C2]	1
S I am surprised by the ideas that come up in a lesson [C3]	1
S I only cover important ideas in a topic [C1]	1
T Students use only the methods I teach them [T2]	0
T I tend to follow the textbook or worksheets closely [T1]	0
T I teach each topic from the beginning, assuming they know nothing [T2]	0
T I avoid students making mistakes by explaining things carefully first [T2]	0
T I tend to teach each topic separately [T1]	0
S Students invent their own methods [D1]	0
S I teach each student differently according to individual needs [C3]	0
T I tell students which questions to tackle [T1]	0

In Table 4.2 the teacher-centred behaviours according to Swan (2006) are highlighted. 'Teacher-centred describes practices one would expect to arise from a transmission-oriented belief system' (Swan, 2006, p.199). Student-centred practices arise from a more constructivist standpoint. The most common practices described by teachers at School A are all student-centred. Teachers at School A believe pupils learn almost all of the time by discussing ideas collaboratively in pairs or small groups [C2]. Most of the time pupils are encouraged to make and discuss mistakes, work on substantial tasks accessible at different levels and compare alternative methods [C1, C2]. These statements seem to fit with the triangular plot above suggesting the majority of teachers at School A hold connectionist beliefs. This is further illustrated by the following:

> *"Misconceptions must be drawn out, highlighted and worked on. It is through conjectures and misconceptions that the majority of learning takes place within my lessons."* (Teacher A4), indicative of [C1, C3].

> *"[When I plan mathematics lessons I think about] …how to give rise to misconceptions, what tasks will allow for students to explore the idea and develop understanding and methodology for it, how students might access a rich task and how it may be used to extend their mathematical thinking (e.g. generalising, extending the question with a 'what if...?'), what resources will support their learning, how to create a sense of need of the maths..."* (Teacher A6), indicative of [C1]

These statements contrast to a certain extent with some of the statements made by teachers at School B. In the weightings questions and the scale responses, School B teachers professed overall connectionist beliefs. However, some responses to more open questions indicate there may be some tensions between what they believe and what they feel they need to do when teaching mathematics. There could, also be a difference between what they say and what they do. The following quotations illustrate a more transmission orientation:

"[Lessons are] structured to promote good behaviour and subsequently good learning" (Teacher B3), indicative of [T1].

"I access prior knowledge, through a starter and build on that knowledge through questioning/investigation/explanation. Students discuss and practice techniques." (Teacher B2), [T2, T3]

'Highly structured' lessons are a significant component of the transmission approach as are explanation and practising techniques.

I will now consider to what extent teachers' views on teaching correlate with pupils' perceptions of lessons.

4.2.2   Pupil perceptions of teachers' practice

The pupil questionnaire was administered to all pupils in year 7 (age 11/12) in both School A and School B during their form time. The pupil questionnaire included sixteen items related to teaching style drawn from Swan (2006). Table 4.3 shows pupils' perceptions of teachers' practices. These items were included in the questionnaire to investigate the degree to which teachers' professed beliefs about teaching are reflected in their day-to-day practice as experienced by the pupils they teach.

Table 4.3: **Pupil perceptions of teacher practices.**

1 = almost never, 2 = occasionally, 3 = half the time, 4= most of the time, 5 = almost always

Statements are ordered by most common practices - percentage of pupils scoring as 4 or 5 (most of the time or almost always) School A: n=129, School B: n=157.

(Note the colouring is provided to allow easier comparison between the relative positions.)

STATEMENT	School A
The teacher encourages us to make and discuss mistakes	68.8%
The teacher expects us to learn through discussing our ideas	68.8%
The teacher tries to prevent us from making mistakes by explaining things carefully first	63.8%
The teacher shows us which method to use, then asks us to use it	61.2%
The teacher asks us to work through practice exercises	60.6%
The teacher tells us which questions to do	56.3%
The teacher expects us to follow the textbook or worksheet closely	54.0%
The teacher asks us to work in pairs or small groups	52.4%
The teacher expects us to work mostly on our own, asking a neighbour from time to time	51.9%
The teacher asks us to compare different methods for doing questions	47.2%
The teacher lets us invent and use our own methods	45.3%
The teacher shows us just one way of doing each question	28.5%
The teacher jumps between topics as the need arises	18.3%
The teacher lets us choose which questions we do	15.2%

STATEMENT	School B
The teacher expects us to follow the textbook or worksheet closely	75.0%
The teacher shows us which method to use, then asks us to use it	73.2%
The teacher tries to prevent us from making mistakes by explaining things carefully first	73.0%
The teacher expects us to work mostly on our own, asking a neighbour from time to time	69.0%
The teacher asks us to work through practice exercises	60.4%
The teacher tells us which questions to do	55.6%
The teacher expects us to learn through discussing our ideas	51.0%
The teacher encourages us to make and discuss mistakes	45.7%
The teacher lets us choose which questions we do	43.5%
The teacher shows us just one way of doing each question	32.2%
The teacher asks us to work in pairs or small groups	30.1%
The teacher lets us invent and use our own methods	28.8%
The teacher asks us to compare different methods for doing questions	28.3%
The teacher jumps between topics as the need arises	26.1%

Table 4.3 shows some significant differences. We see pupils at School A are expected to learn through discussing their ideas indicating [C2], and learn from mistakes [C1].

Some pupil quotations illustrate connectionist practices:

"I work hard and I sometimes make mistakes but [the teacher] helps me learn from them." (Pupil A117), Indicating [C1, C3]

"I like discussing my answers with other classmates because I like to see if we came up with similar strategies" (Pupil A29) [C2]

"In my maths lessons we have class discussions and work together well in pairs and in groups." (Pupil A55) [C2]

Pupils' perceptions of mathematics corroborate closely with what teachers from School A suggested. In response to the question 'how do you think maths lessons could be improved for you?' one School A pupil *said "I think maybe just occasionally we could have work set out of the textbook"* (Pupil A67) suggesting they do not perceive the lessons as containing a lot of traditional exercises as in the transmission approach.

At School B, pupils perceive lessons as mostly adhering to the following format: the teacher explaining a method [T2], carefully so mistakes are avoided and then pupils apply the method using worksheets or textbooks [T3]. Around three-quarters of School B pupils perceive this as common-practice. This suggests a transmission style of teaching is experienced by pupils despite the more connectionist beliefs stated by the teachers at School B.

Some further evidence of the transmission approach can be found in some typical School B pupil responses when asked how they would describe mathematics lessons:

> *"In my maths lessons we always have a worksheet to do but before we start our teacher gives us some examples on the board."* (Pupil B100), indicating [T2, T3]

> *"Miss tells us the task and explains what to do and the method that needs to be used."* (Pupil B111), [T2, T3]

Some typical improvements suggested by School B pupils:

> *"I would like to be able to discuss ideas"* (Pupil B48) indicating [T2] is more common.

> *"Let us work in groups so we can share our ideas"* (Pupil B20) indicating [T3] is more common.

> *"Having fun tasks instead of miss just explaining everything and us writing it down in our books. It would help us in tasks and activities to show what we know, and then learning from our mistakes"* (Pupil B145) indicating a desire for [C1, C2].

These quotations from pupils illustrate they perceive transmission style teaching as commonplace within mathematics lessons and would prefer to 'have more fun' working in groups and discussing ideas rather than copying examples off the board and repeatedly using a prescribed method alone.

Overall analysis seems to suggest transmission is the dominant approach experienced by pupils in School B whereas School A pupils experience more group work and discussion. Some individual items from the questionnaire allow more detailed analysis.

Figure 4.2: **Pupil perception of how often they work on practice exercises in School A and School B**
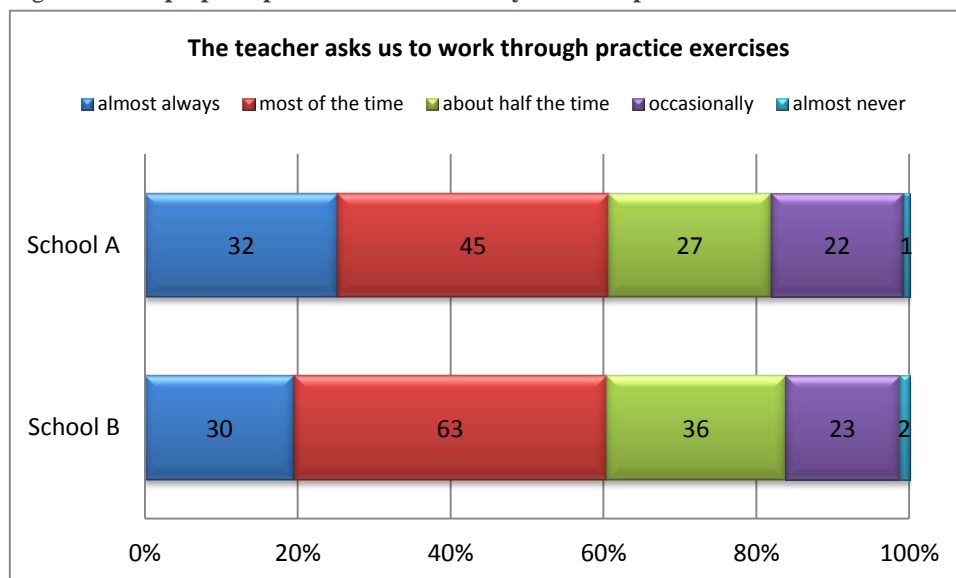
In Figure 4.2, there is little difference suggesting both sets of pupils perceive 'practising' as commonplace. It is unclear from the question phrasing what format this practice takes. It could be 'practice through progress' (Hewitt, 1994) activities, or in School B teachers said they offer a choice of red, amber, green or blue questions which pupils may still perceive as practice exercises. The 'substantial tasks' teachers claimed to use frequently at School A might be perceived by pupils as practice exercises. For example the 'Tilted squares' activity mentioned in one School A observation generates a great deal of practice of several mathematical skills

Figure 4.3: **Pupil perception of how often they work alone in School A and School B**
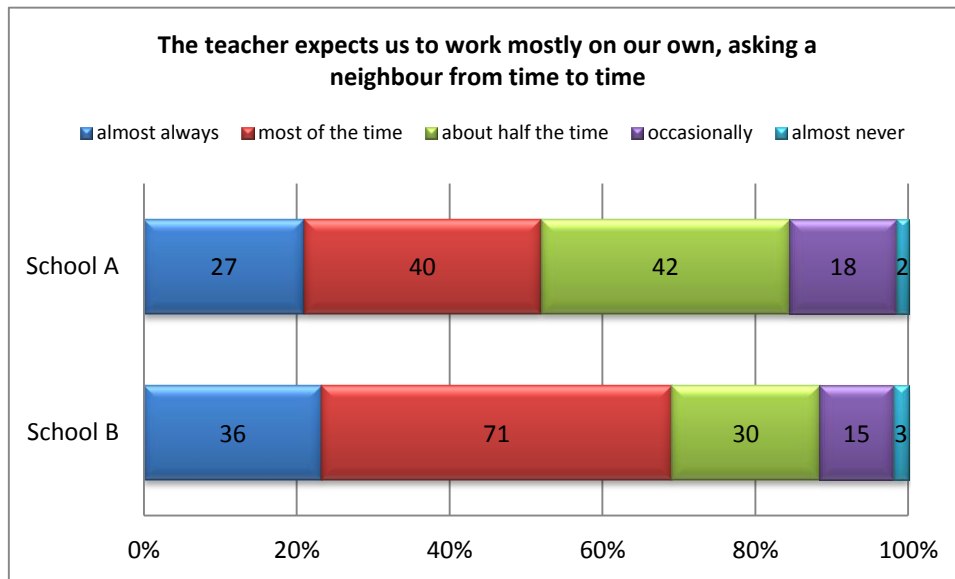
Figure 4.3 shows significant differences (χ^2, p=0.038). Pupils' perceive mathematics lessons containing mostly individual work far more frequently in School B than in School A indicating [T2]. School A pupils still work individually *"We work in groups/pairs to solve problems but other times we might work on our own"* (Pupil A25). A School B pupil describes a typical lesson *"In my maths class I sit alone and get on with my work"* (Pupil B127).

Figure 4.4: **Pupil perception of how often they imitate a method in School A and School B**

The teacher shows us which method to use, then asks us to use it

■ almost always ■ most of the time ■ about half the time ■ occasionally ■ almost never

School	almost always	most of the time	about half the time	occasionally	almost never
School A	32	47	32	13	5
School B	62	50	26	15	0
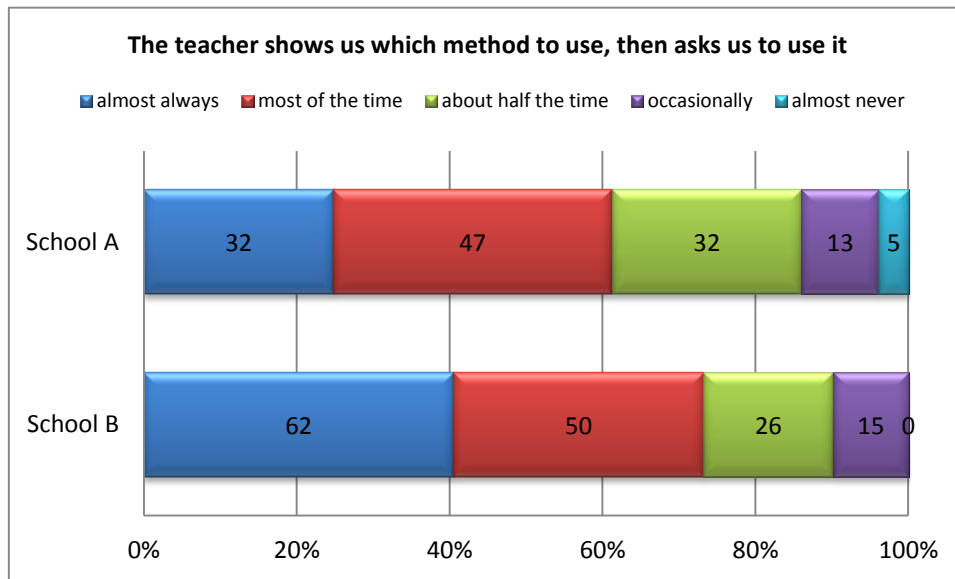
Significant differences between the two schools in Figure 4.4 (χ^2, p=0.009). In School B, a higher proportion of pupils perceive lessons as being about being shown a method and then practising using it [T2, T3]. *"We start the lesson copying example, next we try to do it our selfs [sic]"* (Pupil B149) [T2,T3].

