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THE SUCCESSES AND LIMITATIONS OF RETRAINING NON-SPECIALIST TEACHERS TO TEACH MATHEMATICS

by

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AUTHOR'S DECLARATION

At no time during the registration for the degree of Doctor of Philosophy has the author been registered for any other University award without prior agreement of the Doctoral College Quality Sub-Committee.

Work submitted for this research degree at the University of Plymouth has not formed part of any other degree either at the University of Plymouth or at another establishment.

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Abstract

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THE SUCCESSES AND LIMITATIONS OF RETRAINING NON-SPECIALIST TEACHERS TO TEACH MATHEMATICS

Acknowledging that there are simply too few mathematics teachers, the UK government is investing significantly in retraining programmes to equip non-specialist teachers to teach mathematics. With the new more mathematically rigorous GCSE courses, and the expectation that most post-16 students will engage with some mathematics (studying for A and AS levels, a Core Maths qualification or re-taking GCSE) many more teachers of mathematics will be needed. The questions posed, explore whether retraining could provide an effective way for alleviating the problem of the lack of well qualified teachers for mathematics. This thesis reports on the unfolding stories of eight teachers, from the 2013-2014 cohort, retrained by way of the Plymouth University model with me as course tutor. In this four-year longitudinal study, the teachers were followed during their year of retraining and in the succeeding years. A methodological model is proposed, for conducting intrusive and intimate research, with the researcher at the heart of the study; this is largely based on grounded theory with a constant comparative approach linking data with data, and data with literature. Interviews and lesson observations provided the mainstays for data collection, and summary narratives for each teacher were weaved from the multifarious sources of data. The analysis of the data leads to a set of propositions suggested for the implementation of future retraining programmes.

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List of Abbreviations and Acronyms

APPG	All Party Parliamentary Group
BSRLM	British Society for Research into Learning Mathematics
CIMT	Centre for Innovation in Mathematics Teaching
CMSP	Core Maths Support Programme
CPD	Continuous Professional Development
DES	Department for Education and Science (1964 to 1992)
DfE	Department for Education (1992 to 1995 and 2010 to present)
DfEE	Department for Education and Employment (1995 to 2001)
DfES	Department for Education and Skills (2001 to 2007)
FMSP	Further Mathematics Support Programme
GCSE	General Certificate of Secondary Education
HMI	Her Majesty's Inspectorate of Schools
HOD	Head of Department
IFS	Institute for Fiscal Studies
ITT	Initial Teacher Training
JMC	Joint Mathematical Council
KS3	Key Stage 3
KS4	Key Stage 4
NAO	National Audit Office

NCETM	National Centre for Excellence in Teaching Mathematics (England)
NCSL	National College for School Leadership
NCTL	National College for Teaching and Leadership
NIP	Numicon in Practice
NQT	Newly Qualified Teacher
OECD	Organisation for Economic Co-operation and Development
OOF	Out Of Field Teaching
PCK	Pedagogic Content Knowledge
PD	Professional Development
PGCE	Postgraduate Certificate of Education
PISA	Programme for International Student Assessment
POST-ITT	Post-Initial Teacher Training
PRE-ITT	Pre-Initial Teacher Training
QTS	Qualified Teacher Status
RLS	Research Lesson Study
SCITT	School-Centred Initial Teacher Training
SKE	Subject Knowledge Enhancement
SKE+	Subject Knowledge Enhancement Plus
TALIS	The Teaching and Learning International Study
TAM	Teaching Advanced Mathematics
TAS	Teaching Across Specialisations
TDA	Teacher Development Agency
TGM	Teaching GCSE Mathematics

TIMSS	Trends in International Mathematics and Science Study
TOOF	Teaching Out Of Field
TSST	Teacher Subject Specialism Training

Chapter 1: An Introduction to the Research

1.0 My Ontological and Epistemological Stance

> *'What a wise parent would desire for his own children, that a nation, in so far as it is wise, must desire for all children.' (Tawney, 1931, Equality).*

Inevitably my prior experiences will play a significant role in how I shape and frame my research. My own personal beliefs were kindled many years ago, and are deeply held and often political. These beliefs, stemming from my life experiences, together with my way of being in the world (my constructed reality) constitute my ontological position. The story of how this position developed, my epistemology, is illustrated below.

I grew up in a northern town during the 1980's. Two miners' strikes coloured the political and literal landscape of the time. The 'Billy Elliott' story (Billy Elliot, 2000) brilliantly captures this time and space of County Durham in the 1980's and vividly paints the picture of my adolescent era. As I started secondary school, the school itself entered its second year as a brave new Comprehensive School; previously it had been a Secondary Modern School. Academic aspirations and opportunities had historically been low for the students of this school, the mines and steelworks being the future for many. The school was now split, with the upper school still in 'Secondary Modern' mode, and the lower school as 'Comprehensive'. The school's approach to managing this new system was to continue to segregate students using 'streaming'; the top two streams equivalent to the old grammar school intake, and the rest the old secondary modern. No mixing between the top two streams and the 'rest' ever took place in the classrooms or on the sports field.

From an early age, mathematics was my strength at school. My primary head teacher had believed it was mathematics above all else that was significant. Reading, writing and spelling could wait, it was the mathematics that was critical. Perhaps my primary head teacher had been enlightened: the government press release (GOV.UK 2014d: 1) highlights research by the Institute for Fiscal Studies (IFS) showing ‘children with high mathematics scores at age 10 earn 7.3 per cent more at age 30 than others, even after pupil characteristics and later qualifications are controlled for’. Reading skills at age 10 also attract a premium, but not as significant as that for mathematics.

As I moved into secondary school, I moved into the top mathematics set. ‘Sets’ are class groups based on prior attainment. Typical for the times, the ‘best’ teachers taught the top sets. What ‘best’ actually means is a debate academics have continued throughout the decades. Children, on the other hand, usually have very clear ideas and ‘know it’ when they ‘see it’ (Fenstermacher and Richardson 2000: 2). In more recent times it has been more typical for the ‘best’ teachers to be allocated to the C/D borderline classes, a legacy of the league table era which reported on 5 A* to C grades. Since 2016, Progress 8 (GOV.UK 2014a) has replaced the 5 A* to C measure. Progress 8 takes into account progress made by all pupils and so attempts to be a far more equitable measure of student progress and therefore school performance.

In English schools, it is now common to group children into sets from a very young age. Boaler (2009) believes we do something ‘very cruel to children in maths classrooms, that sets us apart from just about every other country in the world. We tell children from a very young age, that they are no good at maths’ (2009: 95). Boaler (2000) describes research in England which found that 88% of children who were placed in ability groups at age 4, remain in the same ability groupings at age 16. By contrast, Finland do not set or stream their students until the age of 16, believing it to be unequitable to do so (OECD 2010a).

Setting or streaming students for mathematics can have far reaching consequences beyond the boundaries of the classroom. The high esteem in which our society holds mathematics, means it is a high stakes subject. Being in a 'low' set for mathematics can assign a label to a child which can impinge their self-esteem and ironically their self-efficacy (Boaler et al 2000, Boaler 2009, Ireson et al 1999, William and Bartholomew 2001). Mathematics teachers deployed to teach 'low' sets need be amongst the most highly skilled practitioners, to avoid crushing confidence further and to help students make the 'substantial gains' required to make progress and close the gap with their peers (McKinsey 2007: 14). However, as highlighted in the Made to Measure report (Ofsted 2012: 9), it is common practice for weaker teachers to be deployed to teach 'lower sets or younger pupils'. This is likely to continue as 'less experienced, temporary and non-specialist teachers' are 'unlikely to have the subject knowledge to teach higher-attaining sets' (Ofsted 2012: 66). Senior leaders appear to accept, perhaps too readily, 'that ground would need to be made up in the future' as the learning for younger and lower-attaining pupils 'was affected by weaker teaching' (Ofsted 2012: 66). It can be argued that this 'ground' is never recovered and the gap between the higher and lower attainers simply stretches ever wider (Marshall 2013). The McKinsey (2007: 14) report confirms this to be so, with students placed with the 'worst teachers' regressing, the students actually get 'worse', and so the gap in mathematics attainment grows larger.

Back in the mining town in the 1980's and I was in the 'best' mathematics class with the 'best' mathematics teacher. *And* he was an exceptionally good teacher.

Even today when I think of qualities that may encapsulate an effective teacher, Mr. Stacey springs to mind. He knew his stuff and he had good classroom management skills (perhaps not particularly challenged with a top set) but it was much more than that: He liked us, he liked teaching us. His humour and warmth were obvious even to unworldly 12 year olds. He believed in us and elicited loyalty from us. We were engaged and motivated and we wanted to do well for him as well as for ourselves. We were challenged by the mathematics and had to work (and think) hard; it was a satisfying experience. This was not procedural or clerical mathematics and it was not discovery mathematics. As a whole class we were taught the content and then expected to use what we had been taught to solve the exam style problems. Early entry for ‘O’ level mathematics led to success for the whole class. He continued to teach us and success for all, in ‘O’ level Statistics, followed a year later. For a school that had so recently been a secondary modern, this was a huge success story.

As Maya Angelou (2014) once said: ‘people will forget what you said, people will forget what you did, but people will never forget how you made them feel’; and I remember how Mr. Stacey made us all *feel good* about mathematics. There is no doubt that Mr. Stacey, as an effective and knowledgeable mathematics teacher, made a significant and meaningful difference to my future outcomes and my life chances. His passion and love for the subject, and for teaching, remain a powerful influence on me and on my professional life.

Since my own school days, and becoming a mathematics teacher myself, I have developed strong views about education. I believe absolutely and completely in ‘comprehensive’ education but comprehensive in the truest form, where all children can mix regardless of their prior attainment. In my view, testing children at age 10 or 11, in order to segregate them into different schools and so determine their future, is brutal, bordering on the cruel. Boaler (2000) believes likewise. Summerhill, the iconic and original free school, shares a similar philosophy: ‘It seems to be a modern trend that assessment and qualification define education. If society were to treat any other group of people the way it treats its children, it would be considered a violation of human rights’ (Summerhill, 2017).

As a mathematics teacher and educator for over 20 years I have witnessed much teaching and learning, in a variety of contexts. As a Head of Department and Senior Teacher I have been involved with recruiting and retaining teachers. Now as a lecturer - and in a landscape with a shortage of mathematics specialist teachers - I am ‘retraining’ non-specialist teachers to teach mathematics. Skilled and effective mathematics teachers are a valuable and scarce resource; they are a resource schools are keen to secure.

1.1 An Overview of the Research

> *‘Schools report significant challenges recruiting skilled mathematics teachers.’ (Smith 2017b)*

How to provide enough *effective* teachers of mathematics in our schools and colleges has long been a dilemma. Smith identified the shortfall in his 2004 report, Making Mathematics Count, where he described the shortage of qualified mathematics teachers as the most serious obstacle in ‘ensuring the future supply of sufficient young people with appropriate mathematical skills’ (2004: 4). The government’s Building our Industrial Strategy green paper (HM Government 2017: 40) highlights the continuing skills shortage and states steps will need to be taken to ‘improve basic mathematics provision’.

Many elements have now combined to exacerbate the shortage of teachers and deepen the dilemma, creating a ‘perfect storm’:

. The improving economy has led to more options for mathematics graduates; teaching may appear less attractive, particularly from a financial perspective.
. Student numbers in secondary schools are rising with the demographic bubble.
. Higher demands in teaching time required for the new, more rigorous, mathematics GCSE, introduced in 2015.
. The requirement for significant numbers of post-16 students to re-take mathematics GCSE or study Functional Skills, following the Wolf report (GOV.UK 2011a).
. Greater numbers of students opting to study A level mathematics.
. The introduction of the new post-16 Core Maths qualification in 2014 (GOV.UK 2014e).
. The as yet unknown implications of Brexit on teacher numbers.

This ‘storm’ has now been confirmed by the National Audit Office (NAO 2016) who, in 2016, reported on the Department for Education’s (DfE) missed trainee recruitment targets for mathematics for the previous four years. The shortages in recruiting mathematics teachers is compounded by the fact that mathematics teachers are amongst the group most likely to prematurely leave the profession (NAO 2016). According to Jane Jones (2016), the current HMI, this shortage of mathematics teachers means around 30% of mathematics lessons are taught by teachers without a relevant degree. For the shortage crisis to be resolved, and for the DfE to meet its recruitment targets, teaching would need to attract one in every five of all mathematics graduates (Smith 2017a). Smith (2017b) confirms the Government has now acknowledged that mathematics teacher supply is never going to be resolved (by traditional routes) and that alternative approaches need to be sought; unlike a storm, the current ‘shortage’ situation will not simply resolve itself. Recognising this, the government has introduced a number of initiatives, including professional development programmes to retrain teachers from other specialisms to teach shortage subjects (GOV.UK 2016b).

The focus of this research is to consider the impact of one of these government funded retraining programmes (supported by Plymouth University) on a group of teachers, amidst a national shortage of effective teachers.

My *motivation* for this research can be seen to be stemming from my own school days, discussed in 1.0. Mathematics teachers make a difference. Effective mathematics teachers can enhance life opportunities and impact on ‘future success’ (Coe *et al* 2014: 2). The drive to provide more effective mathematics teachers is a serious one. With more effective mathematics teachers we can make real and lasting differences to the future outcomes of our future generations. Given the very real difference effective teachers can make to individuals and to society, economically as well as culturally (Cockcroft 1982, Smith 2004, Smith 2017b) there is little wonder that countries are seeking the best way to boost their numbers.

My *opportunity* for conducting this research arose from my position as course tutor on the retraining programme, supported by Plymouth University. From this privileged position I have been able to follow eight retrained teachers over a period of 4 years. I acknowledge, that as course tutor for the retraining programme involved in this study, I am also at the heart of this research. I am delving deeply into what I do: I retrain the teachers and I am researching the retrained teachers. The question of whether I am researching, and therefore evaluating, my own teaching practice is a reasonable one. To a certain extent this could be considered to be the case. But, as is explored in Chapter 2, the teaching element can only ever be one part of a retraining experience (Fenstermacher and Richardson 2000). Other factors and circumstances must be aligned and functioning for quality professional development to be established. These other factors and circumstances, including support systems and context, will figure prominently in the research.

In essence, this research is an explorative, longitudinal study over 4 years, following the progress of eight teachers who have been retrained by way of a particular model of mathematics professional development. Encompassing over 50 lesson observations, numerous interviews, and questionnniares - the research centres on whether any illuminating themes will emerge; and whether retraining teachers appears to be a reasonable option for filling the gap between supply and demand for effective teachers of mathematics in secondary and tertiary education.

The literature search, documented in Chapter 2, explores a range of subjects. The rationale for their selection was threefold: the backdrop to the research invoked an exploration of issues surrounding the shortage of effective mathematics teachers, a consideration of 'effectiveness', and the concept of non-specialist teachers; the ethos of the retraining programme suggested an in-depth exploration of subject and pedagogical content knowledge; the participants' perspectives prioritized consideration of classroom observations, mentoring and coaching, collaborative practice and context and culture. (The nature of the methodology determined that the literature search to be an iterative, fluid and dynamic process.)

Chapter 3 takes a closer look at the retraining opportunities for non-specialist teachers to teach mathematics. Chapter 4 introduces the research questions and considers the methodology and methods employed throughout this study. The stories emanating from the eight participants are captured in Chapter 5, and are analysed in Chapter 6. The final chapter, Chapter 7, draws together the findings and outlines suggested propositions in the light of this research.

Chapter 2: The Literature Review

2.0 Introduction

This literature review commences with a consideration of the shortage of specialist mathematics teachers in England. With the acknowledgement that the government is seeking greater numbers of effective practitioners by way of retraining, there is a detailed exploration of what is considered to be *effective* mathematics teaching; this, in absence of a globally agreed definition. A reflection on how to promote effective practice, and a consideration of the issues surrounding non-specialist teachers of mathematics, then follow.

2.1 Shortage of Specialist Mathematics Teachers in England

One of the key problems to be solved in the mathematics education in England, is that demand for specialist mathematics teachers is far in excess of the supply (Smith 2004, Smith 2017b). Howson (2002) points out there is a clear distinction between *qualified mathematics teachers* and *teachers who teach mathematics*; and these two distinct sets of teachers can be seen to be described as *specialist* and *non-specialist*, with specialist teachers better equipped to be, or become, more *effective* practitioners (Cockcroft 1982). As to what constitutes being appropriately qualified, Smith (2004) suggests the consensus view is well captured by the categories adopted in the Cockroft (1982) report. These are listed in Table 2.1.

Good	Trained graduates, or equivalent, with mathematics as the first, main or only subject of a degree course. Bachelors of Education (BEd) with mathematics as a main specialist subject. Teachers whose general qualifications were of either of these types with mathematics as a subsidiary subject provided their main specialism was in a related subject, such as computer studies, physics or engineering.
Acceptable	Trained graduates, graduate equivalents, or BEd with mathematics as a second or subsidiary specialism if their first subject was not related. Untrained graduates with mathematics as first, main or only subject. Teachers holding the Certificate in Education, having followed a secondary course in which mathematics was their first, main or only specialism. Teachers with no initial mathematical qualifications who had a further qualification resulting from a course of at least one year in which mathematics was the main subject.
Weak	Teachers holding the Certificate in Education, having followed a secondary course with mathematics as a second or subsidiary subject, provided their first or main subject was related. Teachers holding the Certificate in Education having followed a Junior or Junior /Secondary course with mathematics as their first or main subject. Teachers in the immediately preceding category with subsidiary mathematics, provided their main subject was related. Graduates in any subject provided their course included a related subject.
Nil	Qualified teachers without any recorded mathematics (qualifications) and not covered by any previous specification. Teachers holding the Certificate in Education with mathematics subsidiary to an unrelated subject. Teachers without any initial qualification possessing a further qualification which did not lead to graduate status and in which mathematics was not the main subject.

Table 2.1 Categories of Qualifications of Teachers Used in the Cockcroft Report (1982)

Smith (2004) added to the categories of good or acceptable qualifications, those who had undertaken the pre-ITT Mathematics Enhancement Courses (MEC) being piloted at the time; MEC was designed to boost subject knowledge prior to a teacher training qualification. These categories may currently seem somewhat outdated with, now, numerous routes into teaching including school-based teacher training models (such as SCITT's (School-Centred Initial Teacher Training)). Teachers operating within academies no longer even need QTS (Qualified Teacher Status).

In general, Howson (2002) argues for specialist teachers of mathematics at secondary or tertiary level, to have degrees in mathematics or a least a mathematically related subject. Howson (2002) acknowledges that teachers without the best qualifications can be effective and indeed outstanding; likewise, teachers with the highest qualifications maybe ineffective and poor practitioners. Nevertheless, he uses the words of a 1912 Staff Inspector for Mathematics to succinctly stress the point:

> 'The efficiency of teachers [cannot]… be measured by… academic qualifications. None the less when the question is not of an individual or of a small group, but of a large number, it remains true that the lack of good qualifications must seriously limit the efficiency of teaching.'
>
> (cited in Howson 2002: 81)

Slater et al (2009) found that 'teacher effectiveness is not closely related to observable teacher characteristics such as teaching qualifications' (2009: 637), supporting the findings of others (in particular Kane et al, 2007). In fact, Slater et al (2009) found from the 'few observable teacher characteristics' that they were able to correlate with estimated teaching effectiveness (for example, gender, age, education), only 'very low levels of experience' was statistically significant in explaining 'teacher effectiveness' (2009: 642). Clotfelter et al (2007), on the other hand, report that teacher qualifications *do* have a significant impact on effectiveness, and that this is particularly so for mathematics. This reflects the findings that teachers' subject knowledge for mathematics teaching is 'more strongly linked to variations in student outcomes, than in some other subjects' (Ingram et al 2018: 10, Hill et al 2008).

Section 2.2 takes a closer look at what effective mathematics teaching might entail, and the relationship between subject knowledge and teacher effectiveness is addressed in section 2.31. Primarily, it may be helpful to define the term 'effective' using Campbell *et al*'s (2004) definition, which is more closely aligned to 'efficacy': Teacher effectiveness is 'the power to realise socially valued objectives agreed for teachers' work, especially, but not exclusively, the work concerned with enabling students to learn' (2004: 4).

The shortage of specialist teachers is now recognised by the government and they are 'working strategically to overcome maths shortages' (Watterson 2015, TSST launch meeting). Where once policy-makers were solely committed to the idea of teacher flow within the profession (the 'flow in', sufficiently replacing the 'flow out'), now there is recognition that this is an inadequate supply chain. The shortage of effective teachers is particularly prevalent for mathematics and it appears a specifically stubborn problem; listed in Table 2.2, are some key reasons as to why this may be so.

•	Where once the majority of mathematics graduates entered the teaching profession, this is now not the case (in 1938 over 75% of mathematics graduates did so (Howson 2002)). Mathematics graduates simply have more options than most. And as Smith (2004) points out, many of these options are 'perceived as considerably more attractive than teaching' (Smith 2004: 5).
•	There are simply too few graduates of mathematics; the 'graduate output in those subjects is too low' (Smithers and Robinson 2013: 50).
•	With too few mathematics graduates choosing to enter the profession, competition is minimal; Mathematics graduates entering the teaching profession are less well qualified than their counterparts in other subjects. In subjects where there is more competition to enter the profession, teachers hold significantly higher qualifications. For example, 83% of trainee History teachers have a 2:1 or above; this compares with 51% for mathematics (Smithers and Robinson 2013).
•	Potentially there is a dichotomy between personality-types most attracted to teaching and personality-types most attracted to studying subjects such as mathematics and physics (Porkess *et al* 2011, Smithers and Robinson 2013).
•	A lack of subject specialist teachers in formative (primary) years in England create the conditions for future shortfalls of mathematics graduates. Other countries do otherwise and Finland and South Korea, for example, where graduate output is sufficient, build from the bottom with subject specialist primary school teachers (Smithers and Robinson 2013). The Williams (2008) review recommended that 'there should be at least one mathematics specialist in each primary school' in England (2008: 4), but this has not been endorsed or enacted. Children's mathematics is often below standard when they move to secondary school (Porkess *et al* 2011).

Table 2.2 Key Reasons for the Shortage of Effective Mathematics Teachers

From the recent Smith report (2017b), it is clear that schools are reporting 'significant challenges' in recruiting skilled mathematics teachers (2017b: 10). The demand for specialist mathematics teachers is continuing to grow (as outlined on page 6). This demand for mathematics specialist teachers must compete with the demands of the, often more lucrative, labour market - both drawing from a 'relatively small graduate pool' (Smith 2017b: 10). This problem is not new and Howson (2002) describes the insufficiency of well-qualified mathematics teaches as a problem that, 'for several decades, governments have chosen to ignore' (2002: 76).

The report 'Preparing Teachers and Developing School leaders for the 21st Century, Lessons from Around the World' (Schleicher 2012) places the UK in a group of The Organisation for Economic Co-operation and Development (OECD) countries with above average shortages of mathematics teachers. The report uses data collected from the 2009 PISA (Programme for International Student Assessment) questionnaires which asked head teachers to comment on whether their school's capacity to deliver mathematics was hindered by the lack of specialist teachers. This perceived shortage places the UK (with a score of 26% for mathematics shortages) as 10th highest (experiencing shortages) amongst the 33 participating OECD countries. For comparison purposes, countries well documented for their success in mathematics education, Finland and Japan for example, score 2.5% and 4.0% respectively on this shortage of mathematics teachers scale.

Surprisingly, mathematics was not on the list of red alert subjects highlighted by Howson (2017) at the All-Party Parliamentary Group (APPG) in March 2017. These alert lists are compiled using a teacher-supply model based on advertised vacancies. However, as schools look for alternative approaches to costly advertising, Howson (2017) believes that this teacher-supply model may now be defunct: ‘vacancies are a poor indicator of teacher demand’ (White et al, 2006). School-based teacher training models provide the potential for host schools to recruit their own trainees without the need to advertise. The privilege of immediate access to trainee teachers, afforded to these schools, has a direct impact on all remaining schools who must now draw their new recruits from a significantly reduced pool. The imbalance and inequity between schools eligible to host training (with Ofsted inspections of ‘good’ or ‘outstanding’) and the ‘rest’ may thus be perpetuated and potentially exaggerated - better schools able to recruit specialist teachers, the ‘rest’ struggling to do so.

With a growing crisis widely acknowledged, Smith (2004) reported: ‘we have a serious shortage of specialist mathematics teachers in schools and colleges’ (2004: v). The following section considers the implications of such teacher shortages.

2.1.1 What is the Impact of Mathematics Teacher Shortages?

The Smith inquiry (2004) stated that the shortage of specialist mathematics teachers is the most serious problem we face in ensuring the future supply of sufficient young people with appropriate mathematical skills. This shortfall has been accentuated in recent years by the increased demands on mathematics provision (see page 6). Sobering observations concerning the shortfall, were listed by Ofsted in the ‘Mathematics: Made to Measure’ report (Ofsted 2012: 4-10) and are outlined in Table 2.2:

• Too many pupils who have a poor start or fall behind early in their mathematics education never catch up. The 10% that do not reach the expected standards at age 7 doubles to 20% by age 11 and nearly doubles again by 16
• Improving the consistency and quality of teaching within a school is crucial if all pupils, rather than some, are to make sustained good progress
• Less experienced, temporary and non-specialist teachers were more likely to teach lower sets or younger pupils
• By age 16 many young people fear and have little understanding of mathematics
• Few students do any mathematics in post-16 education
• Most young people at age 18 do not have enough mathematics for the next phase of their lives
• Companies are unable to recruit people with the mathematical skills they need to compete in the global market place and will move their operations to countries where those skills are available

Table 2.3 Observations Regarding the Shortage of Mathematics Teachers (Ofsted 2012)

With a shortage of specialist mathematics teachers, many of our secondary school students are being taught by teachers ‘whose own knowledge of the subject is uncertain’ (Porkess *et al* 2011: 82). And for Porkess *et al*, teachers ‘are absolutely key in determining whether a young person succeeds or fails in mathematics’ (2011: 82). The McKinsey report (2007) highlights that the only way to improve student outcomes is to improve teaching instruction: ‘students placed with top performing maths teachers made substantial gains, while students placed with the worst teachers regressed - they got worse’ (Mckinsey 2007:14). This is reiterated by Schleicher (2012): ‘Ineffective teachers, who remain in post without any professional development opportunities, create adverse consequences for student learning, the reputation of schools and the teaching profession’ (2012: 20).