This is consistent with the transmission approach. A large proportion of maths lessons in School A still contain this element in pupils' eyes.

Figure 4.5: **Pupil perceptions of how often they choose questions in School A and School B**

The teacher lets us choose which questions we do

Legend: ■ almost always ■ most of the time ■ about half the time ■ occasionally ■ almost never

School	almost always	most of the time	about half the time	occasionally	almost never
School A	3	16	38	48	20
School B	23	44	34	35	18

Horizontal axis: 0%, 20%, 40%, 60%, 80%, 100%
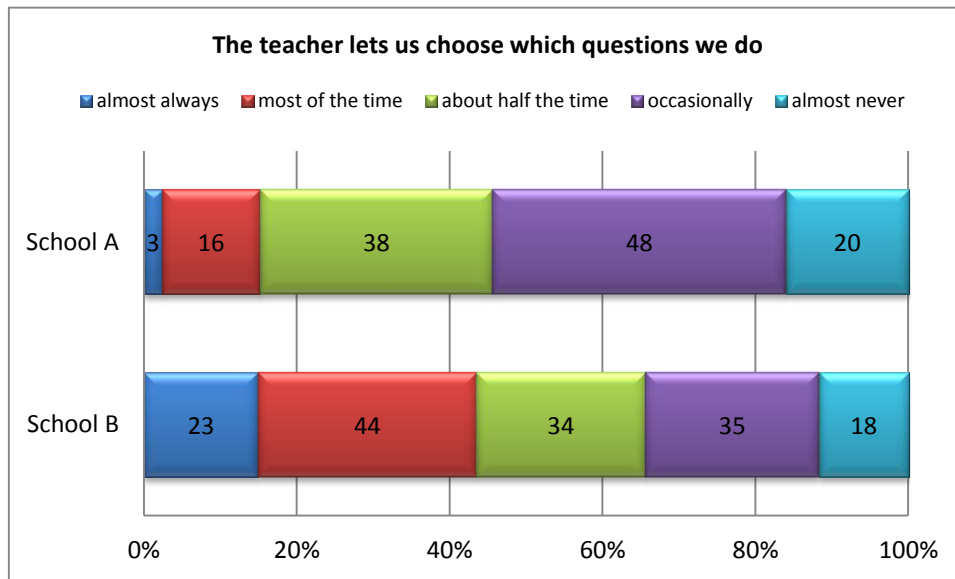
The difference between the two schools in Figure 4.5 is notable. Interviews revealed School B teachers differentiate by letting pupils select from 'easy, medium or hard questions' or share 'must, could, should' type lesson objectives. This was described as common in the mathematics department and witnessed first-hand in the lesson observations. This may explain some of the differences here. In the interviews, it was noted School B pupils seemed to pick the least challenging questions, they *"always start with the reds"* (Teacher B2).

Figure 4.6: **Pupil perceptions of how often they compare methods in School A and School B**
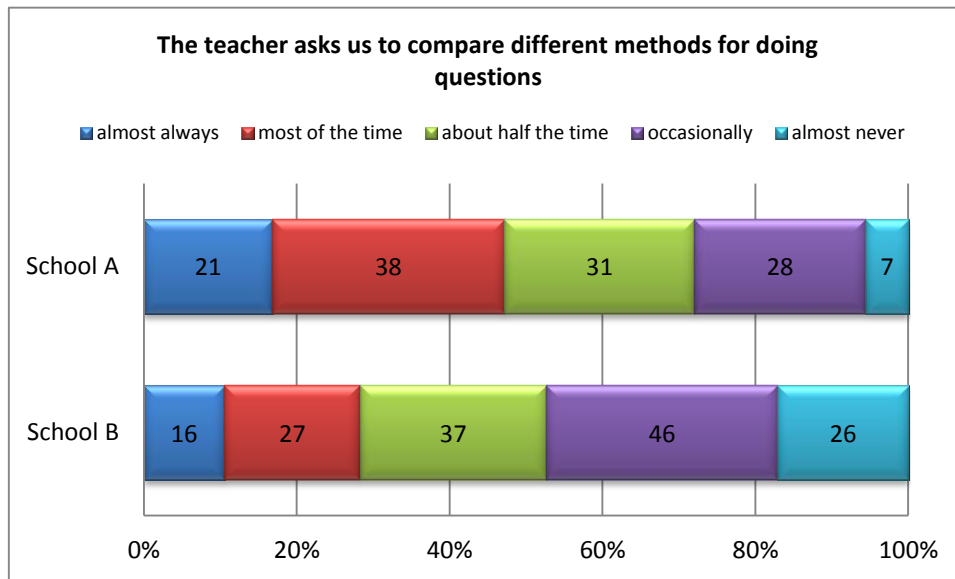
Figure 4.6 shows significant differences (χ^2, p=0.003). School A pupils perceive more time spent discussing alternative methods than in School B. One School A pupil illustrates this approach to problem solving where pupils compare different methods when describing a typical lesson:

> *"1. We have a small starter linked to a lesson 2. We have a problem to solve 3. We share our ideas"* (Pupil A21) [C2].

Figure 4.7: **Pupil perceptions of how often they ask their own questions/make conjectures in School A and School B**
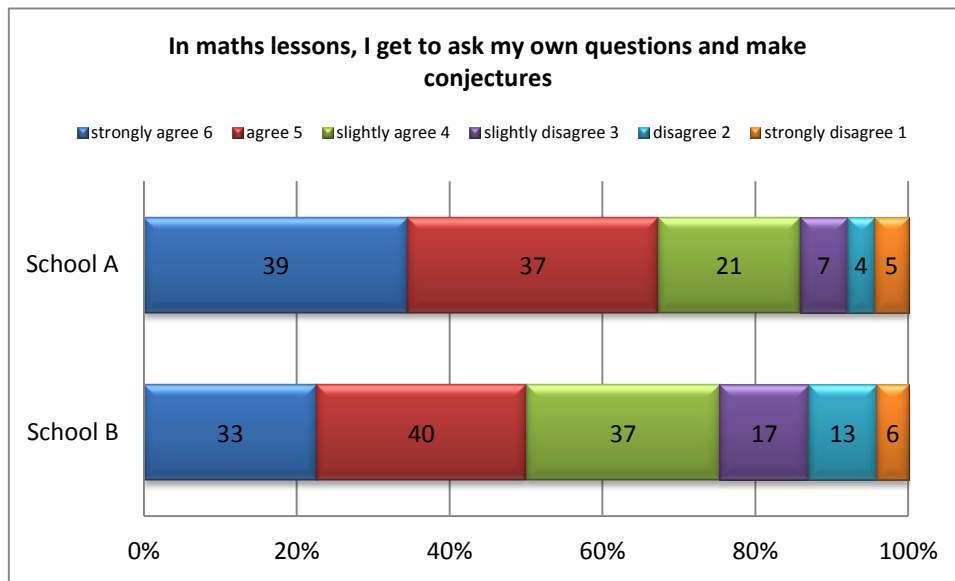
School A pupils feel they are working in a more conjecturing/questioning atmosphere (Figure 4.7). This suggests pupils in School B are given less opportunities to do so suggesting teachers believe mathematics is a given body of knowledge for pupils to learn as opposed to create [T1].

> *"In our maths lessons we always look at something and see if we can make conjectures were [sic] not that bothered on the answer. We try to see if our conjectures are sometimes true never true or always true"* (Pupil A113) [C3]

> *"My maths lessons are more about learning from mine or other people's conjectures. We will see if our conjectures are right or wrong and explain what we have found out."* (Pupil A63) [C2, C3]

Figure 4.8: **Pupil perceptions of how often they discuss ideas in School A and School B**

The teacher expects us to learn through discussing our ideas

■ almost always ■ most of the time ■ about half the time ■ occasionally ■ almost never

School	almost always	most of the time	about half the time	occasionally	almost never
School A	43	45	28	10	2
School B	21	57	45	24	6
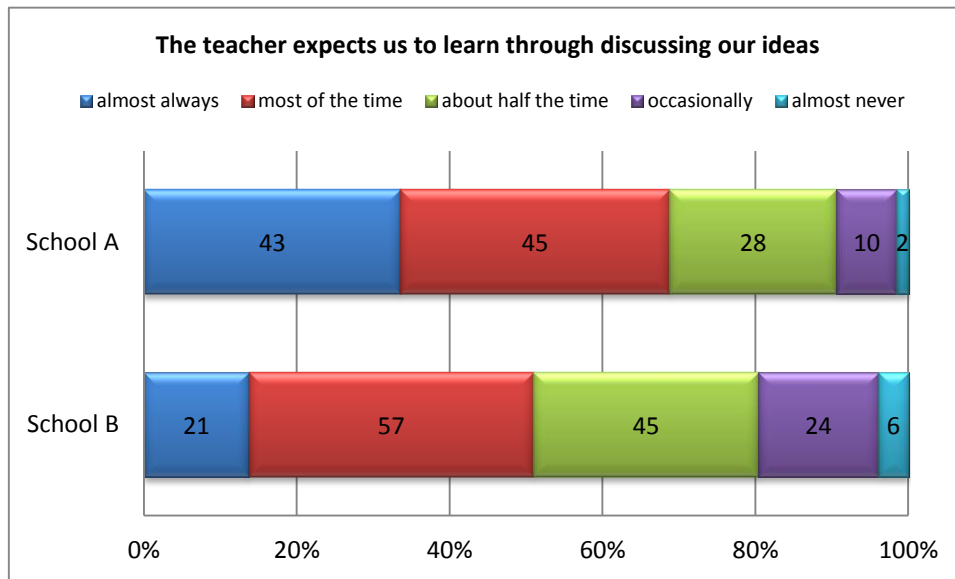
Again, there is a significant difference (χ^2, p=0.00093275) between the two schools seen in Figure 4.8. This suggests more individual work [T3] is perceived in School B. School A has more discussion [C2].This is consistent with the lesson observations.

4.2.3 Lesson Observations

Here I report findings from the lesson observations, three at School A and three at School B. Each observation used a schedule recording what pupils and teachers were doing at the beginning of each minute (see appendix 4). These were pre-coded. Observations were tape-recorded and followed with brief, semi-structured interviews with the class teacher. (For more detail, see appendix1 for 'pen portraits' of the observed lessons).

The lessons observed in the two schools were strikingly different. School A lessons were very student-centred and involved a high level of discussion to expose and discuss misconceptions [C1, C2]. The level of pupil discussion represented a key difference, with School A undertaking a far more collaborative approach.

Table 4.4: **Nature of collaboration during non-teacher led activity in School A and School B**
(School A, n = 102; School B, n = 69. Percentages are accurate to the nearest integer.)

	work alone	consult occasionally	collaboratively
School A	3%	40%	57%
School B	46%	43%	10%

At one-minute intervals the level of pupil collaboration was recorded (see Table 4.4).
All six observed teachers described the lessons as 'typical'. In School A, pupils spent a
far greater amount of time working with others than in School B. Similar proportions of
time were spent with pupils consulting occasionally with peers. The vast majority of the
remaining time was spent on individual work in School B [T2] and on collaborative
work in School A [C2]. In School B the majority of work time in the observed lessons
was spent on individual study. Only a small amount of this time (≈10%) was spent
working collaboratively and in fact, all of the collaborative work occurred in a single
lesson. These findings are consistent with a transmission view of learning as [T2]. In
School A, the majority of lesson time was spent with pupils working collaboratively.
This suggests that teachers in School A had a more connectionist teaching style and this
correlates with their professed views.

4.2.4 Summary of Teaching Styles

This analysis suggests teachers in both schools professed mainly connectionist views on
teaching and learning mathematics. Teachers in School B had a slightly more
transmission orientation according to their self-reported questionnaires. Whilst the
teachers' views appeared to be similar, the pupils' perceptions of teaching styles in
mathematics lessons and what was observed in the two schools was quite different.
Despite professing connectionist beliefs, teachers in School B tended to teach in a more

traditional transmission style. Pupils in School B perceived their mathematics lessons as containing a high degree of individual work following explanations of a method given by the teacher. This analysis is supported by the observation data and the interviews. However, the observation and interview data from School B may not be representative of mathematics teaching in the school, as only a small number of teachers were seen. In School A, pupils and teachers both described a high level of collaborative group work and discussion. The following excerpts from interviews further illustrate the transmission approach witnessed in observations and described by pupils in School B.

TF: *In what ways was that a typical lesson with that group?*

B3:   *Very much so like I definitely would always have a red, amber, green colour coded questions all the time, um*

TF: *So how does that work?*

B3:   *So they choose the questions that they want to work on so a lot of them like always start with the reds then I push them on to a higher colour*

TF: *Is red the easiest?*

B3:   *Red's the easiest*

TF: *And then amber?*

B3:   *Then amber then green then blue. Most of them always start like struggling with the easiest because that's the nature…, that's their… I don't know why but um, but I push them on to the amber and the green. So they're very familiar with the colour coding, and they're very familiar with like copy down the example, we'll do these examples together and then we'll do some questions independently and I mark their work as we're going round. So it was virtually, like identical to what I do normally.*

In the lesson the pupils did indeed copy some examples and then work independently on similar practice questions [T2]. Later in the interview, the teacher expressed some concerns over the style of the lesson:

B3: *I do realise very much so that it was a very led lesson like it was do this, do this, follow this example do this. I get that and I get that that's not like the best way to teach things but for this class I feel like It's worked well to get them to be doing maths and focused. But I know that it's not the best way to teach that lesson.*

This suggests some tension between the way the teacher teaches her lessons and would like to teach them. Another teacher in School B expressed an intention to *"get through"* as much as possible and *"learn the rules"* as well as doing some practice.

B2: *...if they can't do it, obviously go through some examples and give them some practice exam questions.* [T2, T3, T4]

These transmission approaches contrast with the teachers in School A who described the typicality of a lesson as being very much connectionist, misconceptions are planned for and encouraged for discussion in whole class and there is lots of pair and small group work.

TF: *In what ways was that a typical lesson for you?*

A4: *I guess lots of ways, I tried to highlight some misconceptions at the start that did come up so we could work on that as a class and see what was wrong with them, why it was wrong and how we're gonna change it in the future. The class worked collaboratively for the majority of the time so they were asked to talk in pairs a lot. They were asked to do the main activity in groups. And I like, I like them to be working with each other and to be working on misconceptions and to be sort of supporting each other in their own learning. The main activity had various points of support and things to extend within the task so people could work at it at different levels. Whilst some students were still working on the initial task, others could move onto something more challenging.*

These comments were strikingly different to the description of the lessons in School B and indicate much more of a connectionist approach to teaching. Another School A

teacher commented *"It is very typical for my maths lessons to have large portions of the lesson with students involved in discussions, but normally in smaller groups where every now and again we come together as a whole class"* (Teacher A1). This teacher also professed a desire to not *"just give them a rule"*. This links with a more connectionist view of the most effective ways for students to learn mathematics.

I have presented some comparative analysis of teaching styles in the two schools. I now consider similarities and differences between pupil and teacher mindsets.

4.3 Mindset

People with a fixed-mindset believe characteristics like intelligence are fixed qualities defining a person. People with growth-mindsets believe traits like intelligence or mathematical ability can be developed with effort and practice. As discussed, teachers' beliefs about pupils can influence pupils' experiences of learning mathematics. I now analyse teachers' and learners' mindsets.

4.3.1 Teachers' mindsets

In the teacher questionnaire, seven items were designed to measure mindset (adapted from Blackwell et al., 2007; Dweck, 1999). Table 4.5 gives a comparison of responses from teachers in the two schools.

Table 4.5: **Teachers' strength of agreement with mindset statements in School A and School B**.
The total numbers of responses for each statement are indicated.

School A						MINDSET STATEMENTS	School B					
Strongly Disagree (1)	Disagree (2)	Slightly Disagree (3)	Slightly Agree (4)	Agree (5)	Strongly Agree (6)		Strongly Disagree (1)	Disagree (2)	Slightly Disagree (3)	Slightly Agree (4)	Agree (5)	Strongly Agree (6)
4	1	1				You have a certain amount of maths ability, and you can't really do much to change it	1	4	1			
4		2				Your intelligence is something about you that you can't change very much		3	3			
3	2	1				To be honest, you can't really change how intelligent you are		4	2			
5		1				You can learn new things in maths, but you can't really change your basic maths ability		5	1			
			3		3	No matter how much intelligence you have, you can always change it quite a bit				2	4	
				1	5	No matter who you are, you can significantly change your maths ability					6	
				2	4	You can change your maths ability level quite a bit				1	5	

From Table 4.5 it is clear teachers in School A and School B have similar views on intelligence and mathematical ability. Both schools believe ability/intelligence can be increased – this fits with the growth-mindset. What is also clear is the strength of opinions are much stronger for School A. Growth-mindset statements are more strongly agreed with by School A teachers and fixed-mindset statements are more strongly disagreed with. In School B, no teacher strongly agreed with any of the growth statements and only one strongly disagreed with one fixed-mindset statements. Teachers in both schools show growth-mindsets which is surprising as Dweck (2008) suggests only around 40% of people have a growth-mindset, however it is again possible the teachers who responded from School B are not representative and that there are elements of bias. Some quotations illustrate School A teachers' growth-mindsets and how they want to encourage pupils to make and learn from mistakes:

"I want my students to feel confident and not worry about making mistakes." (Teacher A4)

"I want them to get stuck and see how much there is out there. I want them to feel that they can ask. But I want them to feel that they can persist and unstick themselves…" (Teacher A3)

Teachers from both schools were more likely to view 'mathematical ability' as something that could be changed through effort than 'intelligence' but much more so in School B. Again, what teachers in School B actually say during interviews suggests they have a more fixed-mindset. One School B teacher, working with what she described as a *"bottom-set"* said *"…most of them always start like struggling with the easiest because that's the nature…, that's their… I don't know why…"* (Teacher B3), this hints she may have some fixed views of the student's 'ability' and some awareness of them as she checks herself and says she is not actually sure why the pupils always start with the easy questions. Another described a class as being *"Top-set, so the strongest ability"* (Teacher B2) implying mathematical ability may be viewed as a fixed trait.

Teacher responses to the questionnaire suggest teachers from both schools lean towards a growth-mindset but some of the remarks made suggest this may not be the case.

4.3.2 Pupils' mindsets

Pupils were asked a series of questions related to mindset adapted from Dweck (1999) and Blackwell et al. (2007). The items were intended to measure 'theory of intelligence', 'learning goals' and 'effort beliefs' (see Blackwell et al. 2007, p.249-250).

Overall 61% of pupils from School A had a strong growth-mindset compared to 52% of School B pupils.

I will now analyse the statements in more detail as there are some interesting

similarities and discrepancies.

Figure 4.9: **Pupils' effort beliefs in School A and School B**
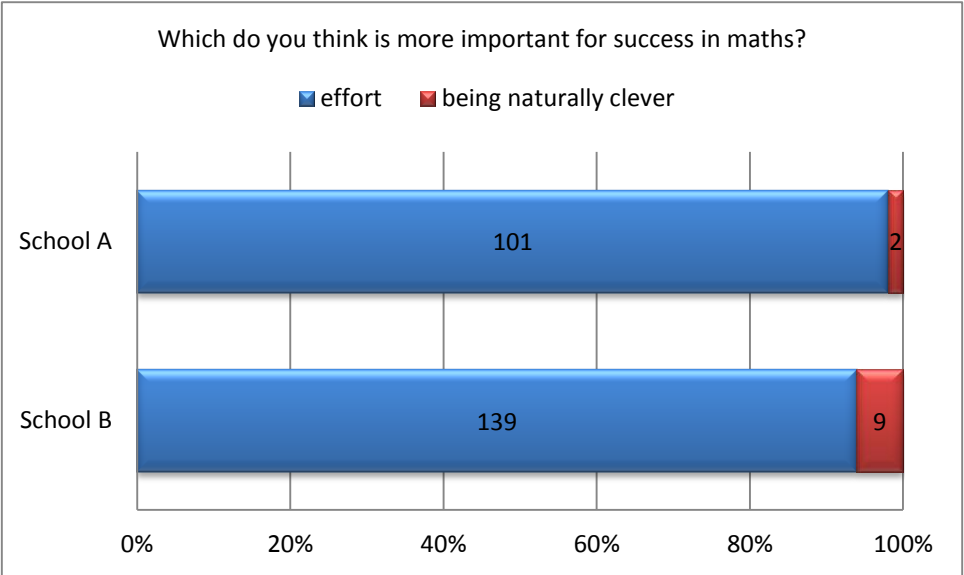
There is a slight difference (Figure 4.9) in favour of School A but the overwhelming

majority of pupils questioned believe effort is more important for success in

mathematics than 'being naturally clever'.

Figure 4.10: **Pupils' beliefs about whether mathematics ability is innate in School A and School B**
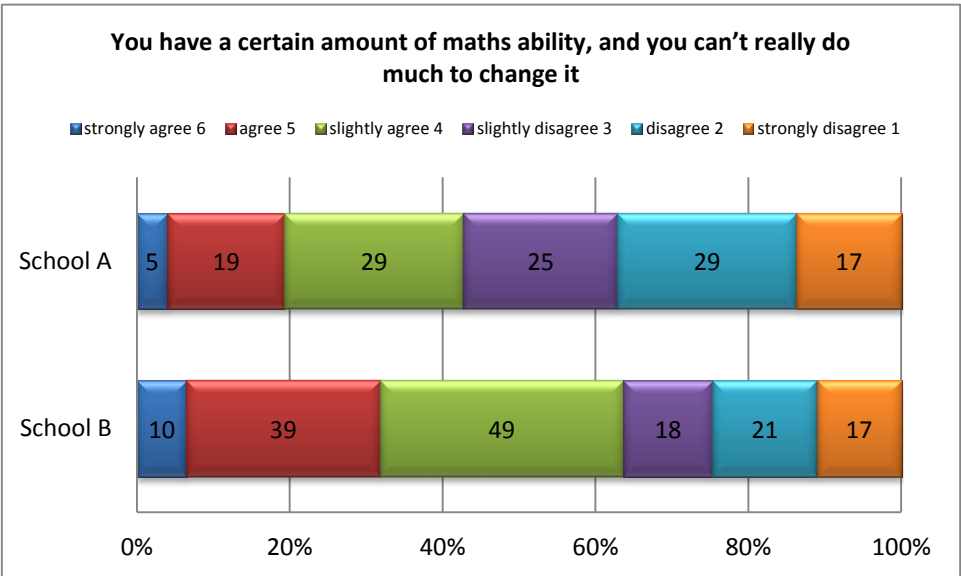
There is a significant difference in Figure 4.10 (χ^2, p=0.023143), around 64% of pupils in School B display a fixed-mindset compared to 43% in School A. This is despite belief that effort is important (Figure 4.9) – School B pupils still tend to believe they cannot change their mathematics ability. This School A pupil illustrates the growth-mindset believing she can grow her mathematical ability through effort:

> *"My maths lessons are fun and interesting. My maths lessons are helping me get better at maths"* (Pupil A12)

Contrast this statement from a School B pupil implying he believes he has a fixed ability the teacher has identified *"I'm always doing work at my level"* (Pupil B135).

Figure 4.11: **Pupils' beliefs about whether mathematics ability can change in School A and School B**
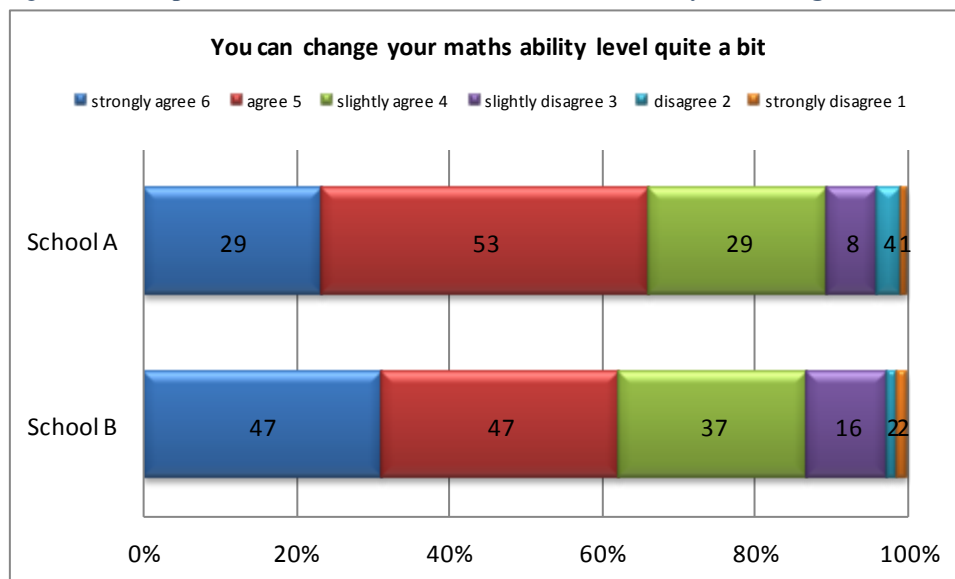
Interestingly, although the question in Figure 4.11 was intended to be a reversal of the previous statement (Figure 4.10), the results are much more similar with only slightly higher agreement in School A This could be due to inclusion of the word 'level'. In the US system where these questions were first used, 'level' has no specific meaning. In the UK system, pupils commonly progress through national curriculum levels so pupils may be more inclined to think levels can increase.

Figure 4.12: **Pupils' beliefs about the value of learning as motivation in School A and School B**
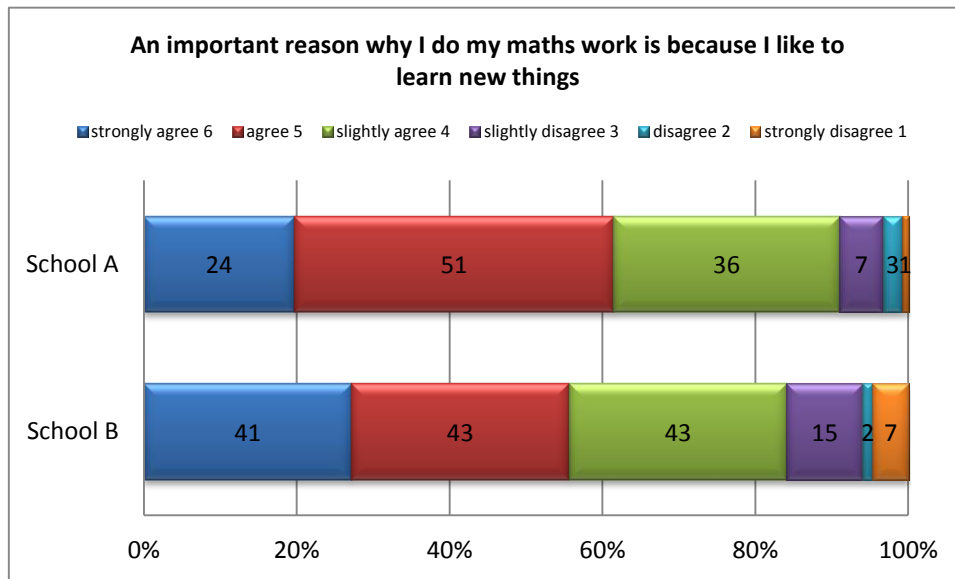
Figure 4.12 suggests slightly more learning orientated goals in School A where 91% express a desire to learn new things compared to 84% in School B. School B express slightly more performance orientated goals.