In England with ‘the least well-qualified to teach mathematics’ typically deployed to teach the ‘bottom sets’ (William and Bartholomew 2001: 285, Ofsted 2012, Howson 2002, Smith 2004), lower-attainers are more likely to ‘face…poorer teachers' (Marks 2012: 58, Kelly 2004). In contrast, 'top sets tended to be allocated well-qualified teachers' (William and Bartholomew, 2001: 285). Ofsted (GOV.UK 2018b) has recently highlighted the need to consider the impact of non-specialist teachers; secondary schools have been directed to evaluate and tackle any inconsistencies in the quality of mathematics teaching between different groups of pupils, 'including those taught by non-specialist teachers of mathematics' (GOV.UK 2018b: 52).

Smith (2017b) highlights that the poor outcomes of post-16 GCSE re-take students is often a symptom of previous fundamental issues with mathematics teaching. This reflects the observation by Ofsted (2012) that lower attaining students have often previously experienced the weakest teaching. Smith (2017b) also suggests many students with *good* GCSE mathematics grades fail to continue with the subject post-16, having been uninspired by earlier stages of mathematics teaching.

Beyond the immediate impact of teacher shortages in secondary and tertiary classrooms, lack of specialists can impact further up the education chain. Universities and employers have long bemoaned the lack of mathematical skills amongst its entrants. The new Core Maths qualification (GOV.UK 2014e) was designed, in part, to alleviate the concerns of future employers and higher education providers – providing an alternative opportunity for continued mathematics education post-16. However, here-in lies another problem: More mathematics teachers are required to teach the new qualification. Currently opting out of mathematics, post-16, is still commonplace, and with the ongoing expansion of university places following the Robbins principle (Robbins 1963), there are ever growing numbers of undergraduates with inadequate mathematical skills: ‘England has more university students with weak numeracy skills than most other countries’ (OECD 2016a). Smith reiterated this recently: ‘Many students are inappropriately prepared for the mathematics in their university courses’ (Smith 2017b: 33). These students are seeking support from their universities, and undergraduate mathematics support groups are now customary (Pell and Croft 2008).

Recruiting and retaining high quality specialist teachers is a challenge for many education systems around the world. In England, a shortage of specialist mathematics teachers inevitably leads to some teachers being required to teach outside their field of expertise (This is explored in more detail in section 2.4.). It is also common for the entry requirements for the profession to be lowered for mathematics trainee teachers (Smithers and Robinson 2013), and it is now not unusual for mathematics teachers in England to be expected to teach larger classes and a greater number of classes. Even if no classrooms are left without a teacher, these solutions to the shortage problem ‘compromise the quality of teaching and learning’ (Schleicher 2012: 56).

2.1.2 What Other Countries Do Differently

'*Above all, the top performing systems demonstrate that the quality of an education system depends ultimately on the quality of its teachers.'* (McKinsey 2007: 23)

Characteristics of countries with strong mathematics teacher workforce
• Teaching is a high status profession
• The working conditions are good
• There are sufficient mathematics graduates
• They have good planning and monitoring models
• They are able to carefully select trainees
• They have effective teacher preparation programmes
• The qualifications are respected
• There is systematic professional development throughout the career in education

Table 2.4 Characteristics of Countries with Strong Mathematics Teacher Workforces

The main difference between countries that have a strong teaching workforce in mathematics (Finland, Japan and South Korea) and those with persistent shortages including England, Australia, and the Netherlands, is that in the former, teaching is a high status profession (Smithers and Robinson 2013). In theory countries with above average shortages would be able to emulate those countries with below average mathematics teacher shortages and adopt similar strategies to raise the status of teaching, such as: promoting good working conditions with attractive pay; the recruitment of high caliber trainees and investing in professional development. Indeed, England has tinkered with, and trialed many approaches to achieve exactly this aim: the recent coalition government aimed to enhance status by raising entry requirements (GOV.UK 2012), offered generous bursaries to those with the highest qualifications and have expanded the Teach First initiative (which recruits highly qualified graduates from prestigious universities). And in fact, the success of the Teach First programme can be explained exactly because it is perceived to have higher status compared with other routes into teaching (Smithers and Robinson 2013). But raising the bar for general entry to the profession, in an attempt to raise the caliber of recruits, may be a risky line to pursue. Annual recruitment targets for trainee mathematics teachers in England have been repeatedly missed (National Audit Office 2016); raising entry requirements could further reduce the pool of potential applicants. The question becomes one of ‘chicken-and-egg’: Which comes first? An attempt to improve the status of teaching by raising the entry requirements and so by strengthen the appeal for high-flying graduates wishing to pursue a ‘professional’ path. Or enhance the appeal of the profession and thereby create demand and competition, and so by afford the opportunity to cherry-pick applicants with the highest entry qualifications. Either way, in countries where teaching does command high status, plenty of applicants are attracted to the profession thereby making it difficult to enter, and the difficulty of entry preserves and enhances the status. The converse can also be seen to be true with teacher shortages leading to lower standards for entry, producing lowered confidence in the profession (Smithers and Robinson 2013, Wiliam 2016).

Boosting teacher salaries may be a solution to enhancing status and appeal of the profession (Smithers and Robinson 2013). One example, Japan, now recognized as an educationally successful country, raised teacher salaries by 30% following World War II (Smithers and Robinson 2013). Undoubtedly cultures and history play a significant part in the success or otherwise, of recruiting mathematics teachers and it may not be as simple as emulating other's ideas. Nevertheless, Finland and South Korea are culturally very different and both enjoy a good supply of mathematics teachers; Meyer and Schiller (2013) characterize the culture of Finland as egalitarian and individualistic and that of South Korea as collectivist and paternalistic. One shared similarity in the education context, however, is in the hours taught. Typical of all 'countries with strong teacher workforces' the hours taught by teachers are fewer than in other countries (Smithers and Robinson 2013: 20). Teachers in Finland, Korea and Japan, for example, all teach around 550 hours per year, whilst teachers in some other countries teach well over 1000 hours per year (for example, Mexico and Chile). Teachers in England teach over 800 hours per year; this is above the OECD average of around 700 hours (OECD 2017).

Teaching in Finland has traditionally been a respected profession, but the Teacher Education Reform Act of 1979 enhanced its status further (OECD 2010). This act transferred teacher preparation from teacher colleges to universities and rigorously overhauled the basic qualification, transforming it into a master's degree. Appealing to the highest attaining graduates, competition for teaching became even more intense (OECD 2010a, Smithers and Robinson 2013). In South Korea, teaching is also very popular with teachers enjoying good working conditions and high esteem (Smithers and Robinson 2013). With a tradeoff of large class sizes for fewer teaching hours, South Korea requires fewer teachers per capita and so can afford to pay their teachers more generously than most OECD countries (OECD 2017).

Alongside issues of recruitment, retention of teachers is another significant issue in England. Attracting qualified graduates into the profession demands much attention, but keeping them there should command equal focus (Parliament. House of Commons Education Committee 2017, Worth and De Lazzari 2017). Berliner (2004) suggests that it takes somewhere between 5 and 7 years for a teacher to acquire high levels of skill (2004: 14). In England we lose around 50% of our mathematics teachers within 5 years of them being trained (Worth and De Lazzari 2017). Before time and experience can shape effective practitioners, many teachers have chosen to leave the profession - another cohort of teachers needing to be trained to take their place.

Opportunities for ongoing professional development can be seen to play a significant role in retention. In countries with a strong mathematics workforce, 'there is systematic professional development throughout the career in education' (Smithers and Robinson 2013). Singapore, for example, recognises the need for their teachers to keep up with a rapidly changing world and provides teachers with an entitlement of '100 hours' of professional development each year (Schleicher 2012: 60). In a number of successful education systems, notably Japan and Finland, teachers collaborate and plan together, observe each other's lessons and provide constructive developmental feedback. Within a system which promotes a collaborative culture, teachers are encouraged to continuously develop (McKinsey 2007).

Finland and South Korea have shown that 'sea change' in education policy is possible (in a relatively short period of time of 30-40 years); providing inspiration for other policy makers around the world, including England. Wiliam (2016) however, warns about 'policy tourism' (2016: 23) suggesting any attempt to base our own education system on any particular imported features from more successful countries is seriously flawed. Wiliam (2016) argues there are two ‘fundamental flaws’ (2016: 21); the first being we may not import the right features, and the second, even if we did, we cannot assume the ‘same thing would work in the same way’ in another country or context (2016: 21). Chung (2010) also cautions against transposing policy directly from Finland but suggests at least two pointers worth pursuing:

- find ways to make teaching mathematics sufficiently attractive that recruitment can be highly selective
- ensure that there are mathematics specialist teachers in primary schools

The first of these points has been previously discussed (page 20). As for the second – this was a key recommendation following the Williams (2008) review, but is yet to be endorsed in England. Primary schools play a ‘critical role’ in providing all young people with the foundations for mathematical learning (Hodgen *et al* 2010: 3) and effective primary teaching requires strong mathematical understanding (Askew *et al* 1997, Hill *et al* 2005). And yet the majority of primary teachers in England do not even study mathematics beyond GCSE (Hodgen *et al* 2010) and have only the minimum pass (Grade C) at GCSE (Advisory Committee on Mathematics Education 2013). McKinsey (2007) highlights the negative impact of low-performing teachers to be most severe during the primary years of schooling, with ineffective teaching inflicting an ‘educational loss which is largely irreversible’ (2007: 12).

In the report, ‘Is the UK an outlier?’, Hodgen *et al* (2010) contrast the low participation rates of post-16 students studying mathematics in England with educational systems in many advanced economies. In England fewer than 20% of post-16 students study any mathematics (excluding GCSE re-takes); in 18 of the 24 countries involved in the study, post-16 participation rates exceeded 50%. And in countries such as Finland and Japan, 100% of students were expected to study mathematics post-16. The follow-up study, ‘Towards Universal Participation in post-16 mathematics’ (Hodgen *et al* 2013) recommends the introduction of a new qualification to provide a clear and attractive alternative to A level, for students to continue to study mathematics. The new Core Maths qualification commenced the following year in 2014, creating a further demand for effective mathematics teachers in schools (GOV.UK 2014e).

Other recent developments including the introduction of the more rigorous mathematics GCSE (as of 2015) and A level (as of 2017), and the requirement for ‘D’ grade (or grade 3) students to re-take their GSSE mathematics, reflect the government’s drive to raise students’ attainment levels in line with those of our international competitors. The PISA results (OECD 2018), often used to gauge progress, may suggest mathematics and literacy to be the most significant subjects in the curriculum. This is arguable. But in the next section, I set out why the need for effective teachers of mathematics is greater than for any other subject.

2.1.3 Why Mathematics Matters Most

The suggestion that the need for effective teachers in mathematics is greater than in any other subject will undoubtedly provoke controversy. Nevertheless, I will examine some considerations as to why this maybe so.

The explosion of available data, league tables and international comparisons (such as TIMSS and PISA) over the last few decades has seen increasing pressure on schools to ‘perform’ better. The narrow range of subjects held up for comparison puts significant focus on mathematics and literacy. Mathematics and literacy may not be more important than any other subject (Wiliam 2016, Smithers and Robinson 2013) but they are the subjects through which countries seek to compare themselves, and so attract intense international gaze. Typically, children are exposed to reading and the development of language both in and out of school. Mathematics, on the other hand, for the vast majority of children, is a subject to be mastered *only* at school. The teacher of mathematics and the mathematics lesson, therefore being the sole points of contact and connection to the subject, often the entire sphere of influence for a child’s mathematical experience (Wiliam 2016, Cockcroft 1982).

Cockcroft (1982) points out that ‘mathematics is not an easy subject to teach’ (1982: 215) but nevertheless there is ‘general acceptance that mathematics is an essential part of the curriculum’ (1982: 215). Cuoco *et al* (1996) also suggest mathematics to be essential as there is a genuine need to help students think more mathematically to empower them for the future which we cannot yet imagine. And the central role of mathematics within the curriculum has recently been enhanced by the new accountability measures, Progress 8, which double-weights the students’ performance in GCSE mathematics (GOV.UK 2014a). Schools have responded by increasing the ‘total curriculum hours’ for mathematics by 8% since 2011 (Worth and De Lazzari 2017: 7). This again, driving the demand for more mathematics teachers.

All students benefit from more effective mathematics teaching but the gains for the lower attaining or younger students are disproportionate, meaning that those students who need the most help stand to gain the most if placed with an effective mathematics teacher (Wiliam 2016, Marshall 2013). Aaronson et al (2007) and Slater et al (2009) also ‘find variations in teacher quality to be more important for low ability students’ (Slater et al, 2009: 642). By increasing the number of effective mathematics teachers in our schools, the achievement of all students will increase but more significantly the gaps in achievement between different sets of students can start to close (National College 2011, Porkess *et al* 2011, Wiliam 2016, Marshall 2013).

According to Anthony and Walshaw (2009), mathematics matters because it plays a central role in ‘shaping how individuals deal with the various spheres of private, social, and civil life’ (2009: 147). And as the subject of mathematics engenders such feelings of fear and negativity by so many, the need for expert practitioners - those that really care about the engagement of their students and who can foster inclusive and safe environments - may be more significant in mathematics than in any other field (Anthony and Walshaw 2009).

Smith (2017b) talks about the negative impact our society imposes upon the subject of mathematics, acknowledging the oft quoted observation that it is culturally acceptable for individuals to confess that they ‘can’t do maths’ (2017b: 81). And yet as a country, we also revere the subject of mathematics, believing such skills are essential for the health and wealth of the nation, necessary for us to successfully compete in a global economy (Building Our Industrial Strategy green paper, HM Government 2017). This weaving together of cultural influences is reflected by Bourdieu’s (2004) idea that mathematics education and society are ‘structurally interlocked’. Attaining a GCSE grade C (grade 4) in mathematics has ‘been constructed as the primary gatekeeper’ for ‘future educational and employment opportunities’ (Noyes 2009: 278). Every student (and parent) appreciates the significance of this mathematics ‘ticket’ (Sani 2010) - a ticket which the most affluent students are ‘over twice as likely to attain’ as the least affluent (Noyes 2009: 282). A clear ‘correlation between poverty and poor performance’ (Marshall 2013: 41) highlights this socio-economic influence on attainment, with ‘stark’ regional differences reflecting both attainment and post-16 mathematics participation (Smith 2017b: 12). A gender disparity, in post-16 mathematics participation, is also evident (Mendick 2005, 2008, Noyes 2009) and Smith (2017b) suggests this reflects ‘deep seated and enduring’ cultural attitudes toward mathematics (2017b: 81). Post-16 participation is currently skewed to a ‘clever core’ (Matthews and Pepper 2007), that is those with a very high prior grade at GCSE; the attainment of which is clearly related to socio-economic circumstances (Noyes 2009).

Expert and effective mathematics teachers, who can counter cultural negativity (Anthony and Walshaw 2009), can be seen to have dramatic impact on the attainment levels of disadvantaged pupils (Marshall 2013).

In summary, mathematics teachers matter more, because they *can* make more of a difference to young lives (Cockcroft 1982). So the question remains: What is effective mathematics teaching? The next section tackles this tricky topic.

2.2 Effective Mathematics teaching: What is it?

In the first instance, we could consider what is effective *teaching* – be it of mathematics or any other subject.

2.2.1 Effective Teaching: What makes the Difference?

> *'Some teachers are better than others, and the difference is significant'*
> (Wiliam 2016: 29)

This enduring debate of whether great teachers are born or are made has led to over five decades of research (Wiliam 2016). Findings suggest that whilst natural inclination (or talent) toward teaching may matter a great deal in the beginning, this influence becomes insignificant over time by the 'effects of practice' (Wiliam 2016: 242). Regardless of any natural talent or otherwise, 'extensive deliberate practice is still needed to become highly accomplished in teaching' (Berliner 2001: 465). Engaging in this type of 'deliberate practice' sets expert practitioners apart from the rest (Wiliam 2016: 4). 'Deliberate practice', according to Ericsson (Ericsson and Pool, 2016) a professor of psychology, involves stepping outside your comfort zone and developing capabilities beyond your current skill-base. Deliberate practice, therefore, can often be uncomfortable and not particularly enjoyable – you have to, metaphorically, fall-down a lot of times. You have to move beyond the comfort zone to the learning zone (Colvin 2009). This can be distinguished from the more regular type of practice which simply involves repeating or doing more of something that has already been mastered. Ericsson's research was the basis of the oft quoted Gladwell's (2008) '10 000-hour rule' but according to Ericsson just doing more of the same is not enough, ‘deliberate practice’ is key. However simply being motivated to engage in deliberate practice is insufficient to engender change; well-defined goals, strategies and direct instruction are also required to achieve expertise (Ericsson and Pool 2016), as too is reflection (Stobart 2014). Interestingly, Ericsson makes the point that committing to this type of deliberate practice - to achieve expert status - is all consuming and may not be the best course of action for the majority; he suggests there is nothing inherently wrong with being average, ‘for much of what we do in life, it’s perfectly fine to reach a middling level of performance and just leave it like that… but there is one of very important thing to understand here: once you have reached this satisfactory skill level and automated your performance…you have stopped improving’ (2016: 12).

Stigler and Hiebert (1999) also promote the investment in deliberate or purposeful practice, and in the ‘development of effective *methods for teaching';* it is this, and not the ‘identification and recruitment of talented individuals’, that will result in long-term ‘improvement in teaching’ (Stigler and Hiebert 1999: 133).

Considering the distinction between *teaching* effectiveness and *teacher* effectiveness, Darling-Hammond (2014) draws our attention to ‘*teacher* quality and *teaching* quality’ (2014: 7). *Teacher* quality might be thought of as the ‘bundle of personal traits, skills, and understanding an individual brings to teaching’ (2014: 7), including subject skills and knowledge along with a set of teacher beliefs, attitudes and behaviours, which help students succeed. *Teaching* quality refers to ‘strong instruction that enables a wide range of students to learn’ (Darling-Hammond 2014: 7); this type of teaching successfully meeting the needs of the subject curriculum *and* the needs of the students ‘in a particular context' (Darling-Hammond 2014: 7). *Teaching* quality can be seen to be part of *teacher* quality, in terms of it being what a teacher would do, but the overall quality of teaching is heavily influenced by the context in which it is cited and by factors 'aside from what the teacher knows and can do' (Darling-Hammond 2014: 7). In difficult circumstances or with limited resources, the quality of teaching will be undermined even for strong teachers. Conversely less effective teachers can be boosted by enhanced surroundings, support-systems and reputable resources. In short, strong '*teacher* quality may heighten the probability of effective teaching', but with due consideration given to context 'it does not guarantee it' (Darling-Hammond 2014: 7).

Darling-Hammond (2014) conjures up the idea of an effective education system being built of interconnecting cogs, encompassing *teacher* quality, *teaching* quality, conducive learning environments and context - all co-operating in an intricate and indeterminate way. The complexities of separating these cogs, to disconnect the *process* (of teaching) from the *people* (the teacher) suggest that: 'it is difficult, and perhaps impossible, to entirely disentangle *teacher* quality from *teaching* quality' (Wiliam 2016: 30).

The context for teaching is clearly significant: Effective teachers in one setting are not necessarily so in another (Berliner 2001, Wiliam 2016, Darling-Hammond 2014). The success enjoyed by Finnish teachers in Finland would not be easily emulated by Finnish teachers elsewhere, as the context would be compromised (Sahlberg 2011). This suggests the system, the context, the curriculum, the students, the support networks, the resources, the teacher and the teaching interact in such a way that enables successful learning. Burghes (2015) suggests our description of effective education should be based on *learner*-focused criteria, with definitions such as 'effective teaching and learning is that which motivates and engages the *learner* to progress mathematically' (Burghes 2015); with processes that have 'the power to evoke a mathematical response' from the learner (Fletcher 1964: 1). And this indeed appears to be the direction of travel for Ofsted with a greater focus on pupil learning and outcomes, and a move away from grading teachers for individual lessons; (GOV.UK 2018b: 12). An adjustment of the focus, to *learning* instead of *teaching*, provides the rational for explaining why a raft of different teaching approaches and styles can appear to function differently in different circumstances. In Finland, for example, the cultural expectations may be sufficient to ensure student engagement and motivation for most of the students for most of the time. In England, to overcome deep-seated and educationally-damaging attitudes towards learning mathematics (Smith 2017b), inspirational teaching may play a more significant role; the most successful teachers often described as those who 'motivate and inspire' their students (Porkess *et al* 2011: 96). In the Ofsted School Inspection Handbook (GOV.UK 2018b) references to a curriculum which 'inspires' (2018b: 47) links outstanding teaching with being 'inspirational' (2018b: 67). Sammons et al (2014) too, suggest that, in the UK context, 'there may be links between characteristics of inspiring and effective practice' (2014: 5). But Sammons et al (2014) go on to point out that there is an 'important distinction between inspiring and effective teaching' in terms of outcomes and the evaluation thereof. Traditionally the evaluation of 'effective teaching' is based on student outcomes in terms of performance – which can be crudely measured by way of examinations. But the question of how 'inspiring teaching' can be observed and measured is more complex (Sammons et al 2014). Indeed, the impact of being inspired at school, may not be realized until many years hence (Hattie, 2012). Whether all inspiring teachers are effective, and whether all effective teachers are inspiring, is another interesting conundrum. According to Sammons et al (2014), there is belief amongst teachers that being inspiring and being effective are ‘two related and mutually dependent aspects of teaching’ (2014: 29) and there is evidence to suggest the ‘two concepts are complimentary’ (2014: 29). Being effective appears to be an ‘important and necessary pre-requisite’ to becoming an inspirational practitioner but, in addition, inspirational teachers are also genuinely interested in their students’ well-being, display ‘a high degree of engagement with their students’, and place a ‘strong emphasis on making learning enjoyable and engaging’ (Sammons et al 2014: 33). In essence, inspiring teachers demonstrate strong social and inter-personal skills and a commitment to, and a liking for, their students (Sammons 2014, Smithers and Hill 2006).

The ongoing difficulty in defining great teaching, may best be summarised by the much used quote from Gates (2013): ‘Unfortunately, it seems the field doesn’t have a clear view of what characterizes good teaching.’ With effective practice seemingly dependent on multifarious factors, it is perhaps not surprising an agreed definition of which, remains elusive. The report by Coe *et al* (2014) for the Sutton Trust explores ‘What makes great teaching?’ and acknowledges that defining ‘effective teaching’ is no easy task. The definition settled upon in their report suggests effective teaching to be ‘that which leads to improved student achievement using outcomes that matter to their future success’ (2014: 2). This then poses further questions: What outcomes ‘matter’ and what do we mean by ‘future success’? The current Chief Inspector of Ofsted, Spielman (2017), believes outcomes that matter are linked to society’s regard concerning the body of knowledge we wish to impart to the next generation, so children can ‘flourish in the future’ (GOV.UK 2017: 2). And what we believe to be culturally important and opt to impart, constitutes the curriculum we choose to design. Agreeing upon valid methods for measuring such future outcomes is not easy. Spielman (GOV.UK 2017) has recently indicated that exam results alone are insufficient to ascertain whether students have ‘received rich and full knowledge from the curriculum’ (2017: 2). Hattie (2015) also reports that it is *engagement* with school (and the number of years of education), not examination grades, that leads to the better outcomes for individuals in later life. Coe *et al* (2014) also argue that ‘enhanced student outcomes’ need not be limited to student academic attainment, but should also include whatever is valued in education (2014: 11). This leads us back to the question Spielman so recently posed: ‘What do we understand to be the real substance of education?’ (GOV.UK 2017: 1). Starting with the question of why education is important, Wiliam (2016: 8) has drawn together four broad categories outlining the purpose of education and these are described in Table 2.5.

1.	Personal empowerment - enabling young people to take greater control over their lives
2.	Transmission of culture - passing on the “Great things that have been thought and said” from one generation to the next
3.	Preparation for citizenship - preparing young people to take active role in society and to make a difference in the world
4.	Preparation for work - ensuring that young people are able to find fulfilling and rewarding employment

Table 2.5 Four Broad Categories Outlining the Purpose of Education

Wiliam (2016) suggests it is the category regarding ‘preparation for work’ which may require the most attention, not because it is the most important but because demands from the world of work are accelerating faster than the improvements in education; education needs to ‘race’ to keep up (Wiliam 2016:

11). Cuoco *et al* (1996) agrees and suggests the aims for mathematics education should evolve with students tasked to 'learn and adopt some of the ways that mathematicians *think* [original emphasis]' (1996: 376), rather than continue the traditional classroom provision mired in properties and procedures. Students should be encouraged to create, invent, conjecture and experiment – and be given the tools to 'understand, and even make, mathematics that does not yet exist' (Cuoco *et al* 1996: 376). Finland is currently implementing radical reform to its school curriculum, with changes 'rooted in the realisation that as the world changes so, too, should education' (Smith, N. 2017). In an uncertain world with 'a future that as adults we can't imagine' (Smith, N. 2017), Finland is attempting to enhance the education experience and future-proof their next generation.