Figure 4.13: **Pupils' beliefs about learning as motivation even when challenging in School A and School B**
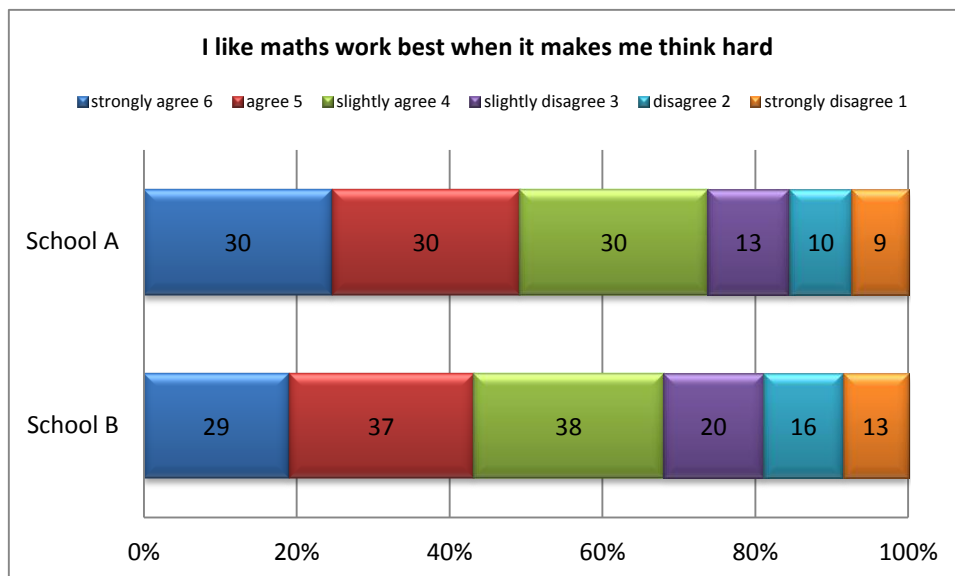
74% of pupils in School A prefer mathematics lessons where they have to think hard compared to 68% in School B (Figure 4.13). Although there is no significant difference

across two schools there was a difference between boys and girls in School B and this was one of only two things they differed on. Only 63% of girls wanted to think hard in School B compared with 73% of boys. The other gender difference at School B regards the statement 'You can learn new things in maths, but you can't really change your basic maths ability'. 51% of boys agreed with this statement whereas 73% of girls agreed. This lends further weight to the suggestion that common gender differences (see Boaler et al., 2000) may be forming.

Figure 4.14: **Pupils' beliefs about learning as motivation when conflicting with short-term performance in School A and School B**
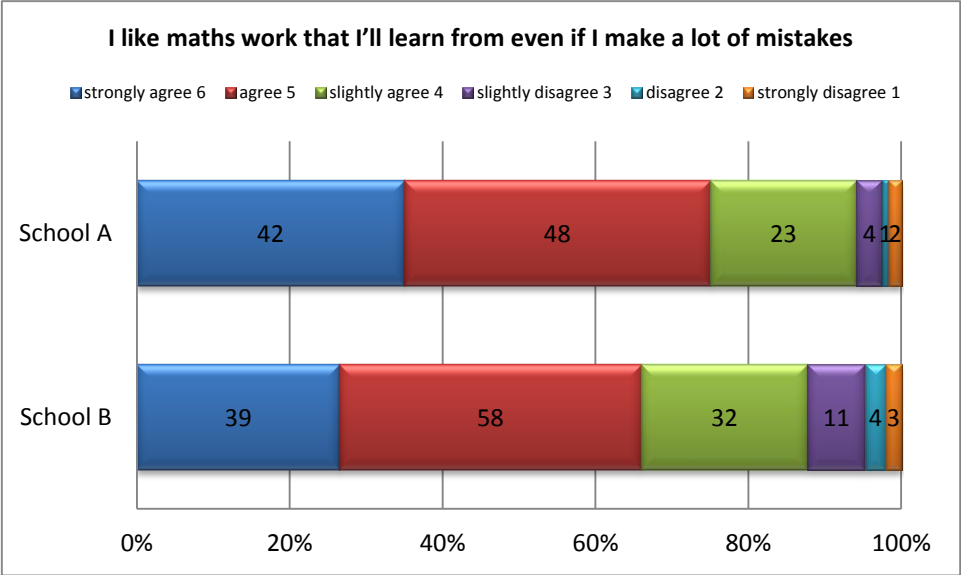
Figure 4.14 shows pupils in both schools appreciate work they can learn from even if they make mistakes. There is a difference between the two schools where 94% of School A pupils agree with this statement compared to 88% at School B. This shows most pupils value learning as a motivator even if it conflicts with short term performance (Blackwell et al. 2007). However, comments suggest whilst pupils in both schools appear to value learning from mistakes pupils from the two schools have different levels of access to this type of learning:

"My math lessons are all about learning from your mistakes and improving on your mathematics skills" (Pupil A103).

This quotation suggests School A pupils have heard clear messages regarding learning from mistakes.

"I enjoy my maths lessons, I am trying to enjoy challenges and to enjoy thinking hard. I'm sure this will develop my brain" (Pupil A9)

This illustrates pupils may be aware of explicit ideas about mindset.

These statements contrast with those from School B where pupils regularly said *"Maths could be improved like to have harder work and to work in groups more"* (Pupil B40) so they have to think and discuss mistakes:

"...instead of miss just explaining everything and us writing it down in our books. It would help us in tasks and activities to show what we know, and then learning from our mistakes" (Pupil B126).

However there are other pupils who do not mind a lack of challenge:

"[Lessons] are fun because they're not that difficult" (Pupil B4).

Figure 4.15: **Pupils' belief that effort is ineffective in achieving positive outcomes in mathematics in School A and School B**
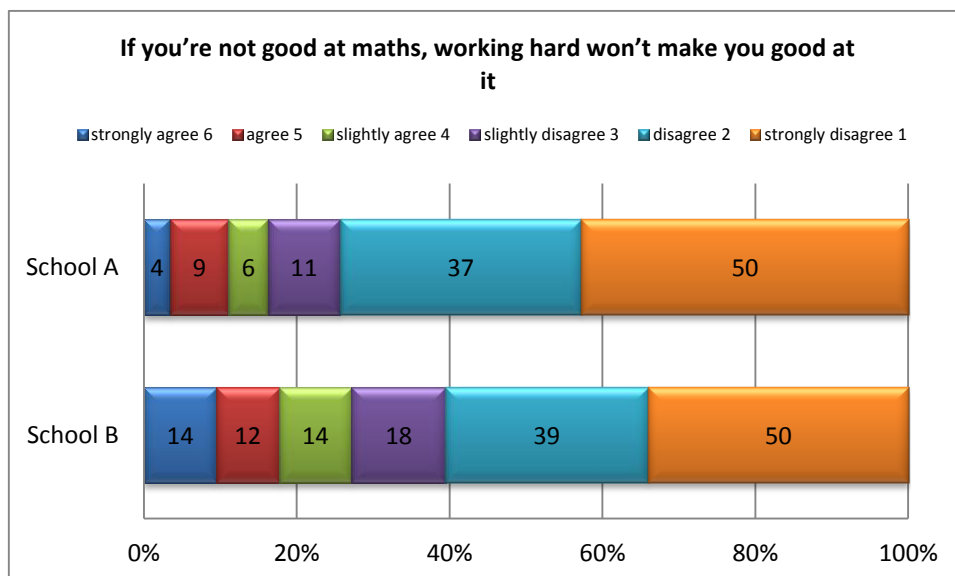
Figure 4.15 shows a significant difference between the schools (χ^2, p=0.033) suggesting pupils at School A believe more strongly that effort is the key to improvement in mathematics. 84% of School A pupils disagreed with the statement 'If you're not good at maths, working hard won't make you good at it' compared with 73% of School B. The strength of disagreement was also notable, around 43% of pupils displayed a 'pure incremental theory' (Blackwell et al., 2007) by strongly disagreeing with this statement compared to 34% of School B pupils.

4.3.3   Summary of findings on mindset

This data suggests both pupils and teachers in both schools tended to have growth-mindsets. These beliefs were held more strongly by pupils and teachers in School A than School B. One teacher commented *"I think the most important lesson for anyone to learn in maths is the harder you work at it, the better you'll do"* (Teacher A4). The results suggest teachers in School A possess stronger growth orientations and they are more likely to structure lessons so pupils make and learn from mistakes. School A pupils appreciate the level of challenge, for example *"My maths lesson is really good and is hard"* (Pupil A91) or *"[teachers] make me work hard in a good way"* (Pupil A14). School A pupils want work that is challenging enough for them to make mistakes they can learn from, as illustrated by this remark *"I learn from my mistakes in lessons"* (Pupil A34).

Pupils in School B are also motivated by learning but in contrast to School A pupils, they don't necessarily feel like they are receiving challenging work:

> *"Maths could be improved like to have harder work and to work in groups more and to have more tasks"* (Pupil B40)

"They could stop giving you as many questions that you are already good at"
(Pupil B87)

4.4   Ability Grouping

As mentioned, the notion of a fixed and knowable 'ability' is highly prevalent in western culture, particularly Britain (see for example Sukhnandan and Lee, 1998). In this study, pupils were not directly asked about 'ability' grouping but it did emerge as an issue. Teachers were asked about 'ability' and some of the findings are discussed.

4.4.1   School A

School A teachers believe setting by ability is generally a bad idea the only exception being when pupils are close to sitting external examinations. They are concerned about how pupils may view themselves as learners and also how it might impact on teaching, *"It may convince a teacher they don't need to differentiate"* (Teacher A1). School A teachers also worry about impact on pupil motivation *"Most students' goal would be to change sets as opposed to become better at the subject"* (Teacher A4) whilst *"going down a set could be devastating"* (Teacher A3). Teachers worried if pupils are setted, those not in 'top-sets' would judge *"...they are not high ability and therefore not good at maths"* (Teacher A2) or *"label themselves as "bad at maths" and may find it hard to recover from that"* (Teacher A3). Potentially damaging effects of 'labelling' students by their ability were highlighted by School A teachers who felt *"Setting labels some students as low ability from a young age which stays with them"* (Teacher A5) and viewed this as *"potentially damaging"* (Teacher A4) as it could *"reinforce the idea that ability is fixed, that talent in maths is innate"* (Teacher A3). Teachers felt these negative connotations could be avoided if pupils were not placed in 'ability' groups but cautioned that teachers must ensure everyone is appropriately challenged *"Teaching*

mixed-ability gives everyone the same chance throughout their school life, through

hormonal changes and changes in their attitude to learning but it has to be taught well

to avoid lowering the bar" (Teacher A5). Interestingly, no School A teachers mentioned

common arguments for setting other than to say it is *"helpful to group broadly when*

approaching GCSE" (Teacher A6).

In School A pupils value working collaboratively on problems using other people's
ideas:

> *"My maths lessons are more about learning from mine or other people's*
> *conjectures. We will see if our conjectures are right or wrong and explain what*
> *we have found out"* (Pupil A63).

Pupils also liked having the opportunity to work on more challenging mathematics than

they'd been allowed to in the past, as one pupil commented *"...in my old school, I was*

in the bottom set for maths still learning the bus stop methord [sic]" (Pupil A88).

4.4.2 School B

Teachers in School B unsurprisingly had more mixed views of setting. Some were in

favour of it because they believed *"It makes it easier for the teachers to plan work*

which focuses on the ability of the students" (Teacher B2) and the *"...learning is more*

catered to the learners" (Teacher B3). It is notable these were the teachers who had a

more transmission orientation. They also felt setting *"in my experience helps reduce*

behavioural issues" (Teacher B3) which perhaps highlights a possible tension which

stops people teaching according to their beliefs and may explain why there is limited

use of collaborative groupwork in School B.

Some of the teachers in School B had a more negative view of setting pupils for

mathematics. One teacher commented *"[setting] restricts pupil potential"* (Teacher

B1), another teacher remarked from their experience *"grouping by ability only benefits the 'top-sets'"* (Teacher B4). Another teacher worried about the impact on pupils:

> *"It concerns me that setting can have a negative effect on students' attitudes and beliefs (e.g. I shouldn't be in this set I'm not clever enough, I'm not very good as I'm in a low set, There is no point in trying I will never move up etc.)"* (Teacher B5).

They also expressed a concern about one of the major arguments for setting, that it reduces the range of attainment in a single group making it easier to teach:

> *"Sets do not mean that there is little differentiation. The 'ability' range in sets is huge"* (Teacher B5).

Even the teachers who were in favour of setting conceded *"In practice of course there is a mix of ability within every set"* (Teacher B2).

Pupils in School B who commented on ability grouping mainly referred to the pressure of the top set *"I enjoy my maths lessons but I sometimes find it hard in the top set"* (Pupil B42), *"Since we are in the top maths set our teachers push us very hard"* (Pupil B62) or boring, monotonous lessons for those in the lower groups, *"Sometimes it can be a bit repetitive"* (Pupil B40), *"Try doing different things and not the stuff we done in primary"* (Pupil B83). These statements agree with the findings of Boaler (1997) that mathematics is stressful in the top sets and tedious in lower groups. I did not have enough information about what set pupils were in and how they felt about it to comment further.

4.4.3   Summary of views on Ability Grouping

School A teachers all viewed setting pupils negatively. Their concerns were very much aligned with the potentially damaging effects of setting described in the literature (see Boaler et al. 2000; Boaler, 2008; Ireson et al., 2002a; Oakes, 1986). Some School B

teachers felt sets could be restrictive and lead to self-fulfilling prophecies regarding

pupil attainment, although others felt there were benefits. They felt setting reduced the

attainment range in a group and also agreed with the assumption this made groups

easier to teach. Some teachers also felt setting reduced behaviour issues, although it is

not clear from my data whether behaviour issues become confined to a smaller number

of groups and indeed whether this is beneficial.

4.5 Summary of findings

In this study I have reported on data from four sources, pupil questionnaires, teacher

questionnaires, lesson observations and teacher interviews. I have mainly considered

differences in the teaching styles utilised in the two schools, the mindsets of pupils and

teachers and the views on ability grouping.

Teachers' beliefs about teaching appeared similar across the two settings. Most teachers

professed overall connectionist beliefs. When teaching practices were analysed, typical

School A lessons involved pupils discussing ideas collaboratively in small groups or

pairs, and being encouraged to make and discuss mistakes whilst working on substantial

tasks accessible at different levels. This was corroborated by pupils who expected

lessons to involve working together and sharing ideas to solve problems.

In School B however, despite professing connectionist orientations, teachers' most

common practices were teacher-centred with the whole class being kept together and the

teacher knowing exactly what mathematics the lesson would contain. Pupils from

School B reported expecting to work mostly on their own, using a method shown by the

teacher and following a textbook/worksheet closely. Many School B pupils professed a

desire to work on more challenging mathematics by discussing their ideas in groups. It

should be noted that many pupils from School B are taught mathematics by teachers who chose not to be part of this study. In conversation (though permission was granted to report it), Teacher B1 suggested those who took part in the questionnaire may be more likely to have a 'more progressive view of teaching' which may explain some of the disparity between teachers' beliefs and pupils' perception of their practices.

Several issues regarding 'ability' grouping were reported on. Teachers in School A were worried about how setting might impact on pupils' beliefs and attitudes and on how teachers teach. Teachers expressed concerns setting may lower expectations and promote a fixed view of mathematical ability. It may also lower teachers' expectations and reduce differentiation. Some teachers in School B felt grouping pupils by 'ability' made mathematics easier to teach but others felt it might limit pupils. Some School B pupils found work too difficult in the top sets and too repetitive in the lower groups.

Regarding teacher mindsets, it was found teachers from School A tended to believe more strongly that ability could be increased through effort than those in School B however both groups reported a growth-mindset overall. Teachers in both schools saw mathematical ability as increasable although some remarks School B teachers made and their actions implied a more fixed-mindset in practice. In School B, teachers felt less strongly about general intelligence and viewed this as more of a fixed trait. Surprisingly a higher than average number of pupils in both schools reported having a growth-mindset. However, the beliefs tended to be stronger in School A. Pupils in School A had a stronger view of intelligence as improvable, were more strongly motivated by 'learning goals' and held stronger beliefs that effort was key to success in mathematics. Pupils in both schools wanted challenging work they could make mistakes on and learn

from through discussion with others. The data suggested pupils were more likely both to believe that this would help them learn and receive these tasks in School A.

I now relate the results to my research questions.

5 Conclusion

5.1 Introduction

The purpose of this research was to investigate the experiences of teachers teaching mathematics and pupils learning mathematics through the lens of grouping practices. Several themes emerged from the literature review, including notions of 'ability' and the impact of grouping practices upon attainment, attitudes and equity. Another theme was teachers' beliefs regarding what mathematics is and how it should best be taught to pupils and teachers' beliefs about pupils themselves. This in turn caused me to consider pupil beliefs and their perception of how they are taught mathematics. The notion of 'ability' dominates UK education in general and mathematics education in particular. These were my research questions:

- To what extent do grouping practices influence mindsets of pupils learning mathematics?

- To what extent do grouping practices influence mindsets of teachers teaching mathematics?

- To what extent do grouping practices influence beliefs of teachers teaching mathematics?

- To what extent do grouping practices influence practices of teachers teaching mathematics?

I begin by summarizing the findings of this study and discussing what can be inferred about my research questions. Some of the limitations of the study relevant to each question are considered. I refer to key themes that emerged in the results, specifically

teaching styles, mindsets and views on ability grouping. I then consider some implications for my future practice and suggest avenues for further study in this area. I end by reflecting on the research process and what I have learnt about conducting research.

5.1.1 To what extent do grouping practices influence mindsets of pupils learning mathematics?

The literature review suggested that many factors could affect pupils' experiences of learning mathematics. Motivation, attributional style and self-theories in particular can have profound effects on the how pupils learn and be particular barriers to learning mathematics (Dweck and Elliot, 1983; Prawat and Anderson, 1994; Eccles, 1986; Dweck & Bempechat, 1983; Dweck, 1999; Bandura and Dweck, 1985). The idea of mindset was investigated as a way of gaining access to these beliefs.

Pupils from School A were found to have a stronger growth-mindset orientation than those in School B. This is significant as mindset has been shown to predict performance in mathematics (Dweck, 2008; Blackwell et al., 2007). Pupils in School A were more growth orientated on each of the three measures; 'theory of intelligence', 'learning goals' and 'effort beliefs'. Previous research (Dweck, 1999; 2008) suggests around 40% of pupils possess a fixed-mindset, 40% have a growth-mindset and the rest are in-between regarding mathematical ability. Both School A (61%) and School B (52%) had above average mindset scores in comparison.

There were significant positive differences in the mindsets of pupils in School A versus those in School B. I might tentatively conclude setting discourages growth-mindsets. However, it is necessary to be 'appropriately cautious' when considering how

conclusively the evidence answers the research question (White, 2009, p.115). White (2009) suggests it is necessary to warrant any conclusion by presenting the chain of reasoning that links the evidence to the claim. The evidence for this claim is that a higher proportion of pupils in School A have growth-mindsets and their views are held more strongly. The warrant for this claim is higher scores on the mindset items implies a more growth-orientated mindset and the claim is that pupils in School A are more growth-orientated than those in School B. Gorard (2013, p.51) suggests it is perfectly proper for researchers to 'strengthen their warrants by weakening their claims'. One way to do this here is to propose that if the reader accepts the differences are a result of grouping practices, then mixed-ability groups may tend to promote a growth-mindset. However, it may be useful to apply Gorard's (2013, p.47) 'inverse warrant principle' to conjecture about what could explain the difference if it is not grouping practices. This will now be considered in further detail as similar arguments are necessary for each research question.

Although schemes of work were similar in the two schools at the beginning of the research period, those in School B have been subject to some change and School B teachers have had to adapt to working under a new head of mathematics. This may have impacted on pupil responses. Factors outside of the classroom in the two schools may have increased or decreased propensity towards a particular mindset in either school, we know, for example that 'extent of setting' within school, i.e. whether pupils are placed in sets for many subjects or few, has an impact on mathematics attitudes and attainment (Ireson et al. 2002b). The differences observed could be due to mathematics teachers in School B teaching numeracy to year seven pupils during form time. It has not been possible to eliminate the possibility the results of this research could be due to some

unseen factor such as ethnicity, socio-economic status or gender. The reason for choosing grouping practices as the favoured explanation for the differing mindsets is the literature suggests that setting can put pupils into a fixed-mindset (Boaler, 2009; 2013; Dweck, 2006) so there is a theoretical basis for the claim.

5.1.2 To what extent do grouping practices influence mindsets of teachers teaching mathematics?

Mindset scores for teachers differ across the two settings but have some surprising commonalities. Self-completion questionnaires suggested that teachers in School A have stronger growth-mindsets than those of School B. However, all the teachers questioned reported growth-mindsets whereas I conjectured fixed-mindsets might be more typical of setted classes. Some remarks School B teachers made in interviews hinted that they may have more fixed views about certain traits than they reported. School A teachers had stronger agreement with growth-mindset statements and stronger disagreement with fixed-mindset statements than those at School B. They also felt more strongly that general intelligence and mathematical ability could be increased through effort. These findings offer some evidence that grouping practices may influence mindsets of teachers.

As with an interview, questionnaire results regarding beliefs are based on beliefs participants claim they hold rather than objective observable data and participants will not necessarily report these accurately (Robson, 2011). This could be a limitation of the self-completion questionnaire and School A teachers may also hold more fixed views than the evidence suggests. Participants might have given responses to please the researcher leading to social desirability response bias (Denscombe, 2010; Robson, 2011; Newby, 2010). As discussed in the methodology, this is a particular potential

issue for School A given relationships involved. Aside from what teachers in School A said, their actions observed in lesson observations suggested more growth orientated beliefs, for example the encouraging of mistakes, the level of collaborative group work and the use of substantial tasks that could be worked on at several different levels. These aspects suggested that teachers did in fact 'practice what they preached'.

5.1.3 To what extent do grouping practices influence beliefs and practices of teachers teaching mathematics?

One of the aims of this research has been to consider how grouping practices influenced teachers' beliefs about teaching. I also wanted to consider the impact on practices. As Fang (1996, p.47) notes, beliefs and practices have a 'complex relationship', therefore I discuss both aspects together. For reasons already addressed it was necessary to verify data around this issue by triangulation. Teachers' beliefs were accessed via Swan's (2006, p. 198) 'low-inference' questions on their practices. These were triangulated with lesson observations and, importantly, pupils' perceptions of teachers' practices. It was found that teachers' beliefs in School A were more connectionist and those in School B were more transmission orientated.

Teachers' self-reported beliefs were connectionist in School A as were the practices they described as occurring most commonly. This was corroborated by the pupils' perceptions. Most pupils in School A perceive typical mathematics lessons as involving a substantial problem or challenge that is worked on collaboratively in pairs or small groups and has several entry points. Mistakes are encouraged, learnt from and pupils develop understanding through discussion. One School A teacher described teaching mathematics as

"...creating a stimulating environment in which the student perceives the need or motivation to learn, facilitating exploration of ideas in non-linear dialogue between students and teacher, giving students feedback on work so that they develop in thinking and learning skills, and providing opportunities for misconceptions to surface and be explored, corrected and developed" (Teacher A6)

A key aspect of the teaching in School A concerns beliefs about mistakes and misconceptions. Teachers actively plan for mistakes to arise so that they can be discussed and worked *on "[when planning, I think about] activities which will draw out the misconceptions or the maths that I want to occur"* (Teacher A4). This indicates a connected/challenging approach to teaching (Swan, 2005) but is also associated with mindset (Dweck, 2008). Utilising mistakes as a tool for learning has been shown to increase mathematics attainment (Dweck, 2008; Blackwell et al., 2007; Boaler, 2008; 2009; 2013). Pupils in School A are conscious of this strategy being used by teachers demonstrating that learning from mistakes has translated from belief into practice, as one pupil succinctly said *"my math lessons are all about learning from your mistakes and improving on your mathematics skills"* (Pupil A103).

In School B, whilst self-reports on teaching styles were slightly more transmission oriented than in School A, the teachers' beliefs were still connectionist overall. However, lesson observations and pupil perceptions indicated that School B teachers' practices were different from their professed beliefs.

Pupil questionnaires and lesson observations indicated that a typical School B mathematics lesson involves the teacher explaining a method for solving a particular class of problem which the pupils copy down. Followed by pupils completing practice questions that use the technique or method they have been shown. Pupils have some choice regarding the relative difficulty of problems though pupils generally tend to

choose the easier problems first. This is evidence of a transmission teaching style. This does not mean however that all lessons follow this structure. One of the School B teachers said *"Lessons involve group work and lots of discussion"* (Teacher B5) and in this teachers' lesson observation, a far greater degree of collaborative discussion was observed (although this was the only lesson in School B where collaboration was observed). Teacher B1 described her typical lesson as:

> *"Students are offered a problem or a question and the class works collaboratively to discuss different methods to solve it. They then work on some questions in pairs… [that] require them to apply their understanding to more complex situations."*

As noted previously, there appeared to be tensions around how some teachers wanted to teach, what they felt was necessary and their worries about 'losing control'. This has parallels with Swan (2006). In School A, all teachers of mathematics (except the researcher) completed the teacher questionnaire, in School B however, only six out of eighteen did. This may explain some of the differences between what teachers said and how pupils perceive mathematics. This could be a failing of the questionnaire design. I discuss some limitations of the questionnaire in the following section.

5.2   Limitations of the study

Firstly, some limitations of the data collection. Newby (2010) supported by Denscombe (2010) suggests questionnaires should appear easy to complete. A flaw of these questionnaires was that they were long, possibly dissuading some teachers from responding. Data was sought on several issues and questions were taken from other studies; I could have included fewer. Completing a questionnaire at all may not have been ideal for busy teachers as they have such limited time, this point was made by Newby (2010) who suggests teachers may be willing to spare a few moments to speak

to a researcher but less inclined to complete a questionnaire in their own time. The questionnaire length also presented issues when analysing. Entering the data for pupils took a substantial amount of time and there was not enough time or space in this project to analyse every aspect in enough depth as such it is necessary to provide an 'edited version of the totality' (Denscombe, 2010, p.309).

Some feedback received on the pupil questionnaire during the trial was that *"the first section [about teacher practices] seemed like it wanted your opinion, but the second [mindset questions] felt like there was a 'right answer' and you just had to find it"* (Pupil A0), this may have caused some bias. As Denscombe (2010, p.170) notes, pre-coded questionnaires impose a structure reflecting "the researcher's thinking rather than the respondent's". These questions remained because they had been used before and had high validity (Blackwell et al., 2007). It could also be that Pupil A0 felt there was a 'right answer' because she had a strong growth-mindset and it seemed obvious to her that, for example, 'you can significantly change your maths ability', it could also have been how she interpreted the research questions which were reversals of others.

A further limitation of this research is the sample. Year seven pupils were used for the pragmatic reasons of access. However, not every pupil who completed a questionnaire consented for their data to be used. This may have led to sample bias; perhaps each pupil who took part was different in some way from a typical pupil. However the volume of data collected reduces the likelihood of this being a problem. A more problematic issue is each pupil had been in their secondary school less than one year. The majority of their experience of mathematics lessons comes from outside of the environment analysed here and it is likely that this has impacted upon their responses. Furthermore, year seven groups in School A are usually taught by experienced teachers

but four of the six teaching groups were being taught or had been recently taught by trainee teachers which could easily have impacted on their responses as 'recency' effects may have reduced overall differences. If there were fewer time constraints this study could have been improved by looking at additional yeargroups. This would have enabled analysis of within school changes as well as across school differences.

Another potential limitation of this work is 'conflict of interest' (Gorard, 2013). This is an ethical issue caused by the fact the researcher cares about the findings. I work in School A and am interested in the findings. I have attempted to limit this by collecting more objective quantitative data but as Denscombe (2010) points out it is rational to present the data in the best possible light and I may have inadvertently edited out some vital detail.

5.3   Further Questions

Throughout conducting this research several questions have arisen for me which may be of interest if looking to build on this research. Firstly, as mentioned previously, this study concerned only year seven pupils. As I conducted the research I found the majority of these pupils were fairly positive in both schools. This raised a question as to whether pupils' mindsets change or remain constant over time and whether there is a greater degree of divergence in the setted or mixed schools. This question could be investigated by conducting either a longitudinal study or a repeated cross-sectional design. A further question is whether the 'extent of setting' in all subjects has an impact on mindsets as Ireson et al. (2002b) found it did impact on mathematics attainment.

An issue that may arise investigating the effect of ability grouping in mathematics in a larger number of secondary schools is whether you could find enough schools that teach

mathematics to predominantly mixed groups beyond year seven. OFSTED no longer gather data on how pupils are grouped (Stewart, 2013) it may be worthwhile investigating the proportion of schools teaching mathematics to mixed groups in each school year. It would be interesting to find out if mixed-ability grouping could act as a 'Trojan horse' (Black, 2005 cited in Kirton et al., 2007) encouraging teachers to develop their practice. Further questions which are pertinent to my future practice as both a teacher and head of mathematics include investigating the most effective ways to teach mathematics to mixed groups. What are the issues for mathematics teachers working with mixed groups and how can they be minimised? The work of Boaler (2008) on 'relational equity' seems like a promising place to begin.

5.4   Reflections on Research

I end by reflecting on the research process. I have learned a lot by undertaking this research project. As well as theoretical aspects of research, the ontologies and epistemologies, the methods and the methodologies, I feel I have also learned the need for meticulousness, research design and fine-tuning. As I have developed as a social researcher over the last two years I feel I have become more questioning, better equipped to answer questions that arise and more sceptical as an audience of other research.