Many teachers and educators will say that they 'know' when they see good teaching, or that they can spot a good teacher. Fenstermacher and Richardson agree: 'Perhaps we cannot define quality teaching, but we know it when we see it' (2000: 2). The idea of 'quality' suggests that teaching can be of high as well as low quality. Again, definitions differ as to what high and low quality represents. Many however are based on the educational effectiveness paradigm (Seidel and Shavelson 2007) in which high quality teaching represents everything which leads to positive effects on student outcomes – this mainly being student achievement. Fenstermacher and Richardson (2000) and Berliner (2001) have, however, emphasized that quality is more than successful teaching, and make distinctions which illustrate the difference between 'good' and 'successful' teaching (2000: 6). 'Successful' teaching has an emphasis on what is taught, and is linked to student achievement (for example, teaching-to-the-test with the primary goal being exam performance), whilst 'good' teaching has an emphasis on how 'it' is taught, employing teaching styles sensitive to the issues of inclusion and morality and can be seen as being more rooted in achieving higher levels of motivation to learn, 'higher feelings of self-efficacy' and 'deeper, rather than surface understanding of the subject matter' (Berliner 2001: 470). Good teaching can be considered to be rooted in the 'task sense of teaching' and successful teaching in the 'achievement sense' of teaching (Fenstermacher and Richardson 2000: 7). The idea of quality teaching being neatly comprised of both 'successful' and 'good' teaching is an appealing one, it is nevertheless 'fraught with complexities' (Fenstermacher and Richardson 2000: 7). It is the quality of *learning* which must be considered, and distinctions can again be made between 'good' and 'successful': 'good' when a learner engages with tasks; 'successful' when a learner also succeeds at them (Fenstermacher and Richardson 2000: 8). Hattie (2003) agrees, suggesting students' motivation and engagement 'account for about 50% of the variance' in terms of attainment (2003: 1). Fenstermacher and Richardson (2000) suggest the quality of learning depends on the four factors outlined in Table 2.6, only one of which pertains to teaching.

1.	Willingness and effort by the learner
2.	A social surround (of peer, family, community, and culture) supportive of teaching and learning
3.	Sufficient facilities, time and resources (opportunities) to accomplish the learning that is sought
4.	Good teaching

Table 2.6 Four Factors for Quality of Learning (Fenstermacher and Richardson 2000: 8)

Using this model, Fenstermacher and Richardson (2000) suggest 'quality teaching' is most likely to arise when all four of the above features combine and, to improve learning, policy initiatives could address any or all of the above four factors for learning. In contrast, traditional policy makers have viewed individual teachers 'as the sole responsible agents for the quality of educational processes' (Kyriakides *et al* 2013: 130). The idea that improvement in teaching alone will result in improvement in student learning is a causal connection that Fenstermacher and Richardson (2000) believe to be 'naïve' and 'wrongheaded' (2000: 10). If it were so, learning successes could be replicated in almost any circumstances, including in differing socio-economic and cultural contexts. This is clearly not the case: As opportunities, facilities, resources and support systems differ, so do student outcomes (Campbell *et al* 2004, Gorad 2017, Darling-Hammond 2014, Berliner 2001, Smith 2017b).

Reflecting the first factor outlined in Table 2.6 above, Slater et al (2009) report 'pupil effectiveness' as being 'the single most important influence' on test outcomes with 'teacher effectiveness' exerting about only 'one quarter' the effect (2009: 641). However, Slater et al (2009) qualify this by highlighting that a 'teacher's effectiveness influences the GCSE performance of…around 30 [students] per class'; 'Hence there is greater leverage for the teacher's effectiveness to matter' (2009:641). Highlighting the gap in GCSE points between 'a poor and non-poor student to be 6.08 GCSE points' (where 1 grade differential = 1 point), Slater et al (2009) calculate that if the poor student was taught by 'good (75th percentile teachers)' across all subjects and the non-poor student taught by 'poor (25th percentile teachers)', this gap could close by 3.4 points (2009: 641). And Slater et al (2009) suggest that choices surrounding teacher deployment could play a significant role in 'alleviating unequal outcomes' (2009: 641).

The context, and the humans involved in the transaction between teaching and learning, is significant (Coe *et al*, 2014); Coe *et al*'s (2014) analysis highlights this, with measures of teacher effectiveness, in terms of student gains, 'only moderately stable from year to year and class to class' (2014: 4). A successful teacher in one context will not necessarily be so in another (Campbell *et al* 2004). Berliner (2001) also believes context to be a significant factor when considering expertise, and one which is often overlooked; the ethos, conditions and climate of an institution can 'powerfully affect' teachers' perceptions and practices (2001: 466).

Ultimately teaching is about human connections and relationships and it appears that 'the behaviour of effective teachers and less effective teachers are not easily characterised; much depends on the particular way that teachers and classes as people relate together' (Coe *et al* 2014: 12). Education is an 'essentially human activity' based on communication, enthusiasm and knowledge (Porkess *et al* 2011: 96). The Schleicher report (2012) highlights the significance of these human relationships with much global agreement regarding important structures and attributes for 21st century learning environments. These attributes are summarised in Table 2.7, below.

• Encouraging engagement
• Ensuring learning is social and collaborative
• Acknowledging students' motivations and the significance of emotional well-being
• Be demanding of every student without overloading
• Promoting connections across activities and subjects
• Using assessment that emphasize formative feedback

Table 2.7 Human Relationships Key for 21st Century Learning Environments

The above list suggests effective teaching requires empathy, and that enhanced learning takes place in a social, collaborative, emotionally intelligent environment. A theory, based on the premise that effective teaching is largely concerned with human-relationships, suggests those attracted to exploring mathematical structures are less likely to be interested in connecting with people (Porkess *et al* 2011, Smithers and Robinson 2013). Smithers and Robinson (2013, iii) report: ‘Relatively few physics and mathematics graduates are attracted to teaching because the pleasures of these impersonal subjects are so different from working with children day-in, day-out’. Teaching is perceived as a career which largely offers intrinsic rewards, such as job satisfaction and relationships, and See (2004) suggests that mathematics and science students are more likely to value extrinsic factors, such as salary and status, over intrinsic values. This reflects Smithers and Hill (1989) study which found that mathematics students were more motivated by extrinsic rewards. Social science and arts students, on the other hand, are more likely to be people-oriented and hence more likely to be attracted to teaching (See 2004).

In the continuing quest to establish what effective teaching actually is, Coe *et al* (2014) believe, all too often, the wrong research questions have been pursued. Various spurious findings have then been espoused which have subsequently been debunked, including the promotion of one teaching style above another, the advocating of large group teaching, or small group teaching or individual teaching. The issue of quality appears to be less about the shape or style of teaching and more about ‘the quality of thought and effort that can occur within these structures’ (Good and Biddle 1988: 116).

Coe at al (2014: 2) sifts six ‘components of great teaching’ from contemporary research; the evidence of which illustrates varying levels of impact on student outcomes. The list outlined in Table 2.8, is offered as an effective practice 'starter kit' with the suggestion that all will feature in the tool-kit of the most effective practitioners:

	Component	**Impact on student outcomes**
1.	Pedagogical Content knowledge (PCK)	Strong
2.	Quality of instruction	Strong
3.	Classroom climate	Moderate
4.	Classroom management	Moderate
5.	Teacher beliefs	Some
6.	Professional behaviours	Some

Table 2.8 Six Components of Great Teaching

'Pedagogical Content Knowledge' (PCK), highlighted above as having a strong impact on student outcomes by Coe et al (2014), is now a common phrase but was first coined by Shulman (1986: 9) to describe the teacher knowledge that links subject content and pedagogy and the interweaving of the two; this is discussed in detail in 2.3.2. Blending of subject knowledge and pedagogy leads to the understanding of why something is so: 'the teacher need not only understand *that* something is so; the teacher must further understand *why* it is so' (Shulman 1986: 9). In a direct refute to Shaw's (1903) oft repeated 'He who can does. He who cannot, teaches', Shulman (1986) aligns himself with Aristotle's view, that those able to teach by translating and communicating their own knowledge, demonstrate greater depths of understanding. This is paraphrased by Shulman (1986: 14): 'Those who can, do. Those who understand, teach.' This is undoubtedly true but it can be argued that advanced industrial nations, like, the UK, the United States, and Germany, have typically not encouraged their ‘best brains to go into teaching; they want them to be at the cutting edge of research, innovation, creativity and wealth generation.’ (Smithers and Robinson 2013: 58). Now, with the UK set to leave the EU, and with the associated prominence of the government’s Building Our Industrial Strategy green paper (GOV.UK 2017) (acknowledging the critical role of education), priorities may be set to change.

To summarise, the quality of teaching depends on numerous factors (Berliner 2001, Campbell *et al* 2004, Darling-Hammond 2014, Wragg 2012, Kyriakides *et al* 2013) such as the context, the curriculum, the students, the systems, the support networks, the resources and the expertise of the teacher: ‘If teaching is to be effective, the policies that construct the learning environment and the teaching context must be addressed along with the qualities of individual teachers’ (Darling-Hammond 2014: 7). As Wiliam (2016) states: ‘we know that teachers make a difference’, we just don’t know ‘what makes the difference in teachers’ (2016: 38). A consideration of the difference effective mathematics teachers can make, and factors which may characterise effective mathematics teaching, follows next.

2.2.2 Mathematics Teachers – Making the Difference

The issues surrounding the shortage of specialist mathematics teachers were presented in section 2.1, with a reference made to the relationship between subject knowledge and effectiveness. This relationship - between subject knowledge and effectiveness - has faced much scrutiny (Davis and Simmt 2006) and there is now ‘widespread agreement that the quality of primary and secondary school mathematics teaching depends crucially on the subject-related knowledge that teachers are able to bring to bear on their work' (Rowland and Ruthven 2011: 1). A consideration of what exactly this subject knowledge needs to be, is discussed in section 2.3.1.

In an attempt to characterise effective practice, Askew *et al* (1997) focused on 'numeracy' as opposed to 'mathematics' for their report *Effective Teachers of Numeracy,* carried out for the Teacher Training Agency (a precursor to today's NCTL). Like the far more recent report by Coe *et al* (2014), their rationale for defining 'effective' was based on the idea of 'learning gains' and it was one of only a few projects to do so at the time. They contrasted less effective and highly effective practitioners, concluding that highly effective practitioners held a set of beliefs which underpinned their practice. These beliefs, summarised by Coe *et al* (2014: 21), are outlined in Table 2.9 and Table 2.10.

Less effective teachers believed in the importance of either:
• pupils acquiring a collection of facts and standard methods, and that pupils varied in their ability to remember these. They used teaching approaches that: - dealt with areas of mathematics discretely - emphasised teaching and practising standard methods and applying these to abstract or word problems without considering whether there were alternative more efficient ways of solving a particular problem. **or** • developing numeracy concepts using practical equipment and waiting until pupils were ready to move onto more formal methods. They used teaching approaches that emphasised pupils working things out for themselves, using any method with which they felt comfortable.

Table 2.9 Outlining Teacher Beliefs of Less Effective Teachers of Mathematics

	Highly effective teachers were characterised by beliefs about:
What it means to be numerate:	• having a rich network of connections between different mathematical ideas • being able to select and use strategies, which are both efficient and effective. They used corresponding teaching approaches that: - connected different areas of mathematics and different ideas in the same area of mathematics using variety of words, symbols and diagrams - used pupils' descriptions of their methods and their reasoning to help establish and emphasise connections and address misconceptions - emphasised the importance of using mental, written, part-written or electronic methods of calculation that are the most efficient for the problem in hand - particularly emphasised the development of mental skills
How children learn:	• almost all pupils are able to become numerate • pupils develop strategies and networks of ideas by being challenged to think, through explaining, listening and problem solving They used teaching approaches that: - ensured that all pupils were being challenged and stretched, not just those who were more able - built upon pupils' own mental strategies for calculating, and helped them to become more efficient
The role of the teacher	• discussion of concepts and images is important in exemplifying the teacher's network of knowledge and skills and in revealing pupils' thinking • it is the teacher's responsibility to intervene to assist the pupil to become more efficient in the use of calculating strategies. These teachers used teaching approaches that encouraged discussion, in whole classes, small groups, or with individual pupils

Table 2.10 Outlining Teacher Beliefs of Highly Effective Teachers of Mathematics

In our society, it is culturally acceptable to profess to being poor at mathematics and it is these negative and 'deep seated' attitudes which limit prospects and participation with the subject (Smith 2017b: 81). And yet in spite of this deeply ingrained cultural belief, highly effective teachers, according to Askew et al (1997), do believe that 'almost all pupils are able to become numerate' (see Table 2.10 above). This may be a powerful and significant factor in defining effectiveness. Dweck (2012) has highlighted the power of people's beliefs. She asserts it is the mindset in which we approach activities which determines the likelihood of success. Certain students in our society cannot achieve, if we have collectively convinced ourselves that certain students in our society *cannot* achieve! The systems, structures and collective practices do not allow it. On the other hand, a collective growth mindset suggests other possibilities (Dweck 2012). Anthony and Walshaw (2009) agree and believe effective mathematics teaching 'acknowledges that all students, irrespective of age, can develop' (2009: 149). Their understanding is that teachers who 'foster positive student outcomes' do so through their 'beliefs in the rights of all students to have access to mathematics education in a broad sense' (2009: 149). This broad sense encompasses an understanding and appreciation of the big ideas of mathematics – a painting of the big picture as opposed to bite size, dumbed down pieces which is often the diet for lower attaining students in England (Boaler 2000). Breadth suggests 'horizon knowledge' which is something Ball *et al* (2008) describe as 'an awareness of how mathematical topics are related' (2008: 403), and a need for mathematics teachers to know (and see) beyond the level at which they teach to be able to lay the foundations for future connections.

Significantly, in the list of six ‘components of great teaching’ compiled by Coe et al (2014: 2), ‘Teacher beliefs’ is listed as having only ‘*some*’ impact on student outcomes. This appears to contrast with the ideas expressed above, by Askew (1997), Dweck (2012) and Anthony and Walshaw (2009). It seems there is no universal agreement on the strength of impact of ‘teacher beliefs’, nor on the precise criteria for how to evaluate or measure these beliefs.

The Deep Progress project, devised ‘to generate deep progress in mathematics’ (Watson et al 2003: 4), focused on the ‘development of mathematical thinking’ alongside the content to be covered (Watson et al 2003: 7). The project involved ten teachers who taught low attaining students, and attempted to reflect teacher beliefs seen as significant for student progress. From the outset the teachers all shared one over-arching belief: ‘all students can learn mathematics’ (Watson et al 2003: 9), echoing one of the beliefs which characterised highly effective teachers, identified by Askew et al (1997) (see Table 2.10). Ultimately, the Deep Progress participant teachers expressed a set of beliefs set out in Table 2.11.

Deep Progress Participants’ Shared Set Of Beliefs:
- ‘all students are entitled to learn mathematics in ways which develop thinking and confidence in problem solving’;
- ‘all students have the right to, and are capable of, full engagement with the subject’;
- ‘All students are entitled to have access to the mathematics necessary to function in society, beyond minimal functioning’;
- ‘a positive experience of mathematics [for students] can empower them mentally because their own thoughts are being valued’ with the associated positive impact on self-esteem;
- ‘Intellectual engagement’ is ‘its own reward’, there is no need to ‘construct artificial ‘real-life’ contexts as motivational devices’;
- ‘final examinations are important’ but within the context of a broad and subject-deep curriculum’

Table 2.11 Deep Progress Participants’ Shared Set Of Beliefs (Watson et al 2003: 9)

The last point (in Table 2.11) has recently been espoused by the current head of Ofsted, Spielman (2018), who suggests Ofsted has fueled the 'teaching-to-the-test' phenomenon in schools, by placing too much emphasis on tests and exam results; instead Spielman believes it 'imperative that the new inspection framework has a [broad and rich] curriculum as a central focus' (2018: 1).

The teacher beliefs, outlined above, are based on the idea of offering students deep-learning opportunities - the chance for challenge and stimulation, rather than simple repetition and easy wins, which may 'only lead to short term, superficial success' (Watson et al 2003: 4). The significance of deep-learning resonates with another teacher belief outlined by Askew et al (1997) which connects 'being challenged to think' with pupil development; and that being 'challenged and stretched' was significant for all learners, 'not just those who were more able' (see Table 2.10). Being challenged, learning from mistakes and seeking deep underlying understandings are prerequisites for successful students with growth mindsets (Dweck 2012). Appreciating that deeper understanding can promote more effective learning of mathematics is not new. Swan (2005) makes a distinction between 'transmission' and 'challenging' teaching, pointing out that the former can appear 'superficially effective when short-term recall is required', but 'less effective for longer-term' (2005: 5). Evidence from cognitive psychology supports Swan's suggestion: 'some approaches that may appear to make learning harder in the short-term… actually result in better long-term retention' (Coe *et al* 2014: 17). Swan's definition of teaching styles undoubtedly builds upon Skemp's (1976) description of 'understanding' mathematics. Skemp (1976) describes the difference between 'instrumental' and 'relational' understanding, with the former relying on rules and knowing how to apply them, the latter 'knowing both what to do and why' (1976: 20). Tall (2013), inspired by

Skemp's ideas, has conducted detailed research into how humans learn to think mathematically, and has concluded that 'learners need to make appropriate sense of ideas and develop fluency in operation' (2013: 416). The beliefs outlined in Table 2.9 and Table 2.10 suggest that the more effective practitioner is proactively promoting this fluency whilst developing 'relational understanding', and the less effective practitioner is content with conveying *only* 'instrumental understanding'. These different modes of 'understanding' are often attributed to different teaching approaches and depicted as opposing practices, for example *procedural* versus *conceptual* or *traditional* versus *guided rediscovery*. Ellenberg (2015) describes the 'war of teaching' styles that continues to rage amongst mathematics teachers: 'On one side, you have teachers who favor an emphasis on memorization, fluency, traditional algorithms, and exact answers; on the other, teachers who think mathematics teaching should be about learning meaning, developing ways of thinking, guided discovery, and approximation' (2015: 56). Ellenberg (2015) does not align himself with either 'side' and believes the best mathematics teachers are drawing from both camps: mathematics should be taught in such a way that 'values precise answers but also intelligent approximations'; existing algorithms should be taught to be deployed effectively and fluently, whilst encouraging 'a sense of play' to work things out (Ellenberg 2015: 58). This belief is reflected in the OECD report (Schleicher 2012) which suggests there is 'no single best way of teaching' and that this is even more so in the 21st century than in the past: 'Teachers today need to know how to combine "guided discovery" with "direct instruction" depending on the individual students, the context of instruction and the aims of the teaching' (Schleicher 2012: 45).

Berliner (2001) suggests the ‘degree of challenge’ (2001: 470) (or the extent to which students are ‘being challenged to think’ (see Table 2.10)) is amongst three key features which distinguish expert and non-expert teachers; extensive pedagogical content knowledge and the teachers’ ‘skillfulness in monitoring and providing feedback’ being the other two key features (2001: 471). Coe *et al* (2014) agree, pointing out that the most effective teachers have deep knowledge of the subjects they teach, and must also be able to appreciate and unravel students’ thought processes and be in a position to identify students’ common misconceptions. The Ofsted (GOV.UK 2018b) grade descriptors, used to describe the quality of teaching and learning as outstanding, include the statements that teachers ‘identify pupils’ common misconceptions and act to ensure they are corrected’ and ‘use questioning highly effectively and demonstrate understanding of the ways pupils think’ (GOV.UK 2018b: 53). Ball and Bass (2000) also believe that subject knowledge, wrapped up and entwined with pedagogy, is a dominant factor of teacher effectiveness: ‘It is not just what mathematics teachers know, but how they know it and what they are able to mobilise mathematically’, that is so fundamental for effective teaching (2000: 95).

Boaler (2009) also talks extensively about the need for learners of mathematics, especially girls, to make connections to develop deeper understanding. Appreciating the needs of learners, links back to the ideas discussed in 2.2.1, and the significance of human relationships and empathy. These attributes are entwined within the idea of teacher expertise in mathematics. Teacher expertise is, of course, defined in terms of cultural expectations and as Li and Kaiser (2011) point out, there is no one global definition of teaching expertise: ‘Different countries have different assumptions about what it means to have expertise in mathematics instruction' (2011: 488). In Japan, mathematics teachers are described according to three levels of competency (APEC 2013: 6), as outlined in Table 2.12.

Level 1:	Teaching by telling; teachers can tell students the important basic ideas of mathematics such as facts, concepts and procedures.
Level 2:	Teaching by explaining; teachers can explain the meanings and reasons of the important basic ideas of mathematics in order for students to understand them.
Level 3:	Teaching by guided 'rediscovery'; teachers can provide students opportunities to understand these basic ideas, and support their leaning so that the students become independent learners.

Table 2.12 Three Levels of Competency of Mathematics Teachers in Japan

It is unacceptable, in Japan, for teachers to remain at Level 1; teachers need to achieve at least Level 2, and strive for Level 3 mastery. But teaching at Level 3 is not easy - plenty of practise and professional development opportunities are required. Lesson Study, a form of collaborative practice, is a widely used school-based professional development initiative to achieve such ends – and is discussed in detail in 2.3.5.

It may be interesting to see how closely this hierarchy of teaching expertise resembles the familiar and oft quoted words from the missionary and author, William Arthur Ward (Ward, 2015: 1): 'The mediocre teacher tells. The good teacher explains. The superior teacher demonstrates. The great teacher inspires.' And it is also interesting to consider that the Level 3 style of teaching could be based on the Socratic Method - perhaps one of the most ancient recognised styles of teaching. The Socratic Method is based on the interaction between people, posing and discussing questions and answers; a form of inquiry and critical thinking. Designed to stimulate and provoke, the Socratic Method provides few answers (Rhee 2012); the idea is to stir students to seek solutions for themselves and so by learn. Polya's (1945) philosophy resonates with the Socratic style (Rhee 2012), with Polya's belief that the purpose of a mathematics lesson is 'to help students, but not too much and not too little' (Polya 1945). The new post-16 Core Maths qualification, launched in 2014, aims to emulate much of Polya's ethos, with 'problem solving' as a principle teaching strategy. Teaching by way of purposeful 'problem solving' is a highly skilled activity; with a shortage of mathematics teachers in England, impacting on 'the capacity to deliver the required volume and range' (Smith 2017b: 2), delivering the new post-16 Core Maths qualification in this image could prove challenging.

Berliner (2004: 19-22) offers a theory for considering teacher development, which catalogues five stages of teacher expertise and development (outlined in Table 2.13).

1	Novice:	Someone just starting out on their career, a student or first-year teacher; requires rules and procedures to deliberately follow.
2	Advanced beginner:	Starts to build up case knowledge and develop conditional and strategic knowledge; they are more insightful and understand which 'teaching rules' can be broken.
3	Competent:	Often, but not always, achieved by third, fourth and fifth year teachers; competent practitioners are more in control of their own priorities and plans.
4	Proficient:	Achieved by a small number of teachers after around 5 years; proficient practitioners perform without conscious effort and can predict class room events intuitively.
5	Expert:	The very few who move to the highest level of apparently effortless fluid performance; their behaviour appears neither calculated nor deliberate and often appear to "go with the flow".

Table 2.13 Five Stages of Teacher Expertise and Development by Berliner (2004: 19-22)

The question then, is how do teachers develop and progress through these stages. Professional development may provide the answer as to how best practice is developed and promoted. This is summed up by the DfE (GOV.UK 2012): 'Schools should develop the expertise of staff' (2012: 4); this sentiment is explored in detail below.

2.3 Promoting Effective Practice for Mathematics Teachers

'Every teacher needs to improve, not because they are not good enough, but because they can be even better' (Dylan Wiliam)

The Teachers' Standards framework (GOV.UK 2011b) introduced in 2012 gives the explicit edict that highly effective teaching is 'what matters in this profession'. Professional development, for teachers at all stages of their careers, is a predominant feature of this framework. The 2015 Sutton Trust report proposed that professional development should be strengthened for all teachers: 'It is through good quality professional development that real improvements in teaching and attainment take place' (2015: 10). An equivalence to other professions is suggested, with the idea that professional development must continue beyond initial qualification, and should be a right for all and a responsibility schools should not shirk (Sutton Trust 2015). Investing in staff cannot be optional. Schools need to 'build up capacity and capital and encourage a culture that values knowledge and understanding' (Sutton Trust 2015: 23).

There are, of course, various forms of teacher professional development and 'Classroom Observations', 'Mentoring and Coaching', 'Collaborative Practice' and 'Lesson Study' are discussed in the following sections; these professional development practices were selected for in-depth discussion as these either featured prominently during the retraining or emerged from the research as significant to the participants. The development of strong subject knowledge and mathematical pedagogical content knowledge (PCK) (Shulman 1986) are central to all these professional development practices, and so a more in-depth consideration of these are considered first.

2.3.1 Subject Knowledge for Mathematics Teaching

As noted in 2.2.2, there is widespread acknowledgement that subject-related knowledge is essential for effective mathematics teaching (Rowland and Ruthven 2011), with evidence that 'poor subject knowledge in mathematics has a negative impact on teaching' (Hodgen 2011: 28). However, there is an ongoing conversation in regard to the form, breadth, depth and application of this knowledge, with the 'suggestion that effective teaching calls for distinctive forms of subject related knowledge and thinking' (Rowland and Ruthven 2011: 1). Reaching a consensus of opinion in terms of what, and how much, mathematics teachers need to know to be effective educators has been challenging with 'little progress' made (Davis and Simmt, 2006: 294, Hodgen 2011). Ball and Bass (2005) have also identified the lack of a definitive opinion regarding the 'actual nature and extent' of teachers' mathematical knowledge: 'whether it is simply basic skills at the grades they teach, or complex and professionally specific mathematical knowledge - is largely unknown' (2005: 16). Davis and Simmt (2006) suggest professional development courses in mathematics for teachers tend to be framed in terms of studying more formal mathematics, on the assumption that this approach is 'vital to effective teaching' but that this assumption is one 'not easily substantiated' (Davis and Simmt, 2006: 294). Hodgen (2011) points out that no link has been established between 'teachers' mathematical knowledge, as measured in terms of academic mathematical qualifications, and effective teaching' and that 'the connection between teacher knowledge and teaching outcomes' is complex (Hodgen 2011: 28). Davis and Simmt (2006) argue that the mathematics teachers need to know is 'qualitatively different from the mathematics their students are expected to master' (2006: 316) but that the research community has 'far to go in identifying what these varieties of mathematics might be' (2006: 316). Ball and Bass (2000) agree, acknowledging that although it may be a popular perspective that 'what teachers need to know is what they teach' - with perhaps the added dimension to 'learn more' in order to see where their 'students are heading' (2000: 86; Rowland and Ruthven 2011) - this does not suffice. Instead, 'it is now clear that such perspectives fail to do justice to the situation' (Rowland and Ruthven 2011: 1) and the enactment of the curriculum relies on further mathematical endeavours, vision and contexts (Ball and Bass, 2000).

Teachers may need a 'more nuanced understanding of the topics in a conventional curriculum' (Davis and Simmt, 2006: 294). An emerging attitude 'among a growing number of researchers' is that 'there is a distinct body of knowledge associated with mathematics teaching' (Davis and Simmt, 2006: 294) encompassing ideas such as: 'how mathematical topics are connected, how ideas anticipate others, what constitutes a valid argument' (Davis and Simmt, 2006: 295). This is not a diluted version of formal mathematics but a 'serious and demanding area of mathematical work' (Davis and Simmt, 2006: 295); one conjecture is that access to a 'web of interconnections that constitute a concept is essential for teaching' (2006: 301). The concept need not only be understood in depth but also the generalisations that arise be 'well connected in their contexts' (Davis and Simmt, 2006: 307). This distinct body of knowledge could be described as 'mathematics-for-teaching' (Davis and Simmt, 2006: 300) - encompassing both mastery of content and the teachers' understanding of the development of that knowledge. An important aspect of this body of knowledge is that ‘it can act as a resource to enable the teacher to act in an unpredicted or unexpected situation’ (Hodgen 2011: 33).

Research on teacher subject knowledge is, as Hodgen (2011) points out, dominated by research in primary education, where practitioners are most commonly generalists. And yet this is a real and live issue for the secondary sector too especially in regard to the ‘long-standing difficulties in recruiting teachers who are confident and conventionally well-qualified in mathematics’ (Rowland and Ruthven 2011: 1).

Hodgen (2011) suggests that although mathematical knowledge does matter, it is insufficient in isolation: It is ‘very much more deeply embedded in practices’ than may have previously been recognised with the ‘interrelationship between knowledge and its use’ a key consideration (2011: 35). Mason and Spence (1999) agree - with mathematical knowledge for teaching ‘realised through the practice of teaching’ (Turner and Rowland 2011: 196).

Researchers have routinely suggested that mathematical knowledge for teaching is ‘distinct and different to the knowledge necessary to practice mathematics’ (Hodgen 2011: 29). Much of this research stems from Shulman’s (1986) idea of ‘pedagogical content knowledge’ which ‘goes beyond the subject per se to the dimension of subject knowledge *for teaching* [original emphasis]’ (986: 9). Pedagogical content knowledge, a ‘special form of knowledge that bundles mathematical knowledge with knowledge of learners, learning and pedagogy’ (Ball and Bass, 2000: 87) is considered in detail next.

2.3.2 Pedagogical Content Knowledge for Mathematics

Pedagogical Content Knowledge (PCK) is knowledge that transcends understanding for the subject for oneself and reaches an understanding of subject matter for teaching in a way that makes the subject 'comprehensible to others' (Shulman 1986: 9). As Hodgen (2011) describes: a mathematical question may examine 'how do you show the statement is true'; a pedagogical question would enquire 'how to you enable others to see the statement is true' (2011: 27).

The impact of Pedagogical Content Knowledge (PCK) on student outcomes, was identified as 'strong' by Coe et al (2014) (see Table 2.8 in 2.2.1). Carter (2015) and others (Sadler et al, 2013 and Hill et al, 2005) suggest that teachers who employ PCK - and understand the way students tackle different topics, strive to make the subject accessible and meaningful, understand the thinking behind students' methods, promote connections, and can identify common misconceptions - are 'more likely to have a positive impact on pupil outcomes' (2015: 8). Kahan et al (2003) suggest that it is PCK which sets apart those who are simply good at mathematics and those who are also good at teaching mathematics: although PCK *is* content-specific, it ranges beyond a knowledge of mathematics and therefore 'a mathematician may not possess it' (Kahan et al 2003: 223). Grouws and Schultz (1996) suggest pedagogical content knowledge includes 'useful representations, unifying ideas, clarifying examples and counter examples, helpful analogies, important relationships, and connections' (1996: 443). An et al (2004) also emphasize connections and define PCK as the 'knowledge of effective teaching' which includes three interconnected components: knowledge of content; knowledge of curriculum; and knowledge of teaching.

Anthony and Walshaw (2009) also acknowledge the need for students to make mathematical connections and believe teachers need to know 'how to extend and challenge students' thinking' by having 'substantial pedagogical content knowledge and a grounded understanding of students' as learners' (2009: 158). Liping Ma (1999) considers this as an important quality in Chinese teachers' professional practice: 'One thing is to study whom you are teaching, the other thing is to study the knowledge you are teaching. If you can interweave the two things together nicely, you will succeed' (Liping Ma,1999: 136).

Mason and Spence (1999) describe different types of knowledge: *knowing-to* and *knowing about*. *Knowing-to* describes 'active knowledge which is present in the moment'; knowledge which is dynamic, current, accessible and useful, enabling a person to 'act creatively' in fresh and novel situations 'rather than merely react' to rehearsed, trained or habitual positions (Mason and Spence 1999: 135-136). *Knowing about* is constituted from '*knowing-that'* (factual), '*knowing-how'* (techniques and skills)*, and 'knowing-why'* (a backstory) (Mason and Spence 1999:135) – and are an attempt to encompass teacher perceptions of the meaning of understanding. These three 'knowings' also captured in the components of teacher knowledge identified by Shulman (1987), namely: subject content knowledge; pedagogical content knowledge; knowledge of related content; knowledge of curriculum; knowledge of learners; knowledge of educational aims; and general pedagogical knowledge.

Shulman's range of knowledge types is intended to equip the effective practitioner to act, 'but *knowing-to* act when the moment comes requires more than having accumulated *knowledge-about'* (Mason and Spence 1999: 139). '*Knowing-to'* act is developed by establishing connections between the past, the present and the future, 'so that in the future, past experience informs (literally) practice in the moment' (Mason and Spence 1999:148). Rich connections can be made when there are multiple links, or a 'web of meaning' (Mason and Spence 1999: 150); links that activate the senses. This *'knowing-to'* knowledge 'requires relevant knowledge to come to the fore so it can be acted upon' (Mason and Spence 1999:139) so, for example, teachers can not only analyse an error but have high levels of fluency and mathematical reasoning to rapidly, 'often on the fly', redress the misconception (Ball *et al* 2008: 397).

Watson and Mason (2007) suggest Schulman's distinctions between subject content knowledge and pedagogic content knowledge are 'not necessarily useful for the task of educating mathematics teachers' (2007: 209) and that a 'considerably more complex model of teacher-knowledge' is required. Such a model should be 'augmented by, among other things, understanding how being knowledgeable about mathematics teaching influences classroom actions'; 'knowing-to act in the moment through having pertinent possibilities come to mind' (Watson and Mason, 2007: 208).

Hodgen (2011) suggests the nature of pedagogical content knowledge is itself, 'something of a contested idea within the education research community' and there is 'no clear distinction between subject knowledge and pedagogical content knowledge' with pedagogical content knowledge possibly a 'useful metaphor to locate teachers' knowledge as embedded within the complex and unpredictable practice of teaching' (2011: 28).

Turner and Rowland (2006) refer to the various forms of knowledge and experience a teacher needs to draw upon as incorporating a ‘Knowledge Quartet’. This Knowledge Quartet, consisting of ‘foundation knowledge’, ‘transformation knowledge’, ‘connection knowledge’ and ‘contingency knowledge’ (Turner and Rowland 2006: 2), illustrates multiple representations of mathematical knowledge, each of which can usefully emerge and be employed in differing circumstances. Foundation knowledge can be seen to be the teacher’s self-knowledge about mathematics together with their beliefs and attitudes towards teaching the subject, perhaps best encapsulated with the practise of procedures, use of textbook questions, correct use of terminology and noticing mistakes and misconceptions. Transformation knowledge is concerned with ‘knowledge-in-action’ (Turner and Rowland 2006: 2) and includes the decisions in terms of the choice of examples and explanations offered, and the use and scope of analogies, illustrations and demonstrations. Connection knowledge is, as it name suggests, about making connections and about the significance of doing so in terms of conceptual understanding. And contingency knowledge is about being able to respond to students in real-time, to answer their tangential questions and to view these ideas as teaching opportunities; ‘In other words, it concerns teachers’ readiness to react to situations that are almost impossible to plan for’ (Petrou and Goulding 2011: 19).

Recognising a scarcity of specifics, in terms of what teachers needed to know and do, The Joint Mathematical Council of the United Kingdom (JMC) released recommendations on ‘Developing mathematics-specific pedagogy in Initial Teacher Education’ to provide such guidance. These recommendations, designed to ‘develop a coherent and rich approach to learning mathematics’ (JMC 2017) are outlined in Table 2.14.

• A focus on developing effective use of a *variety* of approaches to learning
• A need to recognise the value of both procedural and conceptual learning - and the relationships between them
• The use of alternative methods and representations to be informed by a deep understanding of mathematics and an appreciation of how mathematics is understood by learners
• Knowledge of the ‘big ideas’ in mathematics and the connected nature of the discipline of mathematics (within itself and to other subjects/contexts)
• A rigorous use of language and symbols
• Investigative and problem solving approaches to be explored
• Use of reasoning and proof
• The development of skills in mathematical reasoning through the use of high quality questions on the part of both teachers and learners
• Recognizing the importance of talk; Supporting and developing mathematical talk
• Recognizing and working with errors and common misconceptions
• Understanding the role of manipulatives and diagrams in learning and doing mathematics
• Due consideration given as to when to generalise from physical experience to the symbolic and abstract (also often referred to as moving between CPA)
• Promote experiences which progress student learning and challenge thinking, rather than experiences that are repetitive
• Developing learners’ positive attitudes to learning and their confidence to persevere and ‘have a go’; all have the opportunity to make progress and achieve success
• Opportunities for teachers and learners to develop confidence and competence with a range of tools and resources (including digital resources)
• Assessing learning in the specific context of the mathematics classroom
• Considered planning of lessons: recognizing and using prior learning, (within topics in mathematics as well as across topics); skillfully sequencing and selecting mathematical tasks and classroom activities

Table 2.14 Recommendations Designed to ‘Develop A Coherent and Rich Approach to Learning Mathematics’ (JMC 2017)

The current Teachers’ Standards framework (GOV.UK 2011b) require teachers to be proactive in updating their knowledge and to be reflective and self-critical in regard to their levels of expertise. Problems may arise with this modus operandi, when teachers are unable to identify gaps in their own knowledge. As one teacher remarked: 'You don't know what you don't know' (Ofsted 2012). In-school-variation (ISV) also poses problems, and has been identified as a dominant factor in determining national outcomes – and one that overwhelms the variation between schools (National College 2011). The National College (2011) report states, that if in every school, if each group of students 'attained the same standards as the best groups in that school, then national outcomes would be transformed' (National College 2011: 4). A commitment to the development of their teachers is one way in which some schools are attempting to narrow this gap. Providing professional development (from within schools) may both help reduce in-school-variation and help teachers to identify gaps in knowledge and expertise.

In summary, 'Teachers must know the subject they teach' as there is 'nothing more foundational to teacher competency' (Ball *et al* 2008: 404). The McKinsey report (2007), based on effective educational systems from around the world, makes it clear that whilst this is true, teachers also need to observe and reflect and identify what makes for great instruction in their subject and then have in place support in schools to ensure that teachers can deliver great instruction lesson after lesson; that is, provide an environment that sustains great instruction. Ideas concerning in-school professional development and support-systems, are discussed in the following sections.

2.3.3 Using Classroom Observations to Develop Teaching

> *'While not every school is effective, all schools will have within themselves some practice that is relatively more effective than elsewhere in the school. Every school can therefore look for generally applicable good practice from within its own internal conditions.'*
> (Reynolds 2008:18)

According to the DfE, and outlined in the Teachers' Standards document (GOV.UK 2011b), the most successful education systems in the world are 'characterised by high levels of lesson observation'. Observing teaching and being observed, and having the opportunity to plan, prepare, reflect and teach with other teachers can help to improve the quality of teaching (GOV.UK 2011b). Teachers benefit from observing one another's practice in the classroom; Teachers learn best from other professionals (Wragg 2012).

Observing colleagues teach may appear to be a simple professional development tool and yet opportunities to do so appear scarce for some teachers. Gore (2013) points out that observing others teach is one of the best things teachers can do to improve their own teaching but paradoxically inexperienced teachers rarely have the opportunity to observe, whilst experienced teacher trainers are presented with many opportunities to do so. Contrarily, lesson observations can be an inadequate tool for professional development if less-than-best practice is modelled. Poor practice could be endorsed and encouraged (Burghes and Robinson 2010).

Classroom observations are seen to be most effective, for professional development, when employed as a collaborative activity for promoting reflective and self-directed learning (Coe *et al* 2014, Wragg 1994). High stakes performance-management or Ofsted-type observations, are not seen to be developmentally effective (Coe *et al* 2014, Wragg 1994). This is reflected by the findings of the National College report (2011): observation was more successful when it was viewed as part of a developmental culture as opposed to one where the ‘culture appeared to be more judgmental’ (2011: 3). Coe *et al* (2014) also found that classroom observation is most effective when undertaken as a collaborative and collegial exercise amongst peers. However, the research also emphasizes the need for challenge in the process which may therefore involve senior teachers or external experts (Coe *et al* 2014). This links with the ideas of Lesson Study (discussed in 2.3.5), originating from Japan, where these external experts are referred to as ‘knowledgeable others’.

To summarise, using lesson observations for professional development is most effective when it involves a collaborative approach (Centre for the Use of Research and Evidence in Education (CUREE) 2005). ‘Mentoring and Coaching’ and ‘Lesson Study’, two forms of collaborative professional development, are discussed in the following two sections.

2.3.4 Mentoring and Coaching

> *A well designed system* (of CPD*) will empower educators as individuals and their organisation. Thus it will empower those whom they serve* (Joyce and Showers 2002:3).

The National College for Teaching and Leadership (NCTL) (2013) refer to mentoring and coaching in terms of ‘empowering’ others (2013: 1) and describe them as being at the heart of professional support and development. The terms ‘mentoring’ and ‘coaching’ are often used synonymously, however Lord *et al*

(2008) suggest that: mentoring is concerned with ‘growing an individual’ both professionally and personally, often characterized by an expert-novice dynamic; coaching with a narrower remit, relates to ‘specific areas of job performance and outcomes’ (2008: iii).

Renshaw (2009) offers some distinctions between the two, but combines elements of coaching within his definition for mentoring. These definitions are highlighted in Table 2.15.

Coaching:	• is an enabling process aimed at enhancing learning and development with the intention of improving performance in a specific aspect of practice. It has a short-term focus with an emphasis on immediate micro issues. (e.g., How can I improve my performance in this particular area?)
Mentoring:	• is a more developmental process, including elements of coaching, facilitating and counselling, aimed at sharing knowledge and encouraging individual development. It has a longer-term focus designed to foster personal growth and to help an individual place their creative, personal and professional development in a wider cultural, social and educational context (e.g., Why am I doing what I do? How do I perceive my identity? In what ways does this impact on my professional life and work? Where am I going? What determines my long-term goals?).

Table 2.15 Coaching and Mentoring Definitions (Renshaw 2009: 3)

With significant cross-overs between the two, it is common for both terms to be employed simultaneously. Various descriptions in the literature encompass both (Lord *et al* 2008:13) and these are summarised in Table 2.16.

.	Providing a sounding board and a critical friend	Hobson and Sharp (2005); Robins (2006); Simkins *et al* (2006)
.	A learner-centred teaching-learning process	Renshaw (2008); Simkins *et al* (2006)
.	Providing information and support, rather than advice	Robins (2006)
.	Posing challenge within a safe environment	Robins (2006)
.	Problem solving	Hafford-Letchfield *et al* (2007); Hobson and Sharp (2005); Robins (2006)
.	Being reflective ('providing a "mirror" to enable a learner to explore their aims, objectives, hopes and fears' (Hafford-Letchfield *et al* 2007))	Hafford-Letchfield *et al* (2007); Robins (2006)
.	Providing 'scaffolding'	Hobson and Sharp (2005); Robins (2006)
.	Creating a partnership, in which mentor/coach and mentee/coachee must both be engaged and motivated	Simkins *et al* (2006)

Table 2.16 Synchronous Definitions of Coaching and Mentoring

These varying descriptions suggest multifarious models for mentoring and coaching, summarized by Lord *et al* (2008: 21), in Table 2.17.

Model	Description	Reference
Apprenticeship model	Mentor acts as the master teacher, conveying the rules and values to be emulated	Child and Merrill (2003)
Competence model	Mentor relates training and assessment to practice. Mentors perform the role of trainer, assessor and gatekeeper of the profession.	Child and Merrill (2003)
Reflective model	Mentor adopts the role of critical friend who assists in the evaluation of teaching, to develop a reflective practitioner.	Child and Merrill (2003
Mentor as model	Mentor inspires and demonstrates.	Hobson and Sharp (2005)
Mentor as acculturator	Mentor helps the mentee become accustomed to the particular professional culture.	Hobson and Sharp (2005)
Mentor as sponsor	Mentor opens doors and introduces the mentee to the right people. Power and control is not shared; the mentor has primary responsibility for managing the process. Directive styles such as coaching and guiding are used.	Hobson and Sharp (2005); Robins (2006).
Mentor as provider of support	Mentor provides the mentee with a safe place to release emotions or let off steam.	Hobson and Sharp (2005)
Mentor as educator	Mentor listens, coaches and creates appropriate opportunities for the mentee's professional learning.	Hobson and Sharp (2005)
Development model	Non-directive styles such as counselling and facilitating are used. Balance of formal and informal arrangements. Personal and professional change through reflection.	Robins (2006)

Table 2.17 Descriptions of Specific Mentoring and Coaching Models (Lord *et al* 2008: 21)

Joyce and Showers (2002) have highlighted the powerful impact coaching can have on teaching and learning, advocating 'coaching as an essential ingredient in using new knowledge to change practice' (2002:1). In 2005 the then DfES (precursor to the DfE) commissioned a national framework for mentoring and coaching (CUREE 2005). The intention was to disseminate good practice with the aim of increasing the impact of continuous professional development on student learning. With this impact now recognized (Hattie 2012), Table 2.18

highlights some of the positive effects associated with student learning (CUREE 2005).

• Enhanced students' learning, motivation and outcomes
• Enhancement with teachers' commitment, beliefs, attitudes, self-esteem and confidence in making a difference to their students' learning
• Enhancement with teachers' repertoires of strategies and their ability to match their teaching approaches to students' different needs
• Enhanced teachers' attitudes to their students, the curriculum and to learning, and teachers' commitment to CPD

Table 2.18 Positive effects of Mentoring and Coaching (CUREE 2005)

Lord *et al* (2008) also report a range of impacts resulting from mentoring and coaching, including engendering a culture of professionalism within which enhanced knowledge and skills can be shared. In light of the Carter (2015) review, of Initial Teacher Training (ITT), several recommendations relating to mentoring and coaching for trainee teachers were advocated. Strong evidence suggested quality mentoring during ITT was critically important for the mentee *and* the mentor and provided professional development for both individuals, whilst simultaneously developing the potential of the whole school. But it was reported that mentoring was not as good as it could be with variable standards across England (Carter 2015). Recommendations were made concerning the recruitment and training of mentors outlining that they should be excellent teachers *and* subject experts, who could demonstrate outstanding practice as well as disseminate valuable ideas and concepts; they should also be rigorously trained (Carter 2015). In response to Carter's (2015) recommendations, non-statutory national standards for school-based ITT mentors, underpinned by the Teachers' Standards (GOV.UK 2011b), were introduced in July 2016 (GOV.UK

2016d). All ITT providers have been encouraged to adopt these mentor standards with the further recommendation that these standards should extend beyond ITT to also include early career teachers. The government white paper *Educational Excellence Everywhere* (GOV.UK 2016c: 3) announced the move to a stronger and more challenging teacher accreditation and it is suggested mentoring could be crucial in this more demanding landscape. The mentor standards are intended to achieve three main aims, and these are outlined in Table 2.19 below.

• To foster greater consistency in the practice of mentors by identifying the effective characteristics of mentoring, leading, in turn, to an improved and more coherent experience for trainees, so that they develop into effective teachers
• To raise the profile of mentoring and provide a framework for the professional development of current and aspiring mentors. The contribution mentors make to their colleagues' practice will help raise standards and in turn improve the quality of teaching across the profession, leading to improved outcomes for children
• To contribute towards the building of a culture of coaching and mentoring in schools

Table 2.19 National Standards for School-Based Initial Teacher Training (ITT) Mentors

The Carter (2015) recommendations - which clearly suggest mentors should have excellent subject knowledge and a clear understanding of what constitutes high-quality teaching in a variety of contexts (GOV.UK 2016d) - embody Wragg et al's (2002) findings: teachers consider lesson feedback most useful when the observer is a subject specialist. Evans et al (2014) conducted a further study into the significance of subject expertise in relation to providing feedback on observed mathematics lessons, and they concluded that written reports from subject specialists were both discernable from those of the non-specialists, and perceived to be 'more useful in terms of helping teachers improve their practice than those written by non-specialists' (2014: 38). With a 'paucity of advice offered by non-specialists' (Evans et al 2014: 39), Evans et al's (2014) findings echoed those of Wragg et al's (2002): feedback from non-specialists could be 'bereft of ideas' and 'bland' (Wragg et al 2002: 200-203). Mathematics specialist educators can offer substantially more in way of feedback – both in relation to subject specifics and to the general teaching of a mathematics lesson (Evans et al 2014, Ingram et al 2018).

Lord *et al* (2008) identify the relationship between mentor and mentee as critical for effectiveness, suggesting that it may be beneficial for the mentor to be from an independent institution. They also consider it critical that the mentor/coach is a knowledgeable, experience and successful practitioner. In addition, important qualities and characteristics and skills were identified as being significant to the effectiveness of a mentor/coach, and include: 'trust, respect, approachability, empathy, flexibility and self-awareness…listening skills, communication skills and interpersonal skills' (2008: 39). Thus enabling a relationship between mentor and mentee to be approached with sensitivity and understanding (Renshaw 2009).

The main elements of a mentoring process, as described by Renshaw (2009), are outlined in Table 2.20 below:

• Developing a non-judgmental, non-threatening working relationship based on empathy, trust and mutual respect
• Establishing a safe, supportive learning environment
• Creating conditions that encourage openness, honesty, informality and risk-taking
• Defining boundaries and ground rules before commencing the process, by drawing up a mentoring or learning agreement
• Building rapport and a clear understanding of who does what and why
• Allowing the person being mentored (the mentee) to determine their own agenda, to select their shared focus and shape their process of learning

Table 2.20 Main Elements of a Mentoring Process (Renshaw 2009: 3)

Obstacles and challenges do exist in implementing mentoring, and these often centre around time and workload pressures. Lord *et al* (2008) suggest sufficient time should be allocated to teachers as part of their timetable commitment; time for lesson observations and time for constructive feedback sessions. Coe *et al* (2014) recommend a specialist teacher be appointed to mentor colleagues; this mentor-teacher could also teach cover lessons to free up others to undertake professional learning activities. Mentoring and coaching are not cheap options for supporting teachers' professional development, and require commitment and support from senior management and leadership teams. It is an investment many believe worth making as it is one which has potentially powerful benefits for both student learning and teacher retention (Hobson *et al* 2015).

It has been suggested that pressures on time could lead to a conflict of interest with the role of mentor being combined with the role of assessor (Lord *et al* 2008). This is to be avoided at all costs (Renshaw 2009). Hobson *et al* (2015) seek to minimize the 'performance' (2015: 101) aspect of observations and evaluation (often related to Ofsted) and call for a more developmental approach to be taken to lesson observations. This, they argue, will provide the scope for support which encourages risk taking, embraces learning from mistakes and enables honest discussions in a safe, non-judgmental environment.

The McKinsey report (2007), cites coaching as a significant and influential component of all top performing educational systems around the globe; and it is seen to have the most impact when school leaders themselves, become immersed in the ideas and benefits of mentoring and coaching (2007:28). Lord *et al* (2008) also describe mentoring and coaching to be more ‘influential’ when they ‘fit’ the wider context of a school or college (2008: viii), with school leaders committed to this programme of professional development.