Undertaking research whilst also working full-time as a head of mathematics has been very challenging at times as work commitments have seemed to interfere with the somewhat creative process of conducting research and vice versa. I have often felt that my work has got in the way of my research which is surprising as in many ways I undertook this study because I wanted to think about my own teaching practice in more detail. I think the most useful things I have learnt about research is that researchers

should attempt to conduct research to the highest standards possible within the

constraints imposed upon them and above all the research methods must be ethical and

fit for purpose.

Appendices

Appendix 1 - 'Pen Portraits' of Observed Lessons

Six lesson observations were undertaken as part of this study, three at School A and three at School B, between 28th March and 6th of April 2014. Each observation was conducted using a schedule recording what pupils and teachers were doing at the beginning of each minute (see appendix). These were pre-coded. Observations were tape-recorded and followed up with the class teacher during a brief, semi-structured interview about the lesson. In total, 165 minutes of lessons were observed in School A and 135 minutes of School B (timetabled lessons are ten minutes shorter than those at School A. I will firstly give a brief 'pen portrait' of the observed lessons. I will then discuss some of the implications.

Teacher A2, School A

This was a year nine revision lesson with a mixed-ability group. Pupils were seated in tables of four and worked together on a number of activities related to previous work involving trigonometry and the Pythagorean Theorem. The first activity involved finding areas and side lengths of 'tilted squares' on grid paper, a later activity required finding missing sides and angles using an enlargement of a 'unit-triangle'. The lesson was setup as pupils working together to find out what mathematics they needed to do more work on. Teacher A2 stated the aim as being "not to finish [all the activities] I want you to work on explaining to each other how you work them out". Pupils worked on tasks in small groups initially and then ideas were discussed as a class. These two things were indicative of [C2], pupils were expected to learn through discussion. When the class worked as a whole the teacher asked questions like "what do you think about it?" "could you do it with a different method?" "Could you show another way of doing it?" indicative of a non-linear dialogue between teacher and pupil where connections are made explicit [C3].

Teacher A4, School A

I observed the first half of a two-hour mixed-ability year ten lesson on probability. When pupils arrived there was a task for pupils to answer some questions on fractions and discuss what made them easier or harder. [C2]. The discussion that followed was a non-linear dialogue [C3] between pupil and teacher and pupil and pupil with the teacher providing prompts to encourage pupils to explain. The main activity involved groups deciding if various scenarios in a game resulted in a fair game. They used tree diagrams to explore the scenarios and later had to investigate their own games to try and find a fair game. This exploration was indicative of [D2]. The task was 'low threshold' in that everyone could start and 'high ceiling' as there was much scope for extension. There was a good deal of discussion [C3] as misconceptions arose naturally through the activity [C2]. Pupils were not doing work where they were disadvantaged by their prior attainment. Pupils worked collaboratively on a rich task with some pupils conjecturing, testing results and working towards generality whilst others were gaining fluency with the fundamentals of probability. Crucially though, these opportunities were afforded to all pupils, regardless of their prior attainment.

Teacher A1, School A

This lesson was with a mixed-ability year nine group on trigonometry. The class used the unit-triangle to calculate lengths as functions of angles. They worked on this in groups initially. This task had elements of [C2] as pupils discussed ideas in groups, [D1] as they created methods and [T3] as the task was like an exercise. The rest of the lesson was mainly whole-class discussion of alternative methods each group had come up with. Everyone was expected to articulate their explanations and reflect on their developing understanding. The former was done through pupils moving to find someone they had not yet worked with to discuss their ideas [C2], the latter was assessed via pupils holding up cards. The teacher described the lesson as typical in that it is often a goal for pupils to discuss [C2] and articulate difficulties [C].

Teacher B3, School B

This lesson was with a year nine "bottom set" and was first half of a double on circles. The lesson was highly organised; equipment was ready at the start and pupils record the date, title and margin and begin work as soon as they come in. pupils are sat at separate desks and the majority of work (66%) is completed in silence. The teacher moves

around a lot and gives praise. The teacher explains examples that pupils copy [T2]. The teacher asks questions where pupils supply the answer to each step in calculations. Pupils then work independently on exercises [T3]. Questions are colour coded from easier to harder although all pupils begin with the easier questions. The 'level' of content covered [T1] is perceived by the teacher as high relative to the pupil's prior attainment.

Teacher B5, School B

This was the second half of a double lesson with set five (of six) year nine on measures. The pupils first had the task to work collaboratively to match items to an appropriate unit for measuring them [C2]. Some support is offered to the class by the teacher as a method to work out the size and type of unit. There is an extension included. Pupils tend to check with the teacher or teaching assistant rather than each other and consult peers only occasionally [T1]. The teacher stops the class periodically to re-explain the method [T2]. The task is substantial [C1] as opposed to exercises. This is the only School B lesson where any pupils work collaboratively.

Teacher B2, School B

This is a year ten 'top set' lesson on rounding and bounds. Pupils are given a question to work on. The pupils who begin the task work alone on it. The initial example is not about measurement so some pupils are confused. The misunderstanding is not used [T4]. The teacher gives an example that pupils copy [T2]. The teacher gives a rule: "So, when we round to the nearest cm, we take off half a cm and add half a cm for the bounds". There is a sense that the teacher perceives this as something to be 'covered' [T1] as it is clear that pupils don't understand this although some can apply the rule. The pupils do an exercise [T3] and consult occasionally with peers whilst they complete this although conversations are not always work related. A common misconception arises in several areas of the room and this is corrected with phrases that appeal to memory such as "it's a convention you have to remember" and "believe me, I promise you".

(This questionnaire was administered via the internet so the presentation was slightly different. Some items were adapeted from Swan, (2006) amd Blackwell et al, (2007)

Experiences of Teaching Mathematics

This is a questionnaire about mathematics teaching.
It is being collected as part of a University of Birmingham research project to gather teachers views and help support learning.
All of your answers will be kept completely confidential.
If you change your mind and wish to withdraw from the study you may contact me before 11th April 2014 and your data will not be used.

Please take your time and be honest. There are no right or wrong answers. This questionnaire is designed to investigate how your beliefs are related to your practices and find out if any things stop you from teaching as you would like to.

Name of school:

How many years have you been a teacher? (include PGCE, GTP etc)

Degree and/or teaching qualifications (inc. subjects)

What are your views on Mathematics, Learning and Teaching?

Give each statement a %, so that the sum of the three % in each section is 100. If you wish, you may add your own personal statements underneath.

Mathematics is...

Give each statement a %, so that the sum of the three % in each section is 100. If you wish, you may add your own personal statements underneath.

Mathematics is... a given body of knowledge and standard procedures. A set of universal truths and rules which need to be conveyed to students.

Mathematics is... a creative subject in which the teacher should take a facilitating role, allowing students to create their own concepts and methods.

Mathematics is... an interconnected body of ideas which the teacher and the student create together through discussion.

Mathematics is... Please add your own statements if you wish

Learning is...

Give each statement a %, so that the sum of the three % in each section is 100. If you wish, you may add your own personal statements underneath.

Learning is... an individual activity based on watching, listening and imitating until fluency is attained.

Learning is... an individual activity based on practical exploration and reflection.

Learning is... an interpersonal activity in which students are challenged and arrive at understanding through discussion.

Learning is... Please add your own statements if you wish

Teaching is...

Give each statement a %, so that the sum of the three % in each section is 100. If you wish, you may add your own personal statements underneath.

Teaching is... structuring a linear curriculum for the students; giving verbal explanations and checking that these have been understood through practice questions; correcting misunderstandings when students fail to 'grasp' what is taught.

Teaching is... assessing when a student is ready to learn; providing a stimulating environment to facilitate exploration; and avoiding misunderstandings by the careful sequencing of experiences.

Teaching is... a non-linear dialogue between teacher and students in which meanings and connections are explored verbally. Misunderstandings are made explicit and worked on.

Teaching is... Please add your own statements if you wish

Practices

Tick one box in each row to show how often the following statements are true in your lessons.

(1 = almost never, 2 = occasionally, 3 = half the time, 4= most of the time, 5 = almost always)

Students learn through doing exercises

Students work on their own, consulting a neighbour from time to time.

Students use only the methods I teach them

Students start with easy questions and work up to harder questions.

Students choose which questions they tackle.

I encourage students to work more slowly

Students compare different methods for doing questions

I teach each topic from the beginning, assuming they know nothing

I teach the whole class at once

I try to cover everything in a topic

I draw links between topics and move back and forth between topics

I am surprised by the ideas that come up in a lesson

I avoid students making mistakes by explaining things carefully first

I tend to follow the textbook or worksheets closely

Students learn through discussing their ideas

Students work collaboratively in pairs or small groups

Students invent their own methods

Students work on substantial tasks that can be worked on at different levels

I tell students which questions to tackle

I only go through one method for doing each question

I find out which parts students already understand and don't teach those parts

I teach each student differently according to individual needs

I only cover important ideas in a topic

I tend to teach each topic separately

I know exactly what maths the lesson will contain

I encourage students to make & discuss mistakes

I jump between topics as the need arises

Beliefs

This section has been designed to investigate ideas about intelligence. There are no right or wrong answers. I am interested in your ideas. Using the scale, please indicate the extent to which you agree or disagree with the following statements

Strongly agree, Agree, Slightly Agree, Slightly Disagree, Disagree, Strongly Disagree

You have a certain amount of maths ability, and you can't really do much to change it

Your intelligence is something about you that you can't change very much

No matter who you are, you can significantly change your maths ability

To be honest, you can't really change how intelligent you are

You can learn new things in maths, but you can't really change your basic maths ability

No matter how much intelligence you have, you can always change it quite a bit

You can change your maths ability level quite a bit

On a scale of one to ten indicate how often you enjoy teaching mathematics?

	1	2	3	4	5	6	7	8	9	10	
Never											**Always**

Your views

In this section you can give as much or as little information as you like:

What are your views on setting students by 'ability' in mathematics?

Write a sentence or two describing your goals when teaching mathematics.

When you plan for mathematics lessons, what are the main things that you think about?

Write a sentence or two describing your mathematics lessons:

Any other comments: This is optional for anything you think has not been covered that you would like to add

Please click this box when you are ready to submit your responses *

Check that you're happy with your responses before clicking.□

This is a questionnaire about mathematics lessons.

It is being collected as part of a University of Birmingham research project to gather student views and help support your learning.

Please be totally honest when giving your answers.

All of your answers will be kept **completely confidential** and will not be read by anybody at school except for myself.

If you choose not to be part of the research then you will still take part in the lesson as normal but your data will not be used.

Whether you take part or not will not affect your normal progress in mathematics.

If you change your mind and wish to withdraw from the study you may contact me before 11th April 2014 and your data will not be used.

I am collecting names so that I can identify who has responded but I will not reveal your answers to anyone!

Name:-……………………………………………………………………………………………….

Please sign here if you are happy for your data to be used:-………………………………………………

Please enter the name of your main maths teacher ……………………………………………………………………………………………

Describe the way you work in maths lessons

How often do the following things happen?

5 = Almost always   4 = Most of the time   3 = About half the time   2 = Occasionally   1 = Almost never

Ring one number only for each statement. Please do not leave any statements out.	Almost always	Most of the time	About half the time	Occasionally	Almost Never
The teacher asks us to work through practice exercises	5	4	3	2	1
The teacher expects us to work mostly on our own, asking a neighbour from time to time	5	4	3	2	1
The teacher shows us which method to use, then asks us to use it	5	4	3	2	1
The teacher lets us choose which questions we do	5	4	3	2	1
The teacher asks us to compare different methods for doing questions	5	4	3	2	1
The teacher tries to prevent us from making mistakes by explaining things carefully first	5	4	3	2	1
The teacher expects us to follow the textbook or worksheet closely	5	4	3	2	1
The teacher expects us to learn through discussing our ideas	5	4	3	2	1
The teacher asks us to work in pairs or small groups	5	4	3	2	1
The teacher lets us invent and use our own methods	5	4	3	2	1
The teacher tells us which questions to do	5	4	3	2	1
The teacher shows us just one way of doing each question	5	4	3	2	1
The teacher encourages us to make and discuss mistakes	5	4	3	2	1
The teacher jumps between topics as the need arises	5	4	3	2	1

How much do you agree with the following statements:

Please ring one number only for each statement	Strongly Agree	Agree	Slightly Agree	Slightly Disagree	Disagree	Strongly Disagree
You have a certain amount of maths ability, and you can't really do much to change it	6	5	4	3	2	1
No matter who you are, you can significantly change your maths ability	6	5	4	3	2	1
You can learn new things in maths, but you can't really change your basic maths ability	6	5	4	3	2	1
You can change your maths ability level quite a bit	6	5	4	3	2	1
An important reason why I do my maths work is because I like to learn new things	6	5	4	3	2	1
I like maths work best when it makes me think hard	6	5	4	3	2	1
I like easy maths work that I can do well on	6	5	4	3	2	1
I like maths work that I'll learn from even if I make a lot of mistakes	6	5	4	3	2	1
The harder you work at maths, the better you will be at it	6	5	4	3	2	1
When I have to work hard on maths, it makes me feel like I'm not very clever	6	5	4	3	2	1
If you're not good at maths, working hard won't make you good at it	6	5	4	3	2	1
I am more confident about maths than I was at primary school	6	5	4	3	2	1
In maths lessons, I get to ask my own questions and make conjectures	6	5	4	3	2	1
I am encouraged to think for myself in maths lessons	6	5	4	3	2	1
I am encouraged to ask questions in maths lessons	6	5	4	3	2	1
I am encouraged to notice things and record them in maths lessons	6	5	4	3	2	1

For these questions, please ring the most appropriate response:

Do you enjoy maths lessons?	All of the time	Quite often	Not very often	Never
Do you think you are good at maths?	Very good	Good	Not very good	Bad
I know what to do when I get stuck in maths	Always	Usually	Sometimes	Never

If somebody put your maths class in order, in terms of mathematical ability, where do you think you would be? *

Very high   In the top half   In the middle   In the bottom half   Very low

Is the work you do in maths lessons at the right sort of level for you?

It is often too difficult   It is usually about right   It is often too easy

Is the pace of your maths lessons right for you?