Lord *et al* (2008) highlight a further potential benefit of mentoring and coaching programmes, by way of alleviating ‘professional isolation’ (2008: viii); an established collaborative learning culture providing a sense of support and community. Renshaw (2009) uses the term ‘co-mentoring’ to describe a collaborative learning process in which both partners engage in an ‘equal exchange of knowledge, skills and experience in relation to a clearly defined shared focus’ (2009: 3). Lesson Study is a model of professional development which involves co-mentoring: a group of teachers collaboratively plan, deliver, observe and discuss lessons that have an agreed pedagogical-content focus. This is discussed in detail in the following section.

2.3.5 Collaborative Practice and Lesson Study

Collaboration is a process which is considered to be at the core of successful professional development programmes (Hiebert *et al* 2002), and collaborative practice has been widely advocated by teachers and academics (Davies and Dunnill 2008). Hiebert *et al* (2002) make the point that collaboration 'ensures that what is discovered will be communicable because it is discovered in the context of group discussion' (2002: 7). The emphasis and focus of collaboration is not in providing social support for participating teachers but in making their knowledge visible and open and understood (Hiebert *et al* 2002).

Lesson Study, originating in Japan, provides a meticulously managed method of collaborative practice and a 'model for large scale, sustainable professional development' (Doig and Groves 2011: 78). Lesson Study, the English translation of the Japanese terms jugyou (instruction or lesson) and kenkyuu (study or research), is used to describe the process commonly used for improving the quality of instruction, especially in mathematics and science (Lewis *et al* 2006). Kyouzai kenkyuu is an element of Lesson Study and can be translated as being concerned with: the research of materials, mathematical content and context, student responses, deep study regarding the content of the subject and how to devise lesson plans (Nishimura 2016). Another element, Jyugyo kentuikai, refers to the post-lesson review (Corcoran and Pepperell 2011). Neriage and matome are also terms linked with Lesson Study. Constructing arguments using students' responses and weaving them together, the learning of the new mathematics is orchestrated by the teacher by way of neriage (Nishimura 2016) and matome is to summarise it all. The huge class-width blackboards, often seen in Japanese classrooms, ideal for neriage and matome (Corcoran and Pepperell 2011, Sani *et al* 2018).

Jugyou kenkyuu has many significant features. A small group of teachers will meet regularly and spend many hours planning and reviewing a single lesson based on previous research regarding students' learning (Hiebert *et al* 2002). This 'research lesson' may be observed by a great number of teachers and university academics, and provides a 'window on the larger vision of education shared by the group of teachers' (Lewis *et al* 2006: 3). The review or feedback session is chaired by the visiting academic (or 'knowledgeable other') with the intention of revising or polishing the teacher's professional knowledge and pedagogy, and their theories of teaching and learning (Lewis *et al* 2006, Hiebert *et al* 2002). From such a thorough review a revised lesson will emerge. The whole cyclical process can thus be summed up as: collaboratively plan, implement, reflect and improve lessons (Perry and Lewis, 2009). However, the aim of such a review is not to simply revise one lesson plan but to build rigour and expertise within the profession, 'by enabling teachers to improve instruction' (Perry and Lewis, 2009: 366) and by being 'part of an ongoing process of deepening understanding of how teachers can bring about the meaningful learning of mathematics' (Corcoran and Pepperell 2011: 215).

This process of professional development has been adapted for western cultures and sensitivities. Lesson Study in England may be summarized by the iterative eight points outlined by Burghes and Robinson (2010: 7), and summarised in Table 2.21.

Stage:	Activity:
1	Choose a suitable topic to study
2	Identify the goals of the unit to study
3	Jointly map out a series of lessons that will achieve these goals
4	Identify the key lesson in the series which then becomes the research lesson
5	Jointly plan the research lesson
6	Others observe the lesson
7	Review and reflect on the lesson
8	Revise the lesson plan and continue the cycle

Table 2.21 Iterative Steps for Lesson Study in England (Burghes and Robinson 2010: 7)

Typically, in England, a Lesson Study group will involve only three teachers and the feedback and review sessions are far less rigorous or critical than in Japan. Rarely is there an outside expert or 'knowledgeable other' in attendance and there have been criticisms that a 'western' version of Lesson Study lacks rigour with a paucity of research and expert input (Pang and Marton 2003). A lack of evidence of the impact of Lesson Study in the western settings has also been cited as an issue (Lewis *et al* 2006). A recent report, Closing the gap: Test and Learn (GOV.UK 2016a), describes the programme by which various interventions were trialed; Research Lesson Study (RLS) was one of these. For advocates of Lesson Study, the results were disappointing. Only NIP (Numicon in Practice) resulted in any significant improvements for mathematics attainment and progress rates. The report did however, suggest that RLS *might* contribute to closing the gap, but in the context of this study none of the results for RLS were considered significant. These findings will undoubtedly be controversial and provoke debate. Burghes and Robinson (2010) make the point that for ‘maximum impact, Lesson Study has to be combined with rethinking what makes effective teaching in mathematics’ – and more work may need to be done in this regard (2010: 19). A consideration of this difficult question remains a constant thread throughout this research study.

Lesson Study is often promoted as an inexpensive and sustainable form of continuous professional development (Dudley 2014). But Lesson Study is ‘hard and requires commitment. It is no quick fix’ (Burghes and Robinson 2010: 7). Lesson Study ‘takes time’ and teacher time is an expensive (and sometimes scarce) resource – with ‘a greater shortage of teacher time in England’ (Bowland 2014a: 3). Head teachers may sometimes endorse collaborative practice but fail to invest in practical support and time allocation (Bowland 2014a: 4). In practice, lack of time and opportunities often squeeze the process. Academic rigour and overt connections to teaching and learning research theories - so key in Japanese Lesson Study - are often absent. And without this rigour there is a danger that poor practice could be promoted and perpetuated (Burghes and Robinson 2010).

Nevertheless, Lesson Study western-style can provide a vehicle for collaborative practice to be regular and sustained. The National College for School Leadership (NCSL) (2005) promoted this idea and produced a series of resources under the umbrella of ‘Networked Learning Communities’. The idea is a Networked Research Lesson Study helps slow a lesson down so more can be seen and more is visible. In this way a teacher ‘can improve, innovate and transfer practice more effectively’, providing a vehicle for new teachers to engage in ‘deep’ professional learning (NCSL 2005: 3).

However, there are real concerns about the impact Lesson Study may have on day-to-day school life; ‘Losing class time with high stakes exam classes’ (Parliament. House of Commons Education Committee 2017: 20), being one such example. With too few mathematics teachers in the classroom in the first instance, permitting release time for teachers to engage with collaborative practice can seem counter-intuitive. Offering realistic, workable models for how schools could organize Lesson Study seems a sensible approach. One such model is used in Singapore: Every Tuesday school starts one hour later for the students; the teachers then use this hour for Lesson Study (Sani *et al* 2018). When a research lesson is ready to be taught, one class is invited to arrive at the ‘normal’ time. A similar approach, of shortening the school day for pupils, has in fact been suggested in the Sutton Trust report (2015), with a dedicated session once a fortnight for focused professional development.

Loss of teaching time, and the impact of this on students, is certainly a significant concern in relation to Lesson Study in England (Wiliam 2016). With little agreement about what Lesson Study actually is, much of what may be worthwhile may be lost in the translation from one culture to another (Wiliam 2016). Hodgen (2011: 39) agrees and suggests ‘translating the Japanese practice of lesson study to western context maybe a misguided attempt to transfer a very contextualised cultural practice’ (Hodgen 2011: 39).

Teacher time is another issue in regard to Lesson Study, with teachers in England teaching far more hours than many of their contemporaries in other cultures (OECD 2017). Lesson Study may simply not be feasible when there is so little time in which to attempt to do it (Bowland 2014a, Wiliam 2016).

Weighing up the costs versus benefits of Lesson Study, Wiliam (2016) questions whether there is sufficient evidence for its value for it to be a priority in schools. However, Lesson Study is 'not about perfecting one lesson', but focuses on 'developing teachers' ideas and experiences of different approaches to teaching' (Doig and Groves 2011: 86). If the 'lesson study approach is built on the collective development of teaching effectiveness through collaborative work and reflection on practice', it may offer a great deal to enhance mathematics teaching' (Corcoran and Pepperell 2011: 213).

Lesson Study requires commitment, and for successful implementation school leadership is undoubtedly key; school leadership is discussed in more detail in the following section.

2.3.6 Context and Culture

> *'If school leaders have one priority, it is to create in their schools the conditions for growth for their students and staff.'* (John Tomsett, Sutton Trust 2015: 19)

Considering the development of expert practitioners, Berliner (2001) suggests there are three factors at play: potential innate talent; considerable deliberate practice (both discussed in 2.2) and the context within which the practitioner operates. Berliner believes it is the *context* which is *the* most significant determinant in securing successful development: 'The working conditions of teachers exert a powerful influence on the development of expertise' (Berliner 2001: 463). It is the school systems, policies and culture which powerfully determine 'teachers' attitudes, beliefs, enthusiasm, sense of efficacy, conception of their responsibilities, and teaching practices' (Berliner 2001: 466).

This has all been reiterated by Darling-Hammond (2014) – and discussed in 2.2.

A common belief is that teachers primarily develop during an initial time frame, typically up to a period of the first 3 to 5 years. The 2015 Sutton Trust report have found that teachers *can* and *do* continue to develop well beyond their initial first few years of teaching. But for this to be the case, teachers need to be well supported at all stages of their careers: ‘Teachers working in schools with more supportive professional environments continued to improve significantly after three years, while teachers in the least supportive schools actually declined in their effectiveness.’ (Sutton Trust 2015: 8). The findings from the 2012 OECD report reinforce the idea that ‘quality professional continuing development’ is essential, for teachers to face future challenges and to deal with the increasing ‘demands of diverse student populations’ (Schleicher 2012: 77).

Research concerning the value of leadership has shown that school leadership is ‘second only to classroom teaching as an influence on learning’ (McKinsey 2007: 29). Effective school leaders set a ‘culture of high expectations’ and encourage ‘continuous improvement’ (McKinsey 2007: 30). Successful systems from around the world expect their school leaders to follow the model of ‘instructional leadership’ as opposed to ‘school administration’ and to be excellent practitioners who can meaningfully engage with the process of coaching to empower and enable others in their teams (McKinsey 2007: 30). Recommendations from the Mathematics Made to Measure report (Ofsted 2012) also make it clear that school leaders should promote the development of staff expertise. Hargreaves (1999) discusses the implications for leaders in terms of what has been discovered in regard to ‘knowledge-creating’ schools. With knowledge created in one of four ways, through ‘socialisation, externalization, internalization, or a combination of methods’, leaders may choose to consider whether professional development offers opportunities to:

- share experience through apprenticeship models or mentoring
- develop tacit knowledge into explicit knowledge through collaborative reflection
- develop ‘learning by doing’ where explicit knowledge becomes implicit
- network with people from different organisations

(Hargreaves 1999: 125):

Professional development is seen to be most successful when embedded in a wider culture of enrichment, encouraged by effective leadership (GOV.UK 2016e); these ideals outlined in Table 2.22.

	Effective leadership of professional development:
•	is clear about how it improves pupil outcomes
•	**complements a clear, ambitious curriculum and vision for pupil success**;
•	involves **leaders modelling & championing effective professional development** as an expectation for all
•	**ensures that sufficient time and resource is available**
•	**balances** school, subject and individual teachers’ **priorities**
•	develops **genuine professional trust**

Table 2.22 Effective Leadership of Professional Development, DfE (2016)

The standards for teachers’ professional development, introduced in 2016 (GOV.UK 2016e: 6), describe five key focus ideas for professional development, outlined in Table 2.23.

1.	Professional development should have a focus on improving and evaluating pupil outcomes
2.	Professional development should be underpinned by robust evidence and expertise
3.	Professional development should include collaboration and expert challenge
4.	Professional development programmes should be sustained over time
	And all this is underpinned by, and requires that:
5.	Professional development must be prioritised by school leadership

Table 2.23 Five Key Focus Ideas for Professional Development, DfE (2016)

Guskey (2005), keen to consider the impact of professional development in education, trialed a four-stage model of evaluation based on an industry exemplar. Realising that professional development efforts were not yielding positive results, Guskey (2005) discovered that although the training aspect was often successful, teachers subsequently returned to schools which then failed to support them. Guskey (2005) added another level to the evaluation model (Level 3) - labeled ‘Organizational Support and Change’ - and we now have the familiar ‘Five Levels of Professional Development Evaluation’, shown in Table 2.24 below.

Evaluation Level	What Questions Are Addressed?	How Will Information Be Gathered?	What Is Measured or Assessed?	How Will Information Be Used?
1. Participants' Reactions	Did they like it? Was their time well spent? Did the material make sense? Will it be useful? Was the leader knowledgeable and helpful? Were the refreshments fresh and tasty? Was the room the right temperature? Were the chairs comfortable?	Questionnaires administered at the end of the session	Initial satisfaction with the experience	To improve program design and delivery
2. Participants' Learning	Did participants acquire the intended knowledge and skills?	Paper-and-pencil instruments Simulations Demonstrations Participant reflections (oral and/or written) Participant portfolios	New knowledge and skills of participants	To improve program content, format, and organization
3. Organization Support & Change	Was implementation advocated, facilitated, and supported? Was the support public and overt? Were problems addressed quickly and efficiently? Were sufficient resources made available? Were successes recognized and shared? What was the impact on the organization? Did it affect the organization's climate and procedures?	District and school records Minutes from follow-up meetings Questionnaires Structured interviews with participants and district or school administrators Participant portfolios	The organization's advocacy, support, accommodation, facilitation, and recognition	To document and improve organization support To inform future change efforts
4. Participants' Use of New Knowledge and Skills	Did participants effectively apply the new knowledge and skills?	Questionnaires Structured interviews with participants and their supervisors Participant reflections (oral and/or written) Participant portfolios Direct observations Video or audio tapes	Degree and quality of implementation	To document and improve the implementation of program content
5. Student Learning Outcomes	What was the impact on students? Did it affect student performance or achievement? Did it influence students' physical or emotional well-being? Are students more confident as learners? Is student attendance improving? Are dropouts decreasing?	Student records School records Questionnaires Structured interviews with students, parents, teachers, and/or administrators Participant portfolios	Student learning outcomes: - Cognitive (Performance & Achievement) - Affective (Attitudes & Dispositions) - Psychomotor (Skills & Behaviors)	To focus and improve all aspects of program design, implementation, and follow-up To demonstrate the overall impact of professional development

Table 2.24 Guskey's 'Five Levels of Professional Development Evaluation' model

Reversing the levels for professional development planning is becoming increasingly common with the consideration of ‘Level 5: Student Learning Outcomes’ as the starting point. This clearly links with lists above (GOV.UK 2016e) – placing a key focus on improving and evaluating ‘pupil outcomes’. In either case, it is at the Level 3 stage of ‘Organisational Support and Change’, needed to facilitate new development, where progress is most likely to falter (Guskey 2005).

In addition to the lack of organisational support, problems also arise when teachers are experimenting with new ideas or approaches - and sense the need for rapid results. In absence of such immediate evidence, teachers often revert to a familiar set of beliefs, these often reflecting the way they themselves were taught (Burghes and Robinson 2010, Stigler and Hiebert 1999, Wiliam 2016). Ernest (1989) argues that teacher beliefs have a powerful effect on the efficacy of teaching mathematics. However, espoused views or beliefs regarding teaching, can sometimes be seen to be quite different to teachers’ enacted versions of teaching (Ernest 1989). Affecting teacher beliefs are two key factors: the ‘social context’ of teaching and the level of ‘teacher’s thought’ (1989: 6). Higher levels of ‘thought’ galvanize a teacher to reflect on, and so narrow, ‘the gap between beliefs and practice’ (1989: 6); beliefs may become more aligned to practice, and this Ernest believes, is a key element in enabling ‘autonomy’ in teaching (1989: 6). In contrast, autonomy could be restricted by constraints set by the ‘social context’ (a mathematics department, for example). Ernest (1989) describes how the powerful influence exerted by these social contexts (the expectations of colleagues, the department norms, the community, the curriculum, the systems and the policies) can lead to a teacher internalising a significant set of constraints. It is these constraints which may determine the dominating influence of how a teacher enacts their version of teaching mathematics: ‘The socialisation effect of the context is so powerful that despite having differing beliefs about mathematics and its teaching, teachers in the same school are often observed to adopt similar classroom practices’ (Ernest 1989: 5).

In England all maintained schools and academies are inspected by Ofsted with the aim to ‘improve the overall quality of education and training’ (GOV.UK 2018b). The debate regarding Ofsted’s impact on schools and teachers, and whether it is fulfilling its remit to improve education, is a long standing one (Scanlon 1999). Survey results from Iris Connect (2014) suggest that more than 90% of teachers believe that inspections make no difference to student academic achievements. Stress related to inspections is significant with 93% of teachers reporting that inspections contribute to stress and 88% of teachers reporting symptoms of anxiety prior to inspection (Iris Connect 2014).

The pressures on schools to perform and achieve competitive GCSE results have been immense and ever increasing, with the dominance of school league tables. Spielman (GOV.UK 2017), recognising some schools may feel a tension between good examination results and a good curriculum, has recently suggested she is prepared to consider whether Ofsted has played a part in distorting the curriculum and the priorities of school leaders. Believing it unlikely school leaders would have deliberately prioritised testing and exam performance above a quality curriculum, Spielman (GOV.UK 2017) recognizes that inspection may well have unintentionally contributed to the emphasis on examination results by reinforcing ‘the focus on measures’ and ‘performance tables’ (2017: 4). According to Spielman (GOV.UK 2017), teaching-to-the-test is a practice not to be recommended and can leave students with ‘a hollowed out and flimsy understanding' (2017: 2). However, as Goldstein (1997) points out, performance tables are reliant on GCSE and Key Stage 2 National Curriculum test results, which encourages teaching-to-the-test and narrows the curriculum for pupils. Smith (2017b) also refers to the problematic 'teaching to the test culture' at GCSE, leading to limited understanding with over-reliance on procedures and memorization, and a general lack of confidence with, and interest in, mathematics (2017b: 81).

Today's league tables now need to reflect Progress 8 (GOV.UK 2014a). Instead of a narrow focus to suggest success (for example, five grades A* to C), the new performance measures reward schools for the teaching of *all* their students, measuring performance across 8 qualifications: Every increase in every grade a student achieves will attract additional points in the performance tables (GOV.UK 2014a), with English and mathematics double-weighted. Traditionally the weakest mathematics teachers have been deployed to the lowest attaining students (Ofsted 2012) and the 'best teachers' allocated to 'those pupils close to the C/D borderline' (Slater, 2009: 644). With effective practitioners able to deliver a disproportionately positive impact, in terms of mathematics achievement gains, for lower attaining students (Wiliam 2016, Marshall 2013), senior leaders (with Progress 8 in mind) may now reconsider the deployment of their weaker teachers.

With the Progress 8 influence, professional development 'as a mechanism to improve teaching' (Garet *et al* 2001: 937) may achieve higher prominence. However, Garet *et al* (2001) point out that 'if we are serious about using professional development' to improve teaching, 'we need to invest', but agree that a major challenge to providing high quality professional development is ‘cost’ (2001: 937). One solution they offer, is to focus resources on fewer teachers. This poses an interesting question regarding which teachers would benefit most (and this question is revisited in 2.4). Financial constraints have certainly impacted on schools. Some school leaders have reported that it is difficult to fund professional development (Spielman, GOV.UK 2017) in the current financial climate. The Sutton Trust Report (2015) suggests, in this time of austerity, schools must ‘resist the urge to squeeze every last hour of teaching’ from teachers; but rather, ‘give them time and space to work on their practice' (2015: 9).

2.3.7 Summary of Professional Development

Boyle et al (2005) suggest certain types of professional development are more likely than others to offer ‘sustained learning opportunities’ (2005: 5). These characterised by those which provide ‘sufficient time’ and space to increase subject knowledge and ‘encourage meaningful changes in classroom practice’ (2005: 5). Such professional development includes ‘collaborative interactions’, coaching and mentoring, networks, and immersion ‘in which teachers engage in the kinds of learning that they are expected to practice with their students’ (2005: 5).

Professional development is not optional; ‘There is no shortcut to being a great teacher’ (Sutton Trust 2015: 9). For non-specialist mathematics teachers teaching out-of-field, the path to becoming ‘a great teacher’ maybe even longer. Issues of out-of-field teaching are ‘mostly overlooked by school-leaders’ (du Plessis 2017) and some pertinent points are considered in 2.4.

2.4 Non-Specialist Mathematics Teachers

A distinction between ‘specialist’ and ‘non-specialist’ mathematics teachers was made in 2.1.

In England teachers *do* have specialisms but these are not related to QTS (Qualified Teacher Status): QTS is non-subject specific (Howson 2015). Senior leaders are therefore free to assign any teaching work within the school to any teacher (Howson 2015). With the ever increasing shortage of specialist mathematics teachers, growing numbers of non-specialist teachers are being directed to teach beyond their area of expertise to teach mathematics. Acronyms, for teachers teaching outside their subject in which they initially trained, are now commonplace, for example TOOF (Teaching out of field), OOF (Out of field teaching) and TAS (Teaching across specialisations).

2.4.1 Teaching Out Of Field (TOOF) / Out Of Field Teaching (OOF)/ Teaching Across Specialisations (TAS)

‘Teaching Out Of Field’ (TOOF), ‘Out Of Field teaching’ (OOF) and ‘Teaching Across Specialisations’ (TAS) are terms which have recently come into play, possibly in recognition of more teachers fulfilling these roles, in what has become an international phenomenon (Crisan and Rodd 2015). TOOF, OOF and TAS are defined as: teaching a subject or stage without the necessary training or qualifications (du Plessis 2015, Crisan and Rodd 2015).

Darling-Hammond (2014) draws parallels between TOOF teachers, teaching in subjects beyond the boundaries of their specialism, with highly skilled medical practitioners being deployed to practice outside their skill base, suggesting it is not an efficient (or considered) use of resource. Questioning the 'fit' between teachers' qualifications and what they are asked to teach, Darling-Hammond (2014) suggests: 'a well-prepared teacher may perform poorly when asked to teach outside the field of his or her preparation' (2014: 7). Ingersoll (2002) suggests that teaching a subject for which one has a little background or interest is not only challenging for the teacher but also detrimental to the student. Smith (2004) also revealed the 'shortages of specialist teachers in mathematics was having an adverse effect on pupils' performance' (2004: 21).

The Teaching Across Specialisations (TAS) Collective website (2016) recently came into being with the advent of the first TAS Collective Symposium in 2014. The website, responding to a growing interest in the issues of TAS, draws to together current research and aims to inform researchers, schools, teacher educators, parents, and policy makers of the issues relating to out-of-field teaching. It is suggested that TAS is beginning to draw the attention of researchers and policy makers worldwide because of 'the evidence showing that teacher quality is a major determinant of student success' (Teaching Across Specialisations Collective 2016). The significance of teacher quality in relation to student outcomes is discussed in detail in 2.1.1.

The Smith (2004) inquiry recognised that the serious shortfall of specialist mathematics teachers would never be met by recruiting mathematics graduates. Therefore, alternative solutions needed to be sought. The inquiry was supportive of the many schemes and initiatives which were in place to boost the numbers considering, and eligible for, mathematics teacher training. These included subject enhancements courses for non-specialist graduates and schemes for encouraging more undergraduates to consider a teaching career. Smith (2004), realising these schemes would potentially attract applicants with varying levels of mathematics knowledge, recommended consideration be given to a new mathematics teacher certification scheme, which awarded certification only to certain ages and stages, for example up to Key Stage 3. This recommendation was not endorsed.

The suggestion by Smith (2004), to enhance professional development for retraining non-specialist teachers *was* endorsed. Issues connected with retraining teachers are discussed in the next section.

2.4.2 Retraining Teachers

In the light of Smith's (2004) recommendations, the Mathematics Development Programme for Teachers (MDPT) was launched in 2009. Qualified teachers who were non-specialist and teaching mathematics at secondary level, were eligible to participate. The MDPT programme was subsequently replaced, in 2011, by the more moderately funded Subject Knowledge Enhancement Plus (SKE+) course.

In section 2.3, expense was discussed as a barrier to professional development. One solution Garet *et al* (2001) suggested was to focus funds on fewer teachers. Directing these restricted resources toward non-specialist teachers may be prudent. Coe *et al* (2014) report on findings from a number of studies that connect the teachers' understanding of the mathematics they are teaching with the efficacy with which students learn it. Collating various studies, including their own, they found the difference between high and low scoring teachers (in terms of pedagogical content knowledge (PCK)) was associated with more than a month's additional learning for students in a year (Coe *et al* 2014). Coe *et al* (2014) describe this effect, as of similar significance to that of the relationship between socioeconomic background and attainment. 'Low scoring' teachers were defined as those who scored 20% or below on PCK tests. Once teachers scored above this, there was no observed relationship with the student learning (Coe *et al*, 2014). This may suggest that a real difference could be made by concentrating PCK professional development opportunities on those mathematics teachers with the least subject knowledge; non-specialist teachers of mathematics are likely to populate this category.

Crisan and Rodd (2011) conducted a research study following five case study teachers who had been retrained through MDPT, and posed the question: how do already qualified teachers of other subjects come to see themselves as mathematics teachers? During the course of their study, Crisan and Rodd (2011) discovered 'affective reactions to standard school mathematics' (2011: 30) with one teacher being reduced to tears when solving linear simultaneous equations. This emotive reaction to mathematics amongst their case study teachers was often underpinned by a lack of confidence, and ability, in their own mathematics. A lack of mathematical sense making, combined with considerable reliance on 'instrumental' methods led to a series of 'defense mechanisms' by many - including 'avoidance' and 'hand-holding' (Crisan and Rodd 2011: 30). Case study teachers typically construed the level of understanding required of a topic, to be of the same standard required of students; depth and rigour of understanding were often absent (Crisan and Rodd 2011).

Certification was seen to be significant. Crisan and Rodd (2011) noted the phrase ‘desperate to get it’ was actually used by at least three of the teachers (2011: 33); accreditation suggesting membership to a community of mathematics teachers, with the associated enhanced employment prospects. Crisan and Rodd (2011) were curious about this ‘gift of membership’ and posed questions about the quality of this membership (2011: 34). Although officially accredited, analysis of their mathematical and pedagogical work showed that these case study teachers still ‘lacked fluency with mathematics and were far from having secure subject knowledge’ (2011: 34). Acknowledging their subject short comings, some teachers framed their difficulties in terms being a help rather than a hindrance, enabling them to empathise with struggling students.

Wenger (1998) suggests teachers ‘negotiate’ their contribution to, and participation within, a community of mathematics teaching (1998: 2). Crisan and Rodd (2011) believe their case study teachers did likewise, using their limitations to position themselves:

> ‘as outsiders (as they do not have a strong mathematical background), they focus their attention on the meanings that really matter to them: their struggle with mathematics gives them a special insight into understanding pupils’ difficulties with mathematics and this privileged viewpoint offers them access to participating and contributing to the mathematics teaching profession’
>
> (Crisan and Rodd 2011: 34).

Linking with the idea of belonging to a community, Grootenboer and Zvenberger (2008) suggest: ‘It is essential that teachers of mathematics (at all levels) have well-developed personal mathematical identities’ (2008: 248), and that this can be an issue for out-of-field teachers (Hobbs 2015). The impact on teachers, being required to teach out-of-field, is not limited to issues surrounding appropriate subject and pedagogical content knowledge but also on teacher-identity affecting self-efficacy, attitudes, motivations and well-being (Hobbs 2015). This impact is not always recognized by senior leaders, or other members of the school community (Hobbs 2015). Hobbs (2015) also highlights the issue of accountability measures in relation to out-of-field teaching and questions whether it is ethical to apply performance measures to out-of-field teachers in the same way as to specialist teachers.

In South Korea, out-of-field teaching is considered an issue even though only 2% of secondary school teachers teach out-of-field (Kim and Kim 2015). These teachers can now acquire a new qualification through Minor Qualification Education (MQE) – a programme designed to help teachers obtain additional qualifications to teach subjects out-of-field when required. It is reported such teachers continue to experience identity crisis as they do not feel fully fledged members of any one teaching community (Kim and Kim 2015).

In Ireland, out-of-field mathematics teaching is commonplace with around 48% of mathematics taught by non-specialists (Ní Ríordáin and Hannigan 2011). These teachers are generally deployed to teach the lower years and weaker students (Ní Ríordáin and Hannigan 2011). A two-year fully-funded part-time Professional Diploma in Mathematics for Teaching (PDMT) was introduced in 2012 to address subject knowledge issues and to upskill teachers (Department of Education and Skills, Ireland). The aims of this programme are listed in Table 2.25.

• acquire the extensive and complex integrated knowledge base including mathematical and pedagogical knowledge that is necessary for effective mathematics teaching at post-primary level with special reference to Project Maths
• demonstrate an ability to integrate this mathematics knowledge for teaching into professional practice as mathematics teachers
• develop a high standard of practical competence in mathematics teaching as reflective practitioners during their programme of study

Table 2.25 The Aims of Ireland's Professional Diploma in Mathematics for Teaching (PDMT)

Teachers' beliefs surrounding the teaching and learning of mathematics and their subject and pedagogical knowledge of mathematics have been evaluated by Ní Ríordáin and Faulkner (2015), both on commencement and completion of the PDMT programme. Findings have shown wide variations in pedagogical content knowledge and conceptual understanding of mathematics amongst participants (Ní Ríordáin and Faulkner 2015). Ní Ríordáin and Faulkner (2015) believe such ongoing research has significant implications for understanding areas in which out-of-field mathematics teachers need most support and for designing such professional development programmes for the future.

In England around 30% of mathematics lessons are taught by non-specialist teachers (Smith 2004, Jones 2016). Only a fraction of these teachers have benefited from retraining opportunities, of which there is still limited research and relevant literature. Further research surrounding retraining teachers is clearly needed.

2.5 Summary

Acknowledging that there are simply too few effective mathematics teachers, the current government is investing significantly and a major plank of the Government's current plan is the Teacher Subject Specialism Training (TSST) retraining programme (GOV.UK 2018a). The Educational Excellence Everywhere Whitepaper (GOV.UK 2016c) announced that the government would ensure that 'teacher subject specialism training (TSST) continues to be available to improve the mathematics subject knowledge of existing non-specialist teachers' (2016c: 26). And this commitment was reiterated by Smith (2017b): 'The department for education is putting in place a range of additional measures to improve teacher supply, including mathematics subject training for non-mathematics specialists and for those returning to the profession (2017b: 10).

Chapter 3 explores the retraining opportunities for non-specialist teachers of mathematics, and in particular the model of retraining employed during this longitudinal research study.

Chapter 3: Retraining Non-Specialist Mathematics Teachers

3.0 A Short History and Background to the Retraining Opportunities in England

‘*There can be no doubt that the most important resource for good mathematics teaching is an adequate supply of competent mathematics teachers.’* Cockcroft (1982: 188)

In 1982, the influential and comprehensive Cockcroft (1982) report was published, summoning up the prevailing state of mathematics education within the UK. In the opening lines of the report were the words from the then secretary of state, Keith Joseph: ‘Few subjects in the school curriculum are as important to the future of the nation as mathematics; and few have been the subject of more comment and criticism’. The Cockcroft (1982) report tackled this criticism head on and prompted widespread discussion and debate – which still resonates within the mathematics community today.

A key concern, identified by the Cockcroft (1982) report, was the shortage of specialist mathematics teachers, and this was thought to be exacerbated with mathematics being ‘especially vulnerable to weak teaching’ (1982: 188). Suggesting there were no other areas of the curriculum, where a teacher had ‘more influence over the attitudes’ and ‘understanding’ than in mathematics (1982: 188), the Cockcroft report continued to advise that a teacher of mathematics ‘may influence for good or ill the attitudes to mathematics of several thousand young people, and decisively affect many of their career choices’ (1982: 188). Hence, it was suggested all students should be entitled to be taught effectually, ‘in the company of enthusiastic and well qualified mathematics teachers' (Cockcroft 1982: 188).

Concluding that the most important resource for good mathematics teaching was an adequate supply of competent mathematics teachers, the Cockcroft report charted a course for the future, outlining strategies for achieving such a supply. Several suggestions were made including: conducting a 'concerted campaign' to attract more mathematics graduates into teaching, backed by financial incentives (1982: 202); undertaking measures so as to *retain* effective mathematics teachers within the profession; improving the effectiveness of existing 'under-qualified teachers' of mathematics, by means of appropriate professional development (1982: 193).

The advantages and disadvantages of different retraining professional development models were considered: part-time courses could provide opportunities for teachers to experiment with ideas between sessions, but the scope for continuity could be limited; full-time courses could enable teachers to devote their full attention to the training, without the distractions of daily school life, but completely remove the teacher from their classroom practice; residential courses could provide additional opportunities for reflection and discussion, but at an additional financial cost. For all these modes of delivery, suitable follow-up sessions were considered to be essential – without which, 'long term effectiveness would be greatly diminished' (Cockcroft 1982: 226).

Limitations, with regard to providing effective professional development for non-specialist teachers, were suggested (Cockcroft 1982). The range of mathematical knowledge and experience amongst non-specialist teachers could conceivably be wide, and organizing the content and level of a course to suit all participants could prove problematic. Teacher development could also be limited with ‘in-service training courses’ resulting ‘in no long-term improvement because of lack of interest or support when a teacher returns to his school’ (Cockcroft 1982: 226). The cost of providing retraining for teachers, with the associated teacher-release time, was also recognized as a potential barrier. Without the will to make the necessary financial provision, the Cockcroft report concluded, there would be insufficient ‘opportunity to influence and improve the quality of mathematics teaching’ (1982: 229).

A little over two decades later, the Smith (2004) report was published: Making Mathematics Count, the title undoubtedly recalling and reviving the Cockcroft (1982) report: Mathematics Counts. Addressing some of the same issues, the Smith (2004) report concluded there were three broad areas of concern with mathematics education in the UK: an inadequate curriculum to meet all learners’ needs; the shortage of specialist mathematics teachers; the need for professional development ‘to support and sustain and enhance current teachers of mathematics’ (2004: 9).

As Cockcroft (1982) had done previously, the Smith (2004) report set out a series of recommendations to address these concerns, and three years later, the government funded Mathematics Development Programme for Teachers (MDPT) was launched.

At the time of the Smith (2004) report being published, and prior to the MDPT being developed, the Mathematics Enhancement Course (MEC), funded by the government, was being piloted. This scheme was aimed at graduates without a mathematics specialism, to ‘boost’ the number of eligible applicants for mathematics *initial teacher training* (Smith 2004: 47). Universities had autonomy to design their own MEC courses with the original

MEC specification recommending 550 of teaching hours (Stevenson 2013). The face-to-face sessions on the MEC were led by experienced mathematics education tutors, and the modelling of good practice for teaching and learning was considered as a strength of the MEC course (Stevenson 2013). These MEC type courses are now under the umbrella of Subject Knowledge Enhancement (SKE) professional development opportunities (GOV.UK 2014c).

Following the MEC, the Mathematics Development Programme for Teachers (MDPT), for *qualified* non-specialist teachers of mathematics, was piloted with three universities between 2007- 2009, before being offered by 12 providers in the following two years (Stevenson 2013). Again, each provider had the autonomy to design their own programme. The MDPT was a fully funded part-time course, eligibility for which depended on teachers (with no mathematics qualifications at degree level) having the support of their head teacher and being allocated a school-based mentor (Crisan and Rodd 2011). In essence, MDPT was intended to enhance subject knowledge, but, as with the MEC, the associated pedagogy was inevitably interwoven (Stevenson 2013). The structure of the course included 30 university days and 10 school-based days, with specific pedagogical tasks to complete (Crisan and Rodd 2011). Supply cover costs were available for teacher release days, and participating teachers were offered a £5000 bursary on completion of the course; completion requiring at least 80% attendance and an assessment equivalent to 40 undergraduate credits (Crisan and Rodd 2011). On successful completion, the teachers were considered to have gained an ‘additional specialism’ in mathematics (TDA 2009: 10, cited in Crisan and Rodd 2011).

In 2011, the MDPT was replaced by a much contracted (in terms of both budget and time) programme for subject knowledge enhancement. This new programme, for qualified but non-specialist teachers of mathematics, was named as Subject Knowledge Enhancement Plus (SKE+) to distinguish it from the existing pre-ITT SKE courses. The eligibility criteria for SKE+ was similar to that for its predecessor, the MDPT, but now also included ‘returners’ - teachers returning to the profession after an absence of 3 years or more (Crisan and Rodd 2011).

From 2012, the Centre for Innovation in Mathematics Teaching (CIMT) at Plymouth University led around thirty SKE+ courses, in a variety of locations throughout England. The Plymouth University SKE+ model was based on a blended learning approach with: one hundred hours of *face-to-face* meetings led by tutors, focusing on key subject knowledge concepts combined with enhancing pedagogy; and one hundred hours of *e-learning* for detailed subject knowledge enhancement and online assessment. As with its predecessor, the MDPT, there was no single or prescribed model for a SKE+ retraining programme. Each tutor had the autonomy to deliver the aims of the Plymouth University SKE+ using their own acumen; the overarching aims outlined in Table 3.1.

. Enhance participants’ mathematical knowledge to give confidence to teach up to and including Higher Level GCSE Mathematics;
. Inspire and enthuse participants new to teaching Mathematics;
. Provide motivating introductory activities, tasks and presentations for teaching.

Table 3.1 The Aims of the Plymouth University Retraining Model

In 2014, SKE+ was terminated by the NCTL and replaced with a ‘teach and learn project’. One year later, having concluded this ‘teach and learn project’ to be successful, it was rebranded as Teacher Subject Specialism Training (TSST) and launched as such in 2015. The TSST courses are funded through schools - not universities - and this is a significant departure from the previous retraining professional development models. The TSST programme is coordinated through Lead Schools, who have successfully bid for funding from the National College for Teaching and Leadership (NCTL).

The aim of TSST (GOV.UK 2016b) is to build the capacity of the mathematics workforce by: upskilling the current non-specialist teachers of mathematics - and so increase the hours of mathematics these teachers feel competent to deliver; growing the workforce by appealing to non-specialist teachers who are *not* currently teaching mathematics but who may be able to do so with the additional support available (GOV.UK 2016b). In addition, TSST is available to specialist mathematics teachers, who have been out of teaching for a minimum of three years and are looking to return to the profession. For the purpose of TSST, non-specialists are defined as teachers ‘who have not undertaken initial teacher training (ITT) in the TSST subject’ (GOV.UK 2018a).

The Centre for Innovation in Mathematics Teaching (CIMT) at Plymouth University now works with Lead Schools across the country, to support TSST Mathematics courses, based on the same blended learning approach developed for the SKE+ provision, and described above. The final assessment is based on attainment on the online Assessment Tests. Success results in a Plymouth University ‘Certificate of Mathematical Mastery in Secondary Mathematics’ at one of three levels: pass, merit or distinction.

Participants on the Plymouth University TSST course can enhance the pedagogical aspects of the training, by taking advantage of two 30-credit master's degree modules, namely: '*Teaching and Learning Mathematics through Problem Solving'* and *'Teaching Mathematics for Understanding'.* These modules are not a compulsory component, however the NCTL is keen that providers of TSST offer an opportunity to study at Masters level.

In addition to the TSST government funded retraining programmes, other models are currently available, and include TGM (Teaching GCSE Mathematics) and TAM (Teaching Advanced Mathematics), both led by MEI (MEI 2017). Eligibility for these courses differ in one significant way to that for TSST: specialist teachers *are* eligible. The TGM course requires active participation at four face-to-face study days, with additional online sessions with a pedagogic focus (MEI 2017). The TAM course requires participation at 7 days, spread over one academic year (MEI 2017). The TAM course is subsidised by MEI, with the initial cost to the school of £600. However, if the teacher attends all the training days and achieves certification, the school is reimbursed to the value of £1200. This financial arrangement may incentivize a school to support the professional development of the teacher: if a teacher is successful, the school is set to recoup most of the costs incurred for teacher release time.

TAM providers attempt to maintain contact with participants after the course, by providing subsidised courses and opportunities. According to Murphy (2015), the creator of TAM, the response is mixed with limited take up of opportunities. A TAM course involves developmental lesson observations with written feedback, by trained TAM observers and each participant is expected to write a response to the observation feedback, in an attempt to explore whether the teacher has assimilated the advice. Talking to Murphy (2015), it is clear the intent to develop a shared ethos amongst the professional TAM leads was supported by the agreed approach to ‘start small and grow slowly’ (Murphy 2015).

In summary, various retraining opportunities for teachers of mathematics do exist. Below is a more detailed account of the retraining experience of the teachers involved in this study.

3.1 The Retraining Programme Involved in this Research

The participating teachers were all enrolled on the 2013-2014 Plymouth University SKE+ programme (outlined above in 3.0). With SKE+ morphing into the current retraining programme of TSST during the lifetime of this longitudinal study, many teachers, including my participants, use the terms of ‘SKE+’ and ‘TSST’ synonymously.

Teachers were required to be teaching at least one mathematics group to be eligible for government funding. (This government stipulated criterion has subsequently been suspended for the current TSST.) The research participants attended one of two venues, at each of which I was the course tutor. Venue 1 was held on a university campus, with 14 participants; Venue 2 (with 10 participants) at a school where demonstration-lessons with pupils could be observed. The participants each experienced 100 hours of face-to-face tuition, over the course of 11 full training days (9am to 6pm), from December 2013 until November 2014. Funding was available to reimburse schools for the 11 days of teacher release time, but travel expenses were not included. Some schools paid their participants for travel, other participants had to self-fund travel expenditure.

With autonomy to design the detail of the face-to-face sessions, the interweaving of pedagogy with mathematical content was a key focus; subject knowledge alone is simply insufficient to develop effective teaching practices (Ball and Bass 2000). Creating a safe environment was also a priority. The social and situated learning theories (Lave and Wenger 1991) suggest participants will contribute more of what they know and be more honest about what they don't, if they feel 'safe'. In any teaching scenario, I invest time in creating a cohesive group with opportunities created for social interactions and networking. Acknowledging the McKinsey (2007) report, highlighting the need for teachers to observe and reflect and identify what makes for great teaching in their subject, demonstration lessons were delivered whenever feasible. In practice this is only possible when the face-to-face sessions are being delivered within a school setting; at Venue 2, this was the case. For a demonstration lesson, I 'borrow' a class of students to teach whilst the participants observe. (The lessons are also frequently filmed – to be used by absent participants or in other training scenarios.) For the SKE+ course, this provided a vehicle for discussion and debate as we reflected on the lesson together. As the course developed, the participants were invited to also do some teaching - to teach a 10 minute segment, for example, or to team-teach a short session. Many, but not all, of the participants embraced this opportunity - as it was seen as a safe environment in which to take risks. Feedback was always given, in a non-judgmental manner - very much incorporating the HACE (Honest; Analytical; Constructive; Empowering) principles advocated during the lectures (Magne, 2016) at Plymouth University: The teacher is always invited to reflect and feedback first, before others are invited by the chair (NS) to contribute to the discussion. The purpose of the demonstration lessons was to give participants a rare opportunity to actually observe a mathematics lesson and to see how ideas discussed during the face-to-face retraining sessions could be put into practice. The process of planning the lesson was *not* collaborative; evaluating and reflecting upon the lessons became - over time and with greater experience and confidence - a negotiated and collaborative effort.

In addition to (but quite separate from) the demonstration lessons, Lesson Study and collaborative teaching practice were introduced to all my participants during the face-to-face sessions, and included cycles of: focus; observation; reflective review. Lesson Study sessions were based, but much condensed, on the principles outlined in Illustration 3.1, the focus being predetermined by the topics being studied on a particular day. The whole group was split into working groups of three and a relatively short time was available during the morning (and then over lunch) for planning the micro-lesson, which would then be delivered by one teacher to the rest of us. Collective effort and knowledge (along with other resources) created the micro-lesson; the ‘efficacy of collaborative approaches to mathematics teacher education is well-established’ (Hodgen 2011: 38). Shared responsibility was assured as no-one knew at the outset who would teach the micro-lesson. Gaps in knowledge and understanding could be explored and teachers could receive guidance and support, thereby preventing the dissemination of poor practice (Burghes and Robinson 2010). With planning complete, straws were drawn to see who would deliver the micro-lesson. All other participants (and NS) observed.

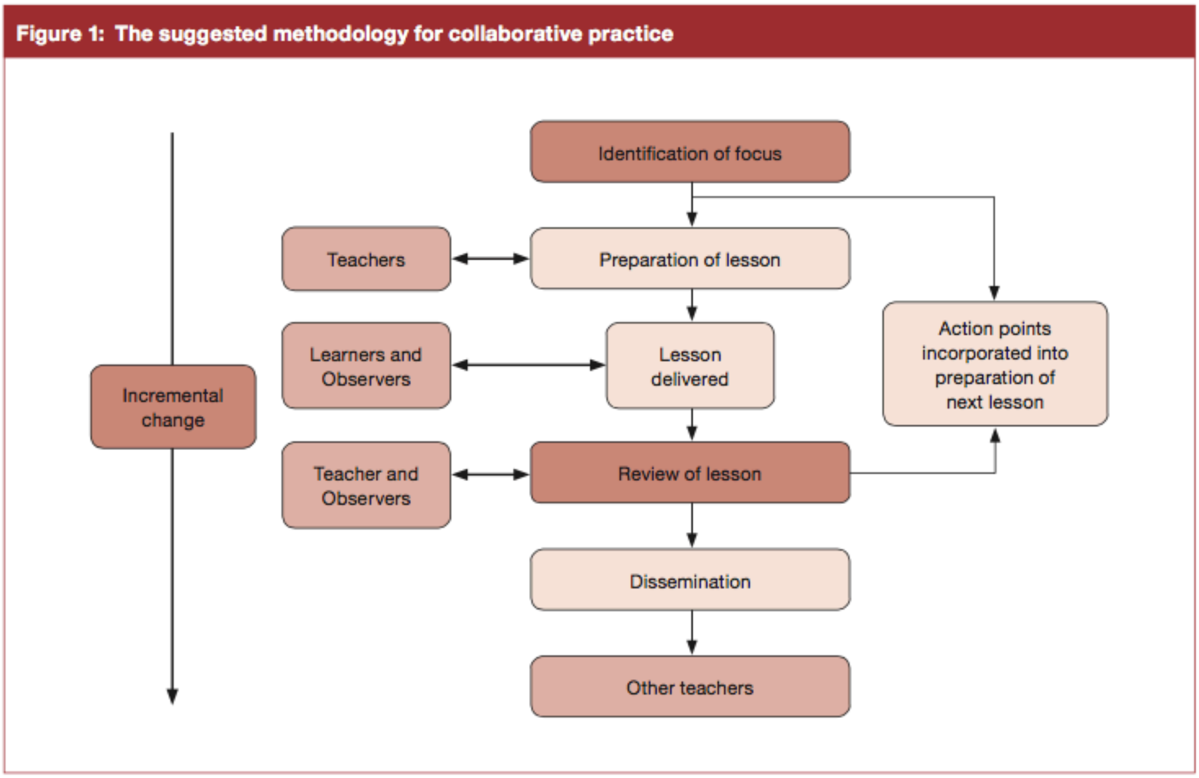


Illustration 3.1   Lesson Study Cycle as Described by Burghes and Robinson (2010: 13)

The micro-lesson (10-15 minutes) was then reviewed, first by the teacher who had delivered the lesson, and then by others who were invited to contribute, with myself chairing the discussion; this echoing the feedback principles employed post demonstration lessons, and so already familiar to participants from Venue 2. With the limitations of time, and of invented scenarios, this collaborative experience was only intended to be an introduction to the principles of Lesson Study.

Using the idea of 'constructive alignment' (Biggs and Tang 2007: 50), I teach and organise retraining sessions in a way that incorporates and highlights the 'Knowledge Quartet' (Turner and Rowland 2006: 2, see 2.3.2). With a focus on conceptual understanding, common misconceptions are deliberately highlighted and addressed and precise use of mathematical language and accurate board skills, demonstrated and encouraged. ‘Problem solving’ is a key teaching strategy I employ. The aim is to use guided rediscovery to drive deeper thinking and to see and make use of the many mathematical connections. Making connections, and developing one’s own understanding, resonates with Piaget’s belief that we only truly understand what we have created, invented or mastered for ourselves (Hunt and Chalmers 2013). This is supported by the much more recent work with neuroscience and the work done by Dweck (2012) highlighting the elasticity of the brain and the significance of having a ‘growth mindset’; the learner as the creator of understanding, underpinning the rationale for teaching by ‘problem solving’. Problem solving is a principle teaching strategy in Japan, and one I observed first hand during a visit in 2012. The most proficient Japanese practitioners, with Level 3 competency (APEC 2013), employ methods of teaching which incorporate ‘guided rediscovery’, enabling students to think for themselves and cognitively construct ideas. It is this, Level 3 type teaching, I strive to model, in the quest to develop effective teachers of mathematics.

3.2 Summary

Clearly the aim of the government funded SKE+ programme was to deliver the DfE’s objective to develop competent and effective teachers of mathematics. But once again we come up against the universally unresolved question: What is effective mathematics teaching? During the meeting to launch TSST (Watterson 2015), Watterson defined this to be teaching which leads to improved student achievement using outcomes that matter to their future success, thereby referencing the definition agreed upon by Coe *et al* (2014).

But as discussed previously (in 2.2.1), it is difficult to interpret both what ‘outcomes matter’ and ‘future success’.

In terms of outcomes, there is agreement (Hunt and Chalmers 2013) that superficial rote learning, often linked with behaviourist learning theories, can only support short term ‘outcome-based’ targets (such as exam success) and do not promote long-term learning (2013: 5). Cockcroft (1982) reported similar conclusions, and one paragraph in particular, shown in Table 3.2, provoked much analysis and discussion; this summarisng the need for so much more than rote, or procedural type teaching and learning.

Mathematics teaching at all levels should include opportunities for: • exposition by the teacher; • discussion between teacher and pupils and between pupils themselves; • appropriate practical work; • consolidation and practice of fundamental skills and routines; • problem solving, including the application of mathematics to everyday situations; • investigational work.

Table 3.2 Cockcroft 1982 Paragraph 243

Ingram et al (2018) highlight the ‘complex relationship between teaching and learning’ and focus on several different observation frameworks to examine this interrelation. The frameworks vary in terms of the levels of low inference recordings and high inference judgements required, and were designed for varying intent, but share several similar indicator items, many of which are broadly encased in the ‘Framework to identify effective mathematics teaching’ (see Table 3.3) (adapted from ‘Guidelines to identify effective teaching’ (Burghes 2005)). An example of which is: ‘The teacher demonstrates genuine warmth towards all students’ (ISTOF system) which could be seen to be similar to ‘[teacher] addresses the children in a positive manor’ and ‘reacts with humour, and stimulates humour' (QOT framework) (Ingram et al 2018, 17-19) and this links with 'Teacher likes being with learners' (Framework to identify effective mathematics teaching, Table 3.3.)