I sometimes find it hard to keep up   It is usually about right   It is often too slow

When you approach a maths question, is it more important to...? (Choose one)

Remember similar work you have done before   Think hard about the work you are doing

In mathematics lessons, is it more important to finish tasks or learn from tasks?

Finish tasks   Learn from tasks

Which do you think is more important for success in maths?

Effort   Being naturally clever

Write a sentence or two describing your maths lessons:

How do you think maths lessons could be improved for you?

Thank-you for your time completing this questionnaire!

Mr Francome

Appendix 4 - Observation Schedule

Teacher	Group	'Ability'	Room	Date	Time	Boys	Girls

Maths Topic

Previous lesson	Next lesson

Teacher

1 accepts feelings
2 praises / encourages
3 uses pupil ideas
4 asks a question
5 explaining method
6 giving directions (task)
7 criticising
10 silence

51 explain misconception B4
31 use pupil misconception

Students

10 work alone
11 consult occasionally

14 do exercise

16 easy→harder

18 use method

12 collaboratively
13 whole class

15 discuss ideas

17 substantial task different levels

19 discuss alt methods

8 respond to question
9 initiate question

	Whole Class	Individual	collaboration	task	level	methods
1						
2						
3						
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28						
29						
30						

Teacher   Students

1 accepts feelings   **10** work alone   **12** collaboratively

2 praises / encourages   **11** consult occasionally   **13** whole class

3 uses pupil ideas

4 asks a question   **14** do exercise   **15** discuss ideas

5 explaining method

6 giving directions (task)   **16** easy→harder   **17** substantial task different levels

7 criticising

10 silence   **18** use method   **19** discuss alt methods

51 explain misconception B4   **8** respond to question

31 use pupil misconception   **9** initiate question

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References

Abraham, J. (1989) Testing Hargreaves' and Lacey's differentiation-polarisation theory in a setted comprehensive. **British Journal of Educational Sociology**, 40: 46-81.

Ahmed, A. (1987) **Better Mathematics: A Curriculum Development Study**. London: HMSO.

Allen, B. and Johnston-Wilder, S. (2004) **Mathematics Education: Exploring the Culture of Learning**, London: RoutledgeFalmer

Allen, B. (2004) "Pupils' Perspectives on learning Mathematics." In Allen, B. and Johnston-Wilder, S. (Eds.) **Mathematics Education: Exploring the Culture of Learning**, London: RoutledgeFalmer

Askew, M., Brown, M., Rhodes, V., Johnson, D. C. and Wiliam, D. (1997) **Effective teachers of numeracy**. London: King's College.

Askew, M., Hodgen, J., Hossain, S., and Bretscher, N. (2010) **Values and Variables: A Review of Mathematics Education in High-Performing Countries.** London: The Nuffield Foundation.

Bakeman, R. (1997) **Observing interaction: An introduction to sequential analysis.** Cambridge: Cambridge University Press.

Ball, S. J. (1981) **Beachside Comprehensive**. Cambridge: Cambridge University Press.

Bandura, M., and Dweck, C. S. (1985) **The relationship of conceptions of intelligence and achievement goals to achievement-related cognition, affect and behavior.** Unpublished manuscript, Harvard University.

Banwell, C., Saunders, K. and Tahta, D. (1972) **Starting Points for Teaching Mathematics in Middle and Secondary Schools.** Tarquin, Diss.

Barker-Lunn, J. C. (1970) **Streaming in the Primary School**. Slough: National Foundation for Educational Research.

Bell, A., Costello, J., and Kuchemann, D. (1983) **Research on Learning and Teaching.** Windsor: NFER Nelson.

Bennett, N., Desforges, C., Cockburn, A., and Wilkinson, B. (1984) **Quality of Pupil Learning Experiences.** London: Routledge.

Bernstein, B. (2000) **Pedagogy, symbolic control and identity (revised edition)**. Maryland: Rowman and Littlefield.

Black, P. (2005) **Dialogue, argument and formative assessment-new visions or re-inventing the wheel?** 14 February 2005. Seminar at King's College London.

Black, P. and Wiliam, D. (2006) "The reliability of assessments" In Gardner, J. (Ed.) **Assessment and Learning**. London: Sage.

Blackwell, L., Trzesniewski, K., and Dweck, C.S. (2007) Implicit Theories of Intelligence Predict Achievement Across an Adolescent Transition: A Longitudinal Study and an Intervention. **Child Development**, 78: 246-263.

Boaler, J. (1997) **Experiencing School Mathematics: Teaching Styles, Sex and Setting**, Buckingham: Open University Press.

Boaler, J. (2008) Promoting 'relational equity'and high mathematics achievement through an innovative mixed-ability approach. **British Educational Research Journal**, 34(2): 167-194.

Boaler, J. (2009) **The Elephant in the Classroom: helping children Learn and Love Maths**. London: Souvenir Press.

Boaler, J. (2013) Ability And Mathematics: The Mindset Revolution that is Reshaping Education. **FORUM**, 55(1): 143-152

Boaler, J. Wiliam, D. and Brown, M. (2000), Students' Experiences of Ability Grouping - Disaffection, Polarisation and the Construction of Failure, **British Educational Research Journal**, 26(5): 631-648.

Bourdieu, P. (1986) "The Forms of Capital", In J. Richardson (Ed.) **Handbook Of Theory And Research For The Sociology Of Education**. New York: Greenwood Press, pp.241–258.

Briggs, D. C. (1970) **Your Child's Self-Esteem.** New York: Doubleday

British Educational Research Association (2011), **Ethical Guidelines for Educational Research**, London: BERA.

Bryman, A. (2001), **Social Research Methods**, Oxford: Oxford University Press

Bryman, A. (2006) Integrating Quantitative and Qualitative Research: How is it done? **Qualitative Research**, 6: 97-113.

Burgess, R.G. (1983) **Experiencing Comprehensive Education: a study of Bishop McGregor School**. London:Methuen.

Burris, C. C., Heubert, J. P. and Levin, H. M. (2006) Accelerating mathematics achievement using heterogeneous grouping. **American Educational Research Journal**, 43**:** 105-36.

Butler, R. (1987) Task-involving and ego-involving properties of evaluation: Effects of different feedback conditions on motivational perceptions, interest, and performance. **Journal of Educational Psychology**, 79(4): 474.

Cimpian, A., Arce, H.-M., Markman, E. M., and Dweck, C. S. (2007) Subtle linguistic cues impact children's motivation. **Psychological Science**, 18: 314-316.

Cobb, P. (1988) The Tension Between Theories of Learning and Instruction in Mathematics Education. **Educational Psychologist**, 23(2): 87-103

Cobb, P., Yackel, E., and Wood, T. (1989) Young Children's Emotional Acts While Engaged in Mathematical Problem Solving. In **Affect and Mathematical Problem Solving,** New York: Springer pp.117-148.

Coolican, H. (1996), **Introduction to Research Methods and Statistics in Psychology**. 2nd Ed. London: Hodder and Stourton

Denscombe, M. (2002) **Ground Rules for Good Research: A Ten-Point Guide for Social Researchers**. Buckingham: Open University Press.

Denscombe, M. (2010), **The Good Research Guide: For Small-scale Social Research Projects.** 4th ed. Maidenhead: Open University Press

Dentzer, E. and Wheelock, A. (1990) **Locked In/Locked Out: Tracking and Placement in Boston Public Schools**, Boston, MA: The Massachusetts Advocacy Center.

Duffield, J., Allan, J., Turner, E and Morris, B. (2000) Pupils' Voices on Achievement: An Alternative to the Standards Agenda**, Cambridge Journal of Education**, 30(2): 263-274

Dweck, C. S., and Bempechat, J. (1983) Children's theories of intelligence: Consequences for learning. **Learning and Motivation in the Classroom**, 239-256.

Dweck, C.S. (1999) **Self-Theories: Their Role in Motivation, Personality and Development**. Philadelphia: Taylor and Francis/Psychology Press.

Dweck, C. (2006) **Mindset: The New Psychology of Success**. New York: Ballantine.

Dweck, C. (2008) Mindsets and Math/Science Achievement [online]. Available from:

www.growthmindsetmaths.com/uploads/2/3/7/7/23776169/mindset_and_math_science_ac hievement_-_nov_2013.pdf [Accessed 21st December 2013]

Eccles, J. S. (1986) Gender-roles and women's achievement. **Educational Researcher**. 15-19.

Ernest P. (1989), The Knowledge, Beliefs and Attitudes of the Mathematics Teacher: A Model. **Journal of Education for Teaching**, 15: 13-34

Ernest P. (1991), The impact of beliefs on the teaching of mathematics. In P. Ernest (ed.), **Mathematics Teaching, The State of the Art.** London: Falmer. pp. 249-254

Fang, Z. (1996) A Review of Research on Teacher beliefs and Practices. **Educational Research**, 38(1): 47-65

Flanders, N, (1961), Analyzing Teacher Behavior, **Educational Leadership** [online], http://www.ascd.org/ASCD/pdf/journals/ed_lead/el_196112_flanders.pdf [Accessed: 27th March 2014]

Freudenthal, H. (1991) **Revisiting mathematics education: China lectures**. Kluwer, Dordrecht

Furinghetti, F. (1996) A theoretical framework for teachers' conceptions. In Pehkonen E. (Ed.), **Current State of Research on Mathematical Beliefs III**. Proceedings of the MAVI-3 Workshop (pp.19–25) University of Helsinki. Department of Teacher Education. Research Report 170.

Furinghetti and Pehkonen, E. (2002) Rethinking Characterisations of Beliefs. In Leder, G., Pehkonen, E., and Torner, G. (Eds), **Beliefs: A Hidden Variable in Mathematics Education?** Dordrecht: Kluwer. pp.39-57

Gamoran, A., and Berends, M. (1987) The Effects of Stratification in Secondary Schools: Synthesis of Survey and Ethnographic Research. **Review of Educational Research**, *57*(4): 415-435.

Gattegno, C. (1971) **What We Owe Children: The Subordination of Teaching to Learning**. New York: Outerbridge and Dienstfrey.

Gillham, B. (2008) **Developing a Questionnaire**, 2nd Ed. London: Continuum

Gillborn, D. and Youdell, D. (2000) **Rationing Education: Policy, Practice, Reform and Equity.** Buckingham: Open University Press.

Good, C., Aronson, J., and Inzlicht, M. (2003) Improving Adolescents' Standardized Test Performance: An Intervention to Reduce the Effects of Stereotype Threat. **Journal of Applied Developmental Psychology**, 24(6): 645-662.

Gorard, S., (2002) Can We Overcome the Methodological Schism? Four Models for combining qualitative and quantitative evidence, **Research Papers in Education***, 17(4): 345-361.

Gorard, S. (2013) **Research Design: Creating Robust Approaches for the Social Sciences**. London: SAGE.

Grigutsch, S. (1998) "On pupils' views of mathematics and self-concept: developments, structures and factors of influence". In Pehkonen, E. and Törner, G. (Eds.) **The State-Of Art In Mathematics-Related Belief Research. Results Of The MAVI Activities.** University of Helsinki. Department of Teacher Education. Research report 195, pp.169-197.

Guardian (1996) Blair rejects mixed ability teaching. **Guardian.** 8 June. p.7.

Guba, E. G., & Lincoln, Y. S. (1981) **Effective evaluation: Improving the usefulness of evaluation results through responsive and naturalistic approaches**. San Francisco: Jossey-Bass.

Gutiérrez, R. and Slavin, R. (1992) Achievement Effects of the Nongraded Elementary School: A Best Evidence Synthesis, **Review of Educational Research** 62(4): 333-376

Gutiérrez, R. (2002) Enabling the Practice of Mathematics Teachers in Context: Toward a New Equity Research Agenda. Mathematical Thinking and Learning. 4(2and3), 145-187.

Hallam, S. & Ireson, J. (2005) Secondary School Teachers' Pedagogic Practices When Teaching Mixed and Structured Ability Classes**. Research Papers in Education**, 20**:** 3-24.

Hallam, S. and Parsons, S., (2013) Prevalence of Streaming in UK Primary Schools: Evidence from the Millennium Cohort Study. **British Educational Research Journal**, *39*(3): 514-544.

Hanington, B. (2003), Methods in the Making: A perspective on the State of Human Research in Design, **Design Issues** 19(4), Massachusetts Institute of Technology

Hargreaves, D., (1967) **Social Relations in a Secondary School** (London, Tinling).

Harlen, W., & Malcolm, H. (1999) **Setting and Streaming: A Research Review**. Revised Edition. SCRE Publication 143. Using Research Series 18. (formerly Practitioner Minipaper Series) Edinburgh: Scottish Council for Research in Education

Hart, K. (1980) **Secondary School Children's Understanding of Mathematics. A Report of the Mathematics Component of the CSMS Programme.** University of London.

Hart, K., ed. (1981) **Children's Understanding of Mathematics: 11-16**. London: John Murray.

Heine, S. J., Kitayama, S., Lehman, D. R., Takata, T., Ide, E., Leung, C., and Matsumoto, H. (2001) Divergent motivational consequences of success and failure in Japan and North America. **Journal of Personality and Social Psychology**, 81: 599–615

Hersh, R. (1986) Some proposals for revising the philosophy of mathematics. In Tymoczko, T.(Ed.), **New Directions in the Philosophy of Mathematics**. Boston: Birkhauser.

Hewitt, D. P. (1994) **The principle of economy in the learning and teaching of mathematics**. PhD dissertation, Open University.

Hewitt, D. (1999) Arbitrary and Necessary Part 1: A Way of Viewing the Mathematics Curriculum. **For the Learning of Mathematics**. 19(3): 2-9.

Higgins, S., Katsipataki, M., Kokotsaki, D., Coleman, R., Major, L.E., and Coe, R. (2014) **The Sutton Trust-Education Endowment Foundation Teaching and Learning Toolkit**. London: Education Endowment Foundation.

Higgins, S., Katsipataki, M., Kokotsaki, D., Coe, R., Major, L.E. and Coleman, R. (2013) **The Sutton Trust-Education Endowment Foundation Teaching and Learning Toolkit: Technical Appendix.** London: Education Endowment Foundation.