For the purposes of this study a working definition of effective mathematics teaching is required. Drawing on all the research discussed in Chapter 2 and above, I will define effective mathematics teaching to be that which promotes or encapsulates the attributes outlined in the 'Framework to identify effective mathematics teaching' (see Table 3.3); this was disseminated to *all* participants on the retraining programme. This framework does demand high inference judgements. To manage this, a system was developed in which the actual lesson observations were recorded as non-judgmental narratives and the post-lesson reflections were co-constructed with the teacher with reference to this framework.

In summary, for the purposes of this study, effective teaching is described as that which promotes active participation and deep thinking amongst learners, to provoke deep understanding.

Teacher is a good communicator, loves mathematics and likes teaching
Teacher orchestrates activities and can respond to unexpected outcomes
Teaching is aspirational and challenging
Teacher gives clear explanations; can select and instruct efficient and effective methods
Teacher can see the ‘big picture’ and promotes mathematical content connections
Teacher promotes deep thinking (For example: Why? How? What if? questioning technique)
Teacher encourages creativity and discovery
Teacher listens to learners
Teacher likes being with learners
All mathematics written by teacher clear, correct and precise; mathematical language embedded throughout
Considered interactive questioning techniques to involve all pupils, and to reflect and evaluate progress
Teacher has control of the class
Non-confrontational ethos in the classroom
Learners keen, enthusiastic and motivated to learn
Ownership of ideas encouraged and active participation expected: including for example, demonstrating and articulating at the board
All learners feel encouraged and are able to make progress
Learners cooperate and collaborate with peers
Learners on task

Table 3.3 Framework to Identify Effective Mathematics Teaching (adapted from ‘Guidelines to Identify Effective Teaching’ (Burghes 2005))

Following eight teachers, over a period of 4 years, I have undertaken an explorative study to consider the impact this retraining may have had. Chapter 4 looks at the research questions in detail and considers the methodology and methods for conducting the study.

Chapter 4: Research Questions, Methodology and Methods

4.0 Introduction

The big puzzle for policy makers is how to solve the problem of the shortage of specialist mathematics teachers in England. Having established the premise that graduate recruitment is insufficient to populate the profession of mathematics teacher, a simple question could be posed: *Is it possible for non-specialist teachers to be retrained to become good mathematics teachers?*

A simple question to pose, is of course not necessarily a simple one to address. Many clarifications are required. What do we mean by ‘good’? What would we consider to be ‘good enough’? What does ‘retraining’ entail and what do we need a teacher of mathematics to be able to deliver? Is *any* teacher better than no teacher? What do we mean by ‘non-specialist’? And are ‘specialist’ teachers necessarily ‘good’ teachers?

With consideration to these deliberations, the specific focus for this research is outlined in detail below.

4.1 The Research Questions

The contextual background framing the research (and outlined in Chapters 2 and 3) is the widely acknowledged shortage of specialist mathematics teachers in England. In conjunction with this are the theoretical considerations and complexities of defining the term ‘effective’ (also discussed in Chapter 2). Retraining has been assumed to be a solution, at least in part, by consecutive governments (GOV.UK 2016). There is however, very little research to support or to refute this strategy; the 'need is growing to learn more about the implications of the out-of-field phenomenon' (du Plessis 2017). The intent of this research is to contribute to the knowledge in this field.

The global question suggested above, '*Is it possible for non-specialist teachers to be retrained to become good mathematics teachers?',* is refined for this research project. The research question is:

Does retraining teachers (in the way described (see Chapter 3)), provide a means to help meet the demand for competent teachers of mathematics?

Designed to inform the above, is the following sub-set of questions:

1. Can the part-time retraining course, delivered as described, affect change in teachers' subject knowledge and mathematical pedagogy?

2. If so, what are the successes of this retraining and what are the limitations?

3. What factors affect whether any changes are sustainable, and so become embedded in long-term practice?

These questions relate to the development of knowledge and skills, for teaching mathematics, amongst teachers who were not initially trained to do so, and who are not mathematics graduates; some of whom also have limited prior mathematical qualifications. In this regard, these teachers are referred to as non-specialist teachers; and 'retraining' refers to the process of upskilling and reskilling qualified teachers to teach a different subject.

Once the focus for the study had been firmly established, the next consideration was *how* to do the research and the following sections outline the philosophical and practical deliberations involved.

4.2 Research Paradigm Perspective

> 'An overall theoretical research perspective, is called a research paradigm' (Ernest 1994: 19).

Selecting the right research paradigm is significant in that it acts as a belief system, guiding the decisions and the interpretations inferred. One's ontology and epistemology are two major constituents of any paradigm and can be seen to largely determine the selection of such. Ontology can be simply described as 'one's view of reality and being' (Mack 2010:5) whilst epistemology as 'the view of how one acquires knowledge' (Mack 2010:5, Cohen *et al* 2011, Ernest 1994, Mack 2010, Yin 2014). Both my ontological and epistemological positions are outlined in Chapter 1 (1.0). These philosophical considerations are significant in research as it is important to recognize that they will 'inform the choice of research questions, methodology and methods' (Mack 2010: 6) and impact on the research findings by way of how the knowledge is revealed and constructed.

The third component of any research paradigm is the methodology. This can be seen to be the theory of the different research methods and the justification for their use, in terms of which ones will be most appropriate for a particular paradigm and for a particular study. The research methods are intrinsic to the methodology and are the instruments – the techniques and research tools (such as interviews or observations) – for collecting and collating the data to use for the generating of new knowledge.

Three classic paradigms were initially considered in relation to this study: the scientific research paradigm; the interpretative research paradigm; and the critical theoretic research paradigm. The scientific (also known as positivist) paradigm assumes ‘definite and certain knowledge’ (Ernest 1994: 21), and is generally experimental and quantitative, concerned with ‘objectivity, prediction, replicability and the discovery of scientific generalisations’ (Ernest 1994: 22). The interpretative research paradigm, belonging to a group of bottom-up research models (and also known under a range of names including: constructivist; alternative; and naturalistic (Cohen *et al* 2011, Ernest 1994, Yin 2014)), is principally qualitative and is concerned with human understanding, and ‘lived truth’ (Ernest 1994: 24) based on observation and interpretation. The critical theoretic research paradigm resembles the interpretive paradigm, but also seeks social critique and social change; in education it is closely associated with Action Research (Cohen *et al* 2011, Creswell 2012, Ernest 1994).

The interpretive paradigm suggested the best fit for this project, both philosophically and practically. The retraining programme in which I was involved, teaching teachers to teach mathematics, presented an ideal opportunity to embark on an explorative qualitative data study and pursue participants in an attempt to understand what is actually happening over a period of time. Interested in developing a deeper understanding of the retraining process for a specific group of teachers, I planned to look and to see - to examine what would emerge - and then to construct an interpretation. An interpretative paradigm does *not* lend itself to global generalisations, but it can illuminate and illustrate common themes by exploring ‘the unique features and circumstances' (Ernest 1994: 25) of the particular to provide examples, ideas and interpretations. A light might shine from the interpretations which may help to elucidate the issues; the idea being to 'illuminate the general through the particular' (Ernest 1994: 26). Incorporating triangulation to 'overcome the weakness of subjectivity' (Ernest 1994: 24), an interpretative research paradigm employs various viewpoints of the same subject matter to unravel and understand human actions and interactions.

The research questions are designed to highlight the factors that have influenced the successes and limitations for the particular participants involved in this study; these may then prove relevant to others in the future.

Aligned with an interpretative research paradigm, is an interpretative methodology, and the decisions regarding the methodology selected for this study, and whether indeed any methodology is needed at all, are discussed in detail in section 4.3.

4.3 Methodology: Considerations and Decisions

4.3.1 An Overview

An interpretative methodology attempts to explore in depth, and to build up rich and detailed descriptions of the individuals being studied. Layers are added over time, developing a thickness to the account or story (Cohen *et al* 2011, Creswell 2012, Ernest 1994, Yin 2014), and this is my precise intention, working with participants over a period of 4 years. Various interpretative methodologies were considered for this study, including: Action Research; Critical Action

Research; Case Study Research (CSR); Grounded Theory. A brief account of the decision process - the exclusion of the first three and the inclusion of the latter - is described below.

Action Research, more closely linked with the critical theoretic research paradigm, has some links to the interpretative paradigm, and is typically undertaken by a group of teachers to investigate or solve a particular problem. The research is often collaborative, with the teacher-researchers working within a group to define the problem, and then working together to arrive at some solution (Creswell 2012). Critical Action Research, also known as Participatory Action Research, is an extension of Action Research, and tends to focus on a wider 'social and community orientation' (rather than solving local and immediate school-related problems) (Creswell 2012: 582). It is concerned with collaborative relationships between the researchers and participants (Creswell 2012). This process is intended to be empowering for all, as it allows a sense of mutual exploration and sense of involvement and experimentation to produce relevant research (Cohen *et al* 2011). The participants are no longer just being 'looked at'; they are actually part of the action. The potential for elements of Action Research, and in particular Critical Action Research, appeared to be evident in my study – in particular the scope for mutual exploration and the intent to turn any power hierarchy between researcher and participants upside down and to 'invoke a commitment to break down the dominance and privilege of researchers' (Given 2008). However, the research questions were not collaboratively defined, and nor were they designed to be collaboratively considered and solved.

Having decided it appropriate, and judicious, to recruit participants to conduct my research, the Case Study Research (CSR) methodology, embedded within an interpretive paradigm, appeared a sensible approach to consider. There were however, fundamental differences between Case Study Research and my intent. My intent was to see what could be seen; I did not set out with a particular theory to prove or to disprove. And as Yin (2014) states, developing a theory 'prior to the conduct of any data collection, is one point of difference between case study research and related qualitative methods such as ethnography and grounded theory' (2014: 37).

Grounded theory allows theory to slowly emerge, or be 'discovered', from the data (Glaser and Strauss 1967) and deliberately avoids specifying any theoretical hypotheses at the outset of an inquiry: theory 'should not precede research but follow it' (Cohen *et al* 2011: 18). And the methodology itself, as well as the theory, can develop gradually and be built up over time (Glaser and Strauss 1967). Grounded theory is often associated with social circumstances or situations, and proponents (including Strauss, Corbin, Charmaz and Benoliel) believe that it allows for a substantive theory, with the capability to explain 'how social circumstances could account for interactions, behaviours and experiences of the people being studied' (Benoliel 1996: 413).

With grounded theory suggesting an initial good 'fit' for this study, I embarked on a more in depth analysis of the theory (detailed below in 4.3.2). This, at least in part, to confirm the decision but also to decide upon which features of the now many versions of grounded theory were most closely aligned to my philosophical and practical perspective. For this, I decided to explore grounded theory from its origins and track the historical developments – before constructing and designing my own tailored methodology (detailed in section 4.4).

4.3.2 The Journey into Grounded Theory

The grounded theory methodology, first developed by Glaser and Strauss in 1967 and disseminated in the book The Discovery of Grounded Theory (1967), appeared an attractive proposition for this project. Mirroring Nelson's (2015) trajectory, I initially considered grounded theory as a 'relatively straightforward choice' (2015: 19); this prior to being exposed to the strength of controversy and critique surrounding grounded theory. Subsequently, and mimicking Nelson's (2015) experience, the process of employing grounded theory then became pitted with periods of doubt, uncertainty, anxiety and indecision. At this juncture, considering the historical context surrounding the conception of grounded theory, and its then subsequent evolution, seemed prudent.

In the 1960s, following two World Wars and the commencement of the Cold War, quantitative data analysis reigned supreme, and qualitative data analysis was considered in need of kudos and status to legitimize its position (Fontana and Frey 2005). As Thomas and James (2006) confirm, grounded theory represented a solution to 'a broader problem about perceptions of the status of qualitatively based knowledge' (2006: 2).

Glaser's quantitative (and positivist paradigm) background led to the prominence of coding; Strauss' qualitative background was in symbolic interactionism (a variant of an interpretive methodology), and his interest lay in the depth of insight qualitative research could provide within social contexts. The symbolic interactive perspective asserts that individuals act according to their meaning-making of the world, constantly adjusting and modifying these constructs – and aligning ‘their actions to those of others’ (Cohen *et al* 2011: 20). Society, it is believed (by symbolic-interactivists), is socially constructed by way of human interaction and human interpretation.

Glaser and Strauss combined these opposing traditions to develop their grounded theory methodology. Since their original publication in 1967, Glaser and Strauss have disagreed on how to apply the original grounded theory method, resulting in an eventual split. The controversy between Glaser and Strauss, appeared to centre around Strauss’ use of preconceived ideas, with Glaser arguing that this would prevent theory *emerging* from the research process. Strauss (with Corbin) went on to publish ‘Basics of Qualitative Research: Grounded Theory Procedures and Techniques’ in 1990, with a more systematic and prescriptive outlook involving predetermined categories. Glaser (1992) claims this version of Strauss’ is not grounded theory, but instead is merely *qualitative data analysis* - with an emphasis on simply describing acts rather than understanding and theorizing them - and is only concerned with producing information, and not theory. Essentially *qualitative data analysis* can be considered to simply describe ‘a cluster of methods, not a methodology’ (Ernest 1994: 24). This division between Glaser and Strauss highlights the intricacies and complexities of implementing the methodology in accordance with the original ideas. Glaser’s version has since come to be known as the ‘emerging design’ of grounded theory, heavily reliant on the constant comparative method, and Strauss’ as the ‘systematic design’ which is more prescriptive and structured (Creswell 2012: 424).

Strauss died in 1996 but over four decades after the original dissemination of the theory, Glaser delivered a lecture (video, 2010), of which I have transcribed part; this illustrated in Table 4.1 below.

'I want you to understand contrary to what you may have read elsewhere that grounded theory is the study of a concept. It's not a descriptive study of a descriptive problem, it's the study of a concept… In the concept names a pattern. In that pattern you're going to see if [it] has general implications every which way you look and then you know if you've really hit because although you're studying it in one substantive area it applies all around you just like the word 'credentialising' or 'super-normalising', everybody knows that term, right, came out of Kathy Charmaz dissertation…'super-normalising', people who have a problem act even more normal to prove they don't have a problem. Now this was done in a study of heart attack victims…but this applies everywhere, applies in skiing…it's a frequent response to some kind of impairment to prove you really don't have it and you super-normalise… In any event you can see super-normalising is a big issue and has general implications …And that's our goal to get to those concept levels so we start seeing it everywhere…'   (Glaser 2010)

Table 4.1 Partial Transcription of Lecture delivered by Glaser (2010)

Glaser reiterates that grounded theory is about much more than accurate description: the goal is to generate concepts, and theory must emerge from the data. The process commences with data and a theory is built based on the systematic analysis of the data. Although primarily an inductive methodology, the theory does incorporate deductive elements to service the iterative inductive cycles (Glaser and Strauss 1967) but Glaser (1998) determinedly points out that any deduction is carefully grounded in the emerging data and based on an induced category. The deductive element can direct the researcher where to go next for data, this the basis for 'theoretical sampling' which is described as the process of data collection 'whereby the analyst jointly collects, codes, and analyses his data and decides what data to collect next and where to find them, in order to develop his theory as it emerges' (Glaser and Strauss 1967: 45).

Strauss' systematic design, on the other hand, is considered to be more dependent on deduction - and the deductive element is seen to be key in explaining the main difference between the two versions (Creswell 2012). Deductive reasoning is generally used to test or confirm previously proposed hypotheses, this aligning with Strauss' systematic design with predetermined categories. Inductive reasoning, open-ended and exploratory, is used to form hypotheses and theories (Patton 2002) and so more closely connected to the emerging ideas of Glaser's grounded theory.

Over the years, grounded theory has continued to evolve. Charmaz, a student of Glaser, has added to the development with a third version: the constructivist design of grounded theory (Charmaz and Belgrave 2012, Charmaz 2014, Creswell 2012). This builds on an interpretative perspective with constructivist methods and assumes that theories are not discovered but are mutually constructed by the researcher and the participants, as a result of interactions within the field (Charmaz and Belgrave 2012). Collected data are co-constructed and are 'coloured by the researcher's perspectives, values, privileges, positions, academic training, and socio-cultural context' (Thornberg 2012: 91). This constructivist grounded theory approach assumes that multiple realities exist and data reflects researchers' and research participant's mutual constructions. The researcher enters, however incompletely, the participant's world and is affected by it (Charmaz and Belgrave 2012), and the focus of the findings is on the 'meanings, ascribed by participants in a study' (Creswell 2012: 429). Charmaz is interested in the values, views, beliefs, ideas, reactions, emotions, and perspectives of her participants and less interested in gathering facts and describing acts. She is keen to limit jargon and rejects exclusive terminology, saying that to do otherwise introduces a level of power and detracts from the point of grounded theory – that is, being able to be part of the participant's world and share, in some albeit limited way, their panorama and perspective.

Significantly, in contrast to many methodologies and indeed to earlier versions of grounded theory, Charmaz sees no need to minimize the role of the researcher, or of the knowledge they might possess. This knowledge and experience, Charmaz believes, will lend insight and value to the research, and the researcher will inevitably make decisions during the course of the research based on these 'values, experiences, and priorities' (Creswell 2012: 430). Research findings will reflect this and any conclusions will be 'suggestive, incomplete, and inconclusive' (Creswell 2012: 430). The constructivist design rejects predetermined categories and the research is written as a narrative, with probing, discursive and explanatory overtures (Charmaz and Belgrave 2012, Creswell 2012).

For constructivist grounded theorists, interviews are the primary method of data collection (Charmaz and Belgrave 2012). The methodology shapes the interviewing style and guides the analyses of the data. Constructivist grounded theorists attempt to be particularly alert to the nuances revealed in these interviews – and can use the scope and flexibility of the interview process to slow the pace to reveal more, 'repeating questions and the key points, gently turning the interviewees words into open ended questions' (Charmaz and Belgrave 2012: 352).

As theory begins to develop and moves beyond a stage where literature can derail the researcher from 'seeing' the data (Glaser 1992), relevant and pertinent literature will become apparent and can then be reviewed. In other words, literature is treated like any other source of data; 'the literature is discovered as the theory is' (Glaser 1998: 69). This is in contrast to more traditional or scientific research, which tends to commence with a detailed and exhaustive literature review; the purpose of which is to generate a research question and to explore the edges of the existing body of knowledge. Grounded theory, in comparison, requires researchers to view the research problem from the research participants' perspectives; grounded theorists cannot therefore sense the edges of this knowledge and need to carefully guard against the risk of literature dictating the data collection and analysis (Glaser and Strauss 1967). To this end, grounded theorists may choose to defer a detailed review of the literature as to do otherwise runs the risk of introducing bias that would be 'inimical' to generating grounded theory (Glaser 1998: 67). The potential 'derailment provided by the literature in the form of conscious or unrecognized assumptions of what ought to be in the data' is something Glaser (1992: 31) warns against. Glaser and Strauss (1967), however, acknowledge that a researcher cannot be void of knowledge, and cannot erase previously accumulated observations and experience prior to entering the field, but nevertheless suggest theoretical sensitivity is key for grounded theory. Theoretical sensitivity relies on entering the field 'with as few predetermined ideas as possible' (Glaser 1978: 2-3) and in particular without predetermined hypotheses. The researcher may then be able to 'remain sensitive to the data by being able to record events and detect happenings without first having them filtered through and squared with pre-existing hypotheses and biases' (Glaser 1978: 2-3). A preliminary review of relevant literature can be useful for raising awareness in and around the broad area of research, but a distinction must be made between conducting a light literature review which may enhance theoretical sensitivity and using a review to establish a theoretical framework.

Thomas and James (2006) suggest that there is little doubt that grounded theory has been ‘a major – perhaps *the* major – contributor to the acceptance of the legitimacy of qualitative methods in applied social research’ (2006: 2). And yet Thomas and James (2006) pose a well-argued critique of grounded theory. As they point out, qualitative research in education usually involves a lot of dialogue – talking to teachers, students, parents, and so on. The inevitable question is what to do then, with all this qualitative data? The idea that grounded theory can offer a sense of direction - a set of procedures to follow, and a ‘means of generating theory’ from all this loose data - is an appealing one (Thomas and James 2006: 3). The issue Thomas and James (2006) have is with ‘grounded theory's status as theory’, and the assertion that it can be ‘discovered’ (2006: 3). They question the need for a theory at all and wonder ‘why people expect their methods for making sense to be called “theory”’ (2006: 6); interpretation and new insights should suffice.

Thomas and James (2006) believe newer developments, such as Charmaz’s constructivist version, do not need to be labelled as grounded theory and can exist as qualitative inquiry in their own right. To continue to align them with grounded theory, they argue, actually undermines and constrains them and has the effect of stifling creativity. Thomas and James (2006) assert: ‘It is imagination and creativity, not induction, that generates real scientific theories’ which is how ‘Einstein could study the universe and change physics with little more than a piece of chalk' (2006: 11). As Popper (1989) put it: 'The belief that we use induction is simply a mistake. It is a kind of optical illusion' (2006: 12).

According to Thomas and James (2006), Charmaz's constructivist grounded theory approach relies on sheer hard work being combined with inspiration until, 'interpretation and new insights' are reached (2006: 26). To Thomas and James (2006), this is reminiscent of Polya (1945) who suggests working with the data and thinking 'until you get a bright idea' (1945: 172) and they query what the 'grounded theoretical ingredients' (Thomas and James 2006: 26) in Charmaz's form of grounded theory contribute in addition to this. And significantly, Thomas and James (2006) question whether Charmaz's constructivist grounded theory approach may in fact 'inhibit rather than enable "common interpretative acts"' (2006: 26). 'Common interpretive acts' are something Schatzman (1991) defines as the way we all seek to sense-make, by engaging with observations and evidence that surround us, in a way that is predisposed by our everyday practice and experience. Schatzman (1991) suggests all human beings naturally use common interpretive acts, and by way of 'review, rehearsal, of talking about it with friends, of employing practical syllogism, recognition, evaluation, coming to a conclusion' (Thomas and James 2006: 26) we can order and comprehend our worlds. Charmaz's suggestion (2000) that 'In short, constructing constructivism means seeking meanings' (2000: 525) by 'viewing the data afresh, again and again' (2000: 526) appears - to Thomas and James (2006) - as indistinguishable to the induction of everyday sense making and to Schatzman's common interpretive acts.

Other critiques of grounded theory come from Layder (1993) and Robrecht (1995). According to Layder (1993), the assertion that the emergent grounded theory should 'fit' and be 'relevant' to the people studied (as suggested by Glaser and Strauss, 1967), actually has a limiting effect on analysis, because it precludes unexpected features and outcomes. And if this is the case, this would then defeat one of the founding tenets of the original Glaser and Strauss (1967) theory: to transcend boundaries. Robrecht (1995) suggests that the systematic procedures to follow grounded theory encourage researchers 'to *look for data* rather than *look at data*' [original emphases]' (1995: 171) and 'divert attention from the data towards techniques and procedures' (Thomas and James 2006). Instead, Robrecht (1995) suggests every-day thinking can be employed and extended to develop an analytical process; this linking with the idea of Schatzman's (1991) common interpretative acts.

As many have struggled with the intricacies or seeming limitations of the original grounded theory, 'simpler' strategies based on grounded theory principles have been suggested. Thomas (2003) offers a simple set of procedures to follow for a general inductive approach 'indistinguishable from those derived from a grounded theory approach' (2003: 9); the five-steps of which are presented in the Table 4.2.

1.	Preparation of raw data files into an easy to use format
2.	Close reading of text, to gain an understanding of themes or categories
3.	Creation of categories
4.	Coding; Overlapping coding is allowed, so too, uncoded text
5.	Continuing revision and refinement of category system, search for subtopics, including contradictory points of view and new insights

Table 4.2 Thomas' (2003) Set of Procedures for General Inductive Approach

Creswell (2012) appears to draw on both the systematic procedures evident in Strauss' grounded theory and on the 'common interpretative acts' and common sense-making described above. He acknowledges there is no absolute way to approach analysing data and that it is in fact a very 'eclectic process' (2012: 238). Creswell does however describe six steps in the 'process of analyzing and interpreting qualitative data' (2012: 261). These steps, very similar to the stages described by Thomas (2003), (and outlined in the Table 4.3) happen simultaneously and iteratively with each cycle achieving greater depth of clarity and insight.

1.	Preparing and organising the data for analysis
2.	Exploring and coding the data
3.	Building descriptions and creating themes
4.	Representing and reporting of findings
5.	Interpreting findings
6.	Validating findings

Table 4.3 Creswell's Set of Procedures for Analyzing and Interpreting Qualitative Data (2012)

With the acknowledgement that there is still much debate about what constitutes a good methodology (Creswell 2012, Cohen *et al* 2011, Becker 1996, Feyerabend 1993) and the tacit consent that common sense is actually significant, the very reasonable questions could be posed: Is any methodology really necessary? Could common sense alone, suffice? These dilemmas are discussed next.

4.3.3 Does Methodology Matter?

> *'There are times in life when the question of knowing if one can think differently than one thinks and perceive differently than one sees, is absolutely necessary if one is to go on looking and reflecting at all.'*
>
> *(Michel Foucault, 1926-1984)*

A common criticism levelled at educational research concerns the quality of such research, and the ensuing lack of relationship between research and policy. Hargreaves sparked this enduring debate, when he referred to educational research as 'second rate' (Hargreaves 1996). Hargreaves was sure 'that educational research should and could have much more relevance for, and impact on, the professional practice of teachers' (1996: 405). In response, Ofsted published a survey of educational research (by Tooley and Darby 1998), in the preface of which the HMCI of the time, Chris Woodhead, says 'much that is published is, on this analysis, at best no more than an irrelevance and a distraction'. Michael Gove has reportedly expressed similar disdain for academic educational research and has apparently implemented policy with little or no regard to prevailing research (Priestland 2013). Gove's famous pre-Brexit line that the British people 'have had enough of experts' could be seen to cement this derision.

One of the major themes materializing from the Tooley and Darby (1998) report, reflected methodological concerns, arising largely from the conduct of qualitative research: Bias and lack of rigour appearing to be the major culprits, detracting from and devaluing research findings. Although Tooley and Darby's findings may be open to dispute, a move to make qualitative research relevant has seen much emphasis placed on methodological rigour. But could constructing a methodological stance along the lines of grounded theory be an ‘optical illusion’ (Popper 1989: 12), providing a sort of smoke and mirrors effect for justifying findings; findings which could be equally concluded by using creativity and common sense, as intimated by Thomas and James (2006) and Robrecht (1995).

Rejecting the observe-and-induce model, Popper (1959) believes experiments should be designed to test, and potentially reject, hypotheses. But Kuhn (1962), noted that scientists do not in reality behave as Popper suggests they should. Instead of rejecting theories when the evidence suggests this to be judicious, scientists resist change and largely continue to operate within the confines of a particular paradigm. Only when an overwhelming volume of evidence forces revolutionary practice does a ‘paradigm shift’ transpire – with new perspectives replacing the old. Feyerabend (1993) also observed that scientists tended not to behave as Popper suggested they ought. In fact, according to Feyerabend, not only were scientists not following Popper’s methods, they were not following any methods at all. Feyerabend famously suggested ‘anything goes’ (1993: 14) and that scientists will use creative and experimental means to solve problems and make discoveries, employing irrational acts and intuition. Basically the rules for research may well be up for debate. This then leads us back to the potential for using common sense and ‘common interpretative acts’ (Schatzman 1991) to reach conclusions.

Natural analysis - using common interpretative acts, prior experience, perceived wisdom or common sense - is undoubtedly useful (Mason 1998, Mason 2002) (one such example, being the ability to recognise when inadequate teacher subject knowledge impacts on the quality of learning.) Mason (2002) suggests all research ‘depends, at heart, on noticing’ (2002: xii) and recommends the Discipline of Noticing (2002) as an intentional and systematic process for reflection and focus which can improve all research but is perhaps particularly relevant when you ‘research yourself to enquire into your own lived experience’ (2002: xii). Mason refers to researching oneself as ‘researching from the inside’ and gives confidence to the idea that this can be both valuable and methodologically sound. Although as Mason suggests, noticing is natural and an everyday type of affair, the Discipline of Noticing can be developed into an instrument which can add both depth and validity to research; ‘Noticing requires sensitivity’ (Mason 2002: 8) and care must be taken not to too readily infer judgements or evaluations. Probing in the course of interviews (and for theoretical sampling, for example) can be used to develop a ‘more vivid impression’ (Mason 2002: 43) of an incident and provide an opportunity to reflect upon ‘salient incidents’ (2002: 46).

Schatzman (1991) proposed the idea of ‘dimensional analysis’ as a way to combine common interpretative acts, or natural analysis, with the power of comparative analysis in grounded theory. Schatzman (1991) developed dimensional analysis as a style of doing grounded theory in which, ‘the tacit processes involved in analysis’ are made explicit (Gilgun 1993: 1). This, in a response to him trying to solve the puzzle of what ‘analysis’ actually is – and recognizing that it is indeed very much driven by personal or professional perspectives. Dimensional analysis, something Schatzman considers all humans do ‘naturally, though not necessarily systematically’ (Gilgun 1993: 2), provides the ‘lens through which to view the various aspects of a situation’ (Gilgun 1993: 2). This perspective combines with the analytic processes to allow (as for traditional grounded theory) the generation of theory directly from data.

The limits of relying solely on natural analysis or common sense, are that common sense, for example, is time and context specific. Common sense of the 1970's is not the same as today's common sense; a teacher's common sense may not mirror that of a politician's. And common sense can, of course, be subject to all sorts of cognitive biases which may inhibit theoretical sensitivity; a researcher may commit 'exclusively to one specific preconceived theory' and no longer be able to see beyond their 'pet theory', possibly becoming 'insensitive or even defensive', determined to see 'everything from this one angle' (Glaser and Strauss 1967: 46). Employing a well-constructed methodology will not necessarily eradicate or filter all these biases, but does at least endeavor to mitigate their influences. And a methodology, in particular of a grounded theory origin, may also inspirit discoveries and unexpected findings, and support deviations beyond the confines of one's own common sense. This idea, to license the unexpected, was a dominant justification for my adoption of a grounded theory methodology.

4.3.4 Summary of Considerations

Concluding that methodology matters, and that research practice is a craft to be mastered (Nelson 2015), I embarked on a constructivist grounded theory path. Whether the findings are indeed different to those that would have been revealed by common sense alone is contestable. But I believe remaining close to the data, constantly coding and comparing, whilst simultaneously employing common interpretative acts, provided the best guiding principles for this project. But as Becker (1996) asserts, there are no recipes for ways of doing social research; rather, one has to have ‘imagination and…smell a good problem and find a good way to study it’ (1996: 70).

In summary, having explored the trajectory of grounded theory (and some of the potential pitfalls and critiques) I set out to frame my own methodology broadly based on Charmaz’s constructivist grounded theory.

4.4 Methodology: Design and Implementation

In the first section below, my methodology design is examined in detail. The methods and instruments employed to implement this methodology are then closely considered in the following section (4.4.2).

4.4.1 Creating the Design

Having grappled with Glaser’s emerging grounded theory, seen the specifics of Strauss’ systematic version, been swayed by constructivist grounded theory, recognised the reinvention and rejection of grounded theory by Thomas and James (2006), considered the ideals of Critical Theory, and rejected Case Study Research, my methodology gradually began to emerge. And this emergence is itself in accordance with grounded theory philosophy.

Acknowledging my role in the centre of this research – and that any findings or discoveries would be mutually constructed between myself and my participants – my methodology design is rooted in constructivist grounded theory. This grounded theory approach to research, clearly requires the investment of both time and emotion (empathy and sensitivity, for example). I had enough time, for a four-year longitudinal study; emotional investment is something I stake in all teaching and tutoring scenarios.

Although the focus for the research was to allow issues and ideas to emerge from the participants' perspective, the backdrop of the study would undoubtedly be coloured by the issues encapsulated in the research question: there is a current demand for competent and effective teachers of mathematics to address the shortage of specialist teachers. The need for effective practitioners to possess sufficient and fluent subject knowledge would be a working hypothesis; this hypothesis suggested from my own lived experience, and from the initial sensitizing literature review. As such, an adjustment was made to the constructivist grounded theory approach to incorporate predetermined themes relating to subject knowledge and teacher effectiveness, along the lines of Strauss' systematic grounded theory. Interweaving the ideas of 'common interpretive acts' (Schatzman 1991) was another added dimension: seeing the outcomes, for example, through my lens as a teacher and educator, passionate about good mathematical experiences for students.

In summary, my methodological approach is rooted in constructivist grounded theory, but blended with elements of systematic grounded theory (with a core phenomenon), whilst incorporating an appreciation of narrative analysis (Ezzy 2002) and a connection with common interactive acts. These elements combine, and together facilitate the drawing together of deep, rich narratives to move beyond the descriptive towards understanding. The participant voices and the layering of thick descriptions, allowing findings to emerge from the data.

The methodological process was not precise, exact or clean. It was at times messy, unsure and uncertain. But emboldened by Charmaz's view, that grounded theory is not a 'blueprint' (Charmaz, 2006: 128) and that it is a 'set of principles and practices, not prescriptions or packages' (Charmaz 2006: 9), I continued observing, interviewing and inducing; acknowledging the data would be inevitably coloured by my own core common sense, or perceived wisdom. And as Seale *et al* (2007) state: 'There is no perfect methodology, all methodological frameworks are provisional' (2007: 7).

Embedded within this inexact and imperfect methodological design, is a significant consideration of the ethical issues and dilemmas; these are discussed in detail in section 4.4.8.

4.4.2 Implementing the Research Design and Use of Methods

Interpretative methodology is based on a naturalistic approach to data collection, such as interviewing and observations, and these were the predominant methods in my study – and are discussed in detail in sections 4.4.3 and 4.4.4 respectively.

As typical for grounded theory research: Once an initial scoping exercise of the literature was complete, I delayed further literature searches to avoid 'derailment' (Glaser 1992: 31). As early theories began to emerge, literature, treated as another source of data, was constantly reviewed. Iterative cycles of collect, review and compare - of data - were then continued.
Initially I decided to select six participants and participants were recruited using a set of criteria approved by the Plymouth University ethics committee. These criteria are shown in Table 4.4.

●Criterion 1: Those currently teaching at least one mathematics class
●Criterion 2: Two participants (meeting Criterion 1), selected randomly, from each of the three following groups* (the groups reflect different background experience): 1. Whole class teaching (i.e. teachers of: Science; Geography; History; R.E.; English; Languages) 2. Managing large groups in different environments (i.e. teachers of: P.E.; Drama; Dance; Music; Art; D&T) 3. Teaching small groups and/or involving a lot of one-to-one tuition (i.e. teachers of: ICT; Business Studies; Child care; Music instrument (individual/small groups)) * If it is not possible to select a participant from a particular group, the participant will be randomly selected from subject specialisms not yet represented.

Table 4.4 The Criteria for Recruiting Participants to the Research Study

In actuality, nine teachers met the above criteria and volunteered to participate in the study; I made the decision to include them all, recognizing it as ethically right to do so (and that natural wastage was possible). At the outset I had: five recruits from Group 1 (whole class teaching); two from Group 2 (managing large groups); and two from Group 3 (teaching small groups). During the first year of the study I did indeed relinquish two participants; being NQTs it became apparent that they did not fit the specific profile for this study as although they were converting from a different subject (from their degree and teacher training) they were not qualified teachers converting to a different domain. I did however gain an additional volunteer – Katy - who had started teaching a mathematics class during the course of the retraining year, and so therefore became eligible (and keen) to participate. My eight participants now comprised: three from Group 1 (two science teachers; one English teacher), two from Group 2 (two P.E. teachers) and three from Group 3 (an I.C.T. teacher, a child care teacher and a teacher working with teenage mums).

A huge advantage afforded me, was the ease of access to my participants. Being a tutor to these teachers, regular contact and frequent dialogue was easy to initiate. Organizing the time and venue for the initial interviews was a simple matter of extending the face-to-face days. Negotiating access for lesson observations, and later interviews, was also straight forward, and arranged via direct email communication.

Alongside interviews and observations, various questionnaires were employed throughout the study and these are discussed in detail in 4.4.5. In the spirit of grounded theory, data collection commenced as soon as the opportunity arose - in other words as soon as the participants started their training. In December 2013, during the first face-to-face session, the standard Mathematics Attitude Questionnaire and Subject Questionnaire for Mathematics SKE+ Evaluation (see Appendices I and J) were administered to all participants; and these would be repeated on conclusion of the course.

Other questionnaires included feedback-on-feedback forms (see Appendix H) to capture reflections from participants on their post lesson feedback and reflective and reflexive questionnaires designed to pick up on previous comments and prime participants prior to a more in-depth interview (see Appendices K, L and M). Participants own personal reflections, in the form of a journal or diary, along with regular dialogue and email communication added to the data collected. In some instances, this research was further triangulated by contributions from an external evaluator of the 2013-2014 Plymouth SKE+ retraining course (Keith Hedger 2014) and lesson observations and associated commentary by Ted Graham (research supervisor).

A schedule illustrating the points of data collection and the methods employed is shown in Table 4.5; a more detailed timeline is shown in the profile narratives for each participant (see Chapter 5).

2013-2014:	
December 2013	Mathematics Attitude Questionnaire1 (Appendix I) Subject Questionnaire for Mathematics SKE+ Evaluation1 (Appendix J)
January – March 2014	Interviews 1 (Appendix C)
January – July 2014	Personal reflections, kept by way of log or diary and emailed from participants to NS Lesson Observations 1 using framework (Appendix N)
2014-2015:	
September – December 2014	Personal reflections, kept by way of log or diary and emailed from participants to NS
October 2014	External course evaluator (Keith Hedger) visit; interview with some participants; evaluation notes made
December 2014	Mathematics Attitude Questionnaire 2 (Appendix I) Subject Questionnaire for Mathematics SKE+ Evaluation2 (Appendix J) Reflections on Course Questionnaire (Appendix K) Pre-Interview 2 Questionnaire (Appendix L)
January – March 2015	Interview 2 (Exemplar: Appendix D) Lesson Observation(s) 2 (and 3)
2015-2016:	
September 2015- July 2016	Lesson Observations (3), 4, 5 (6), (7)* (Exemplar: Appendix G) *For two participants, one lesson was also observed by research supervisor, Ted Graham Feedback-on-feedback questionnaires (Appendix H) Personal reflections, kept by way of log or diary and emailed from participants to NS
October 2015	Interview with Senior Staff (Appendix F)
2016-2017:	
September 2016- January 2017	Lesson Observations (6), (7), 8, 9
January 2017	Final Questionnaire (Appendix M) Interview 3 (Exemplar: Appendix E)
July 2016 – January 2018	Personal reflections, kept by way of log or diary and emailed from participants to NS

Table 4.5 Schedule of Data Collection

The interviews were scheduled: at the start of the course; on completion of the course; and a year or so after completion of the course. Lessons observations were scheduled similarly with one at the start of course, one at the end, and all subsequent ones scheduled during the remaining window of the project. The logistics for organising lesson observations depended much on people's schedules. Observations by a supervisor and the evaluation from the external evaluator were not in the original research design, but - given the opportunity to do so - were included, in the spirit of grounded theory data collection.

Spending prolonged periods of time with my participants, during the 10-hour face-to-face training days, afforded rich opportunities for openness and deep questioning and listening. Conversations flowed freely and reflective interactions became commonplace.

4.4.3 Interviews

Interviewing played a major role in this research and the narratives drawn from the interviews create the major backdrop for the analyses. Charmaz and Belgrave (2012) succinctly sum up the style and contribution of grounded theory interviews; to this, I aspired:

> 'A grounded theory interview can be viewed as an unfolding story. It is emergent, although studied and shaped; open-ended, however framed and focused; intense in content yet informal and execution; and conversational style but not casual in meaning.'
>
> (Charmaz and Belgrave 2012: 361)

The idea, adopted from Charmaz and Belgrave (2012), was for the stories to gradually unfold and develop as myself (as the interviewer) and participants conjointly dug deeper and deeper, and together shaped and made sense of the narrative. Being privileged to work closely with my participants, the relationships between myself and the participants had time and scope to develop deeply – building on mutual respect and trust. And this relationship between the participant and the interviewer, together with the relationship between the participant and the studied phenomena, influences the depth and scope of the emerging story (Charmaz and Belgrave 2012, Fontana and Frey 2005). The participants were engaged and enthused by the area of study and, granted a voice, appeared to applaud the opportunity to share their thoughts, ideas and stories, resulting in layers of narrative dialogue by way of post-lesson feedback, informal conversations, email communications and personal reflections.

Issues such as potential power dynamics between myself and the participants, and the prominence (or otherwise) of the participant voice, certainly necessitated ethical consideration (Creswell 2012), and the ethics of the study are discussed in detail in 4.4.8. Establishing rapport and gaining trust and mutual respect were key considerations in regard to the participants feeling empowered to say what they really believed; this taking time and emotional commitment. These relationships certainly added to the strength of the study (Forbat and Henderson 2003), significantly influencing the depth and reach of the interviewing process, and of the longevity for which participants were prepared to remain involved in this project. Oakley (1981: 49) states, there is no 'intimacy without reciprocity' and this drove the decision to schedule the first interviews for *after* the first face-to-face training session. I wanted to 'give' of myself, and to show what I had to offer in terms of the quality of retraining and the consideration to their needs and concerns. I wanted to 'reveal' something of myself, before asking others to do likewise.

As we have seen previously, grounded theory must guard against forcing the data into preconceived categories (Glaser 1978), but interviewing and asking probing questions, without forcing responses, can be challenging. Using an approach similar to the feminist, communitarian researcher described by

Fontana and Frey (2005), a framework of opening questions and prompts was used for the first interviews, and participants were invited to reply and then allowed scope to expand at will. This form of semi-structured interviews is typical for qualitative research (Wragg 2012). Maintaining an open approach helped to bring to the surface, significant issues and concerns. (Examples of the semi-structured questions for Interview 1, are shown in Appendix C.) The first interviews were either individual or in small groups. The process of the first interviews felt purposeful in its own right: as if a mutual commitment was being established between myself and the participants – laying the ground work and setting the scene. And it felt that 'flow' was initiated. But nevertheless I did experience anxiety afterward, as to whether I had asked the *right* questions and made the most of the opportunities. This is common for novice researchers as given 'the complex nature of qualitative inquiry, it is reasonable to expect new researchers to feel some trepidation' (Watt 2007), and the anxiety dissipated with the realization I would have many opportunities to continually collect, collate, triangulate, analyse and theorise.

This first foray into data collection, with these initial interviews, cemented my fledgling idea that the interview was not merely a tool but was integral to, and inextricable from, the research findings. The actual act of asking questions challenged the interviewees to think and question for themselves, perhaps heightening awareness, and possibly honing, (or perhaps even creating) their beliefs. The interview itself then appeared to become part of the professional development process - serving as an opportunity to reflect and evaluate on the retraining - for the interviewees and myself. A direct consequence of this unanticipated feedback loop was a more finely-tuned and personalised professional development retraining programme. Recognising my position at the centre of this research, I acknowledged the evolution of this cyclical dynamic: My research (both literature and field) informed and enhanced my practice as a course tutor, which then in turn informed my participants (via my face-to-face training sessions) which then in turn informed my research (via interviews, dialogue and lesson observations). This symbiotic relationship has been highlighted by Rowland et al (2014), who also identify 'the roles of researcher and teacher educator' to be 'complimentary and mutually supportive' (2014: 327). The interviews also enriched the rapport and relationship between myself and the interviewees which later led to the possibility for more revealing and intimate dialogue. The interview process had the sense of accelerating, but not forcing, these respectful relationships.

The participants appeared to become enthusiastically involved and empowered by the direction of the research. They were keenly interested in the shortage of mathematics teachers and the issues leading up to, and stemming from this. I started to question and probe traditional, and often deeply entrenched, beliefs and practices, such as the use of setting and streaming of students for mathematics, and the notion of fixed ability such as 'gifted and talented'. Similarly examined were realities such as 'bottom sets' being disproportionally populated by summer born children and the existence of a long 'tail of underachievement' in England (Marshall 2013). The participants then started to pose and ask questions of themselves and their departments. In this sense it certainly felt that elements of Action Research were being kick-started, and that the teachers' mindsets were being challenged; I visualized it as small wheels of independent inquiry spinning at the edges of my study.

For the first interviews I hesitated to express personal opinions. I was aware that a dynamic approaching a hierarchy might be at play, with my views (as the ‘expert’ tutor) influencing, distorting or silencing others. But as Fontana and Frey (2005) say, with the emphasis ‘shifting to allow the development of a closer relationship between interviewer and respondent’ interviewers can ‘show their human side and can answer questions and express feelings’ (2005: 711). Methodologically, this approach ‘provides a greater spectrum of responses and a greater insight into the lives of the respondents’ (2005: 711), and in later interviews I embraced this more robust dialogue without fear of blocking or limiting responses. Charmaz and Belgrave (2012) agree with Fontana and Frey and point out that active involvement in the interview, by the interviewee, can ‘minimize hierarchical relationships’ (2012: 362).

Conscious from the outset that a perception of hierarchy and power play could exert malapropos influence, I was keen to play down the idea of the ‘expert’ tutor interviewing inexperienced teachers of mathematics. Reluctant to present myself in any fashion that could be construed as authoritative I was judicious to portray myself as a teacher, ‘one of them’. But as Fontana and Frey (2005) point out, there was a danger here too, of losing objectivity and going ‘native’. It was a fine line to tread: being *apart* from them (with expertise to offer) but being and empathizing *with* them (as a qualified teacher); being the expert tutor delivering the retraining programme (with an academic research agenda) but also acknowledging myself to be a novice researcher indebted to them for their time and efforts for my personal benefit. Concerns regarding these conflicting demands from the relationships, were assuaged by mutual respect and hard work which acted as a natural bonding mechanism, creating the culture of a collaborative team effort. This undoubtedly strengthened the interviewing and questioning experience and as Charmaz and Belgrave (2012) point out: ‘The strength of the relationship between the interviewee and interviewer’ can play a key role in the 'depth and detail of the data collected' (2012: 359). And this strength of relationship, between myself and my participants, was captured by the independent evaluator, Keith Hedger who visited both venues and described 'the vibrant, cohesive and productive atmosphere of the group' with participants feeling 'privileged to be involved in the tutor's research project' (Hedger 2014). Hedger believed the 'excellent stimulus, support and inspiration provided by a superb tutor', intent on establishing close working relationships was the catalyst for the participants' 'involvement and enjoyment in the tutor's research project' (Hedger 2014).

In anticipation of documenting many new stories, I decided to audio record the first interviews. This is not necessarily a method endorsed by grounded theory purists and it *may* have initially led to slightly more stilted and hesitant responses. Most of the participants did *appear* to relax once the audio recording was underway. However, for one case study in particular, Anna, there was the sense that the audio equipment lent a more formal air to the proceedings and that she may have been trying to guess or predict what I wanted to hear, and to deliver the *correct* response; 'the respondent may deliberately try to please' (Fontana and Frey 2005: 702). This made me reconsider the usage of the audio-equipment - and of the word 'interview', speculating that this may suggest expectations related to job, or other high stakes, interviews. I subsequently replaced the word 'interview' with 'talk'. Interestingly, during a further literature search, I discovered Glaser (2003) did similarly - choosing to define the word interview as a 'conversation', to create the best conditions for a participant to talk about their most pressing issues, to 'instill a spill' (Glaser 1998: 111). On the whole, weighing up the advantages and disadvantages of audio recording and transcribing, I still considered it to be worthwhile. Building rich layers of detailed data was an integral part of my research plan. When the technology failed, and I could not recover one of my interview recordings, the sense of distress was extreme. (Never again did I use only one recording device!) Fortunately having also taken notes, not all the data was lost. However, having transcribed this interview from hand scribbled notes alone, the result felt thin.

Although much ground was covered during the initial interviews, it quickly became apparent that more depth was required at later interviews. And each interview 'provided a foundation of detail that helped illuminate the next' (Watt 2007: 91). Fontana and Frey's (2005) description of empathetic interviewing resonated powerfully, and probably summarises best what I was attempting to master:

> 'Two (or more) people are involved in this process and their exchanges leads to the creation of a collaborative effort called *the interview* [original emphasis]. The key here is the active nature of this process that leaves to a contextual bound and mutually created story - the interview.'
>
> (Fontana and Frey 2005: 696)

The ideals of empathetic interviewing contrast with those of traditional interviewing, which concentrates on the language of scientific neutrality, a neutrality which could be counter-productive and unnecessary for a study such as this. Instead, an active scenario is envisaged and enacted where the interviewer and interviewee become partners in the process. Fontana and Frey (2005) suggest that to do otherwise and to attempt neutrality is inutile, as the interviewer is a 'person, historically and contextually located, carrying unavoidable conscious and unconscious motives, desires, feelings and biases - hardly a neutral tool.' (Fontana and Frey 2005: 696). Qualitative researchers are increasingly reaching the conclusion that interviews, as active interactions between two or more people, lead to contextually negotiated findings (Watt 2007).

Using this approach of empathetic interviewing, employing friendship, humour and inter-personal skills, I gleaned rich, in-depth and experiential accounts from my participants. As Fontana and Frey (2005) point out, ‘The interviewer must be flexible, objective, emphatic, persuasive, a good listener’ (2005: 704). Being sensitive to the dynamics within a group interview was a key consideration, and during the first interviews, I monitored the contributions of the interviewees to ensure there was not a dominant (or recalcitrant) force. With my choice of semi-structured interviews – the situation was carefully managed by offering turn-taking to each of the interviewees for each of the starter prompts.

Acutely aware that these interviews were absorbing precious time from these teachers, I possibly overplayed the gratitude and appreciation. From an ethical stance, this could technically be construed as incentivizing the experience – or alternatively perceived as simple good manners. In fact, it soon became apparent that the participants were enjoying the interview process. This, perhaps no surprise, as the opportunities to be given voice are often rare. Their enjoyment, or at least their willingness to engage, was evident by the length of time the teachers were prepared to stay and talk, often opting to significantly extend the scheduled interview slot.

To avoid participants’ relevant issues from being missed or obscured, and to ensure findings are genuinely rooted in the participant’s perspective, Glaser (1998) advises commencing interviews with a very open and broad question, which permit participants to talk freely about their issues. Having established good rapport with my participants, asking broad, sweeping, exploratory and general questions at the start of the second-round interviews felt both possible and appropriate. For these second set of interviews, theoretical sampling was employed to further probe previous responses. The participants were provided plenty of scope, to voice their opinions and thoughts, even when these seemed ‘extraneous’ (Charmaz and Belgrave 2012: 362). The danger of not doing so, and of sticking to a prescriptive interview schedule, is that this would be inimical to grounded theory methodology, as it risks pre-framing the problem, and leading participants to engage solely with my preconceived ideas. The anxiety experienced following the first set of interviews – that I had not asked the *right* questions – was not repeated