Hodgen, J., Küchemann, D., Brown, M. and Coe, R. (2009) 'Children's understandings of algebra 30 years on', in Joubert, M. (Ed.) **Proceedings of the British Society for Research into Learning Mathematics**. 28(3): 36-41

Hodgen, J. (2010) Setting streaming and mixed ability teaching. In Dillon, J. and Maquire, M. (Eds.), **Becoming a Teacher** (4th ed.) Buckingham: Open University Press. pp. 210-221

Holt, J. (1964) **How Children Fail**. London: Pittman

Hoyles, Celia (1982) The pupil's view of mathematics learning. **Educational Studies in Mathematics**. 13: 349-372

Ireson, J. and Hallam, S. (1999) Raising Standards: Is ability grouping the answer? **Oxford Review of Education**, 25(3): 343-358

Ireson, J., Hallam, S., Mortimore, P., Hack, S., Clark, H. and Plewis, I. (1999) Ability Grouping in The Secondary School: The Effects on Academic Achievement and Pupils' Self-Esteem. Paper presented at the **British Educational Research Association Annual Conference**. University of Sussex at Brighton, September 2-5 1999. http://www.leeds.ac.uk/educol/documents/00001359.htm [Accessed February 20th 2014]

Ireson, J., Clark, H. and Hallam, S. (2002a) Constructing Ability Groups in the Secondary School: Issues in Practice, **School Leadership and Management: Formerly School Organisation**, 22(2): 163-176

Ireson, J. Hallam, S. Hack, S. Clark, H. and Plewis, I. (2002b), Ability Grouping in English Secondary Schools: Effects on Attainment in English, Mathematics and Science, **Educational Research and Evaluation: An International Journal on Theory and Practice**, 8(3): 299-318

Kamins, M., and Dweck, C. S. (1999) Person vs. Process Praise and Criticism: Implications for Contingent Self-Worth and Coping. **Developmental Psychology**, 35: 835- 847.

Keddie, N. (1971) "Classroom Knowledge" In: Young M. (Ed.) **Knowledge and Control** London: Collier-MacMillan

Kerry, T. (1980) RE: a Suitable Case for Mixed Ability? **British Journal of Religious Education**, 3(2): 46-52

Kirton, A., Hallam, S., Peffers, J., Robertson, P., & Stobart, G. (2007) Revolution, Evolution or a Trojan Horse? Piloting Assessment for Learningin Some Scottish Primary Schools. **British Educational Research Journal**, 33(4): 605-627

Kitwood, T. (1977) **Values in Adolescent Life: Towards a Critical Description.** PhD thesis, School of Research in Education, University of Bradford

Küchemann, D. (1981) "Algebra" In Hart, K., (ed.) **Children's Understanding of Mathematics: 11-16**. London: John Murray

Kulik C-L.C and Kulik J.A. (1982) Effects of Ability Grouping on Secondary School Students: A Meta-Analysis of Evaluation Findings, **American Educational Research Journal**, *19* (3), 415-428.

Kulik C-L.C and Kulik J.A. (1984) Effects of Ability Grouping on Elementary School Pupils: A Meta-Analysis. **Annual Meeting of the American Psychological Association**.

Kulik, J.A., and Kulik, C.L.C. (1987) Effects of ability grouping on student achievement. **Equity and Excellence in Education**, 23(1-2): 22-30.

Kulik, J. A. (1992) **An analysis of the research on ability grouping: Historical and contemporary perspectives**. National Research Center on the Gifted and Talented: University of Connecticut.

Kyriakides, L., Creemers, B. P., & Antoniou, P. (2009) Teacher Behaviour and Student Outcomes: Suggestions for Research on Teacher Training and Professional Development. **Teaching and Teacher Education**, 25(1): 12-23

Lacey, C. (1970) **Hightown Grammar**. Manchester, Manchester University Press.

Lacey, C. (1974) Destreaming In A `Pressured' Academic Environment, In Eggleston, J. (Ed.) **Contemporary Research in the Sociology of Education.** London: Methuen.

Lakatos, I. (1978) **Philosophical Papers**, Vol.2. Cambridge: CUP

Leahy, S. And Wiliam, D. (2009) **Embedding Asessment for Learning – a professional development pack** (CD-ROM). London: Specialist Schools and Acadamies Trust

Lerman, S. (1990) Alternative perspectives of the nature of mathematics and their influence on the teaching of mathematics. **British Educational Research Journal**, 16(1): 53-61.

Likert, R. (1932) A Technique for the Measurement of Attitudes. **Archives of Psychology**. 22: 5-55

Linchevski, L. and Kutscher, B. (1998) Tell Me with Whom You're Learning, and I'll Tell You How Much You've Learned: Mixed-Ability Versus Same-Ability Grouping in Mathematics**. Journal for Research in Mathematics Education**. 29: 533-54.

MacIntyre, H. and Ireson, J. (2002) Within Class Ability Grouping, Group Placement and Self-Concept, **British Educational Research Journal**, 28(2): 249–263.

Mason, J. and Johnston-Wilder, S. (2004) **Fundamental Constructs in Mathematics Education** .Abingdon: RoutledgeFalmer

Meece, J. L., Parsons, J. E., Kaczala, C. M., & Goff, S. B. (1982) Sex Differences in Math Achievement: Toward A Model Of Academic Choice. **Psychological Bulletin**. 91(2): 324.

Mueller, C. M., and Dweck, C. S. (1998) Intelligence Praise Can Undermine Motivation and Performance. **Journal of Personality and Social Psychology**. 75: 33-52

Nash, R. (2006) Controlling For 'Ability': A Conceptual and Empirical Study of Primary and Secondary Effects. **British Journal of Sociology of Education**, 27: 157-72

Newby, P. (2010) **Research Methods for Education.** Harlow: Pearson Education

Oakes, J. (1986) Keeping Track, Part 1: The Policy and Practice of Curriculum Inequality. **Phi Delta Kappan**, 68(1): 12-17

Oakes, J. (1995) Two cities' tracking and within–school segregation. **Teachers College Record**, 96**:** 681-90.

OECD. (2010) **PISA 2009 Results: Overcoming Social Background – Equity in Learning Opportunities and Outcomes (Volume II).** Paris: OECD.

OFSTED (1995) Standards and Quality in Education. Annual Report of Her Majesty' s Chief Inspector of Schools, 1993/94, Part 1 (London, Office for Standards in Education).

OFSTED (2010) **Finnish pupils' success in mathematics** [online]. Available from: http://www.ofsted.gov.uk/sites/default/files/documents/surveys-and-good-practice/f/Finnish%20pupils%27%20success%20in%20mathematics.pdf [accessed 21st July 2014]

OFSTED (2012) **Mathematics: made to measure** [online]. Available from: http://www.ofsted.gov.uk/sites/default/files/documents/surveys-and-good-practice/m/Mathematics%20made%20to%20measure.pdf [accessed 21st July 2014]

Pajares, M. F. (1992) Teachers' Beliefs and Educational Research: Cleaning Up a Messy Construct. **Review of Educational Research**. 62(3): 307-332.

Peak, B. and Morrison, K. (1988) Investigating Banding Origins and Destinations in a Comprehensive School, **School Organisation**. 8(3): 339–349

Pehkonen, E., & Pietilä, A. (2003) On Relationships between Beliefs and Knowledge in Mathematics Education. In **Proceedings of the CERME-3 (Bellaria) meeting**. http://www.erme.tu-dortmund.de/~erme/CERME3/Groups/TG2/TG2_pehkonen_cerme3.pdf [Accessed: 20th February 2014]

Piaget, J. (1975) **To Understand is to Invent. The Future of Education**. New York: Viking Press

Piggot, J. (2007), **Rich Tasks and Contexts**, [online]. Available from: http://nrich.maths.org/5662 [accessed 16th March 2014]

Pollard, A., Osborn, M., McNess, E. Broadfoot, P. (2001) **What Teachers Do: Changing Policy and Practice in Primary Education**. London: A&C Black

Prawat, R. S., and Anderson, A. L. (1994) The Affective Experiences of Children during Mathematics. **The Journal of Mathematical Behavior**, 13(2): 201-222.

Rattan, A., Good, C., and Dweck, C. S. (2012) "It's Ok—Not Everyone Can Be Good At Math": Instructors With An Entity Theory Comfort (And Demotivate) Students. **Journal of Experimental Social Psychology**, 48(3): 731-737

Rattan, A., Savani, K., Naidu, N., Dweck, C. (2012) Can Everyone Become Highly Intelligent? Cultural Differences in and Societal Consequences of Beliefs about the Universal Potential for Intelligence, **Journal of Personality and Social Psychology**, 103(5): 787–803

Raudenbush, S. (1984) Magnitude of Teacher Expectancy Effects on Pupil IQ as a Function of the Credibility of Expectancy of Induction: A Synthesis of Findings from 18 Experiments. **Journal of Educational Psychology**. 76: 85–97

Reid, M.E., Clunies-Ross, L.R., Goachier, B. and Vile, D. (1982) **Mixed Ability Teaching: Problems and Possibilities**. Windsor: NFER-Nelson.

Robson, C. (1993) **Real World Research: A Resource for Social Scientists and Practitioner-Researchers**. Oxford: Blackwell.

Robson, C. (2011) **Real World Research: A Resource for Users of Social Research Methods in Applied Settings.** Chichester: Wiley

Rosenthal, R., and Jacobson, L. (1968) **Pygmalion in the Classroom: Teacher Expectation and Pupils' Intellectual Development.** New York**:** Rinehart and Winston.

Rudduck, J., Chaplain, R., and Wallace, G. (1996) **School Improvement: What Can Pupils Tell Us?** London: David Fulton

Sackett, G. P. (Ed.) (1978) **Observing Behavior: Theory and Applications in Mental Retardation** (Vol. 1) University Park Press.

Sale, J. E., Lohfeld, L. H., and Brazil, K. (2002) Revisiting the Quantitative-Qualitative Debate: Implications for Mixed-Methods Research. **Quality and Quantity**, 36(1): 43-53

Schwartz, F. (1981) Supporting or subverting learning: peer groups patterns in four tracked schools, **Anthropology and Education Quarterly**, 12: 99-121

Sierpinska, A. (1994) **Understanding in Mathematics**. London: Falmer.

Slavin, R.E. (1990) Achievement Effects of Ability Groupingin Secondary Schools: A Best Evidence Synthesis. **Review of Educational Research**. 60: 471-490.

Slavin, R.E. (1996) **Education for All**. Lisse: Swets and Zeitlinger.

Skemp, R. (1976) Relational Understanding and Instrumental Understanding, **Mathematics Teaching**, 77: 20-26

Spencer, H. (1878) **Education: Intellectual, Moral and Physical**. Williams and Norgate, London.

Stevenson, H.W., and Stigler, J.W. (1992) **The Learning Gap: Why Our Schools are Failing and What We Can Learn from Japanese and Chinese Education**. New York: Summit Books.

Stigler, J. W. (1999) **The TIMSS Videotape Classroom Study: Methods and Findings from an Exploratory Research Paoject on Eighth-grade Mathematics Instruction in Germany, Japan, and the United States.** Washington: DIANE Publishing.

Stigler, J. W., and Hiebert, J. (2009) **The Teaching Gap: Best Ideas from the World's Teachers for Improving Education in the Classroom.** New York: Simon and Schuster.

Sukhnandan, L. and Lee, B. (1998) **Streaming, Setting and Grouping by Ability: A Review of the Literature**. Slough: National Foundation for Educational Research.

Swan, M. (2005) **Standards Unit- Improving learning in mathematics: Challenges and Strategies.** DfES http://www.lancsngfl.ac.uk/secondary/math/download/file/PDF/Standards%20Unit%20-%20Improving%20learning%20in%20mathematics.PDF [Accessed: 20th July 2014]

Swan, M. (2006**) Collaborative Learning In Mathematics: A Challenge to our Beliefs and Practices.** London: NRDC

Stewart, W. (2013), "Streaming is Out, Now you can go with the Flow",*Times Educational Supplement* [online] Available from http://www.tes.co.uk/article.aspx?storycode=6329982 [Accessed 20th February 2014]

Terwel, J. (2005) Curriculum differentiation: multiple perspectives and developments in education. **Journal of Curriculum Studies**, 37**:** 653-70

Thom, R. (1973) "Modern Mathematics: Does it Exist?" In Howson, A.G. (ed.) **Developments in Mathematical Education**, Cambridge: CUP. pp.195-209

Thompson, A. G. (1984) The Relationship of Teachers' Conceptions of Mathematics and Mathematics Teaching to Instructional Practice. **Educational Studies in Mathematics**, 15(2): 105-127.

Thompson, A. (1992) "Teachers' beliefs and conceptions: A synthesis of the research." In Grouws, A.(Ed.), **Handbook of Research on Mathematics Learning and Teaching.** New York: Macmillan. pp. 127–146

Tomlinson, S. (1987) "Curriculum option choices in multi-ethnic schools". In Troyna, B. (Ed.) **Racial Inequality in Education**. London, Tavistock.

Vaughn, V. L., Feldhusen, J. F., and Asher, J. W. (1991) Meta-Analyses and Review of Research on Pull-Out Programs in Gifted Education. **Gifted Child Quarterly**, 35(2): 92-98.

Watson, A., de Geest, E. and Prestage, S., (2003) **Deep Progress in Mathematics: Improving Attainment in Mathematics**, Oxford: Open University Press

Webb, E., Campbell, D., Schwartz, R., and Sechrest, L. (1966) **Unobtrusive measures: Non-reactive Research in the Social Sciences**. Thousand Oaks: SAGE

Wells, G. L., & Olson, E. A. (2003) Eyewitness testimony. **Annual Review of Psychology**, 54(1): 277-295.

White, P. (2009) **Developing Research Questions: a Guide for Social Scientists**. Basingstoke: Palgrave and Macmillan.

Wickström, G., & Bendix, T. (2000) The" Hawthorne effect"—what did the original Hawthorne studies actually show? **Scandinavian Journal of Work, Environment & Health**. 26(4): 363-367.

Wigley, A. (1992) Models for Teaching Mathematics, **Mathematics Teaching**, 141: 4-7

Wilson, M. and Cooney, T. (2002) "Mathematics Teacher Change and Developments". <u>In</u> **Beliefs: A hidden variable in mathematics education?** Springer Netherlands. pp. 127-147

Wood, T. (1998) Alternative Patterns of Communication in Mathematics Classes: Funneling or Focusing. **Language and communication in the mathematics classroom.** Reston VA: National Council of Teachers of Mathematics. pp. 167-178.

Yeager, D. S., & Dweck, C. S. (2012) Mindsets that Promote Resilience: When Students Believe that Personal Characteristics Can Be Developed. **Educational Psychologist**. 47(4): 302-314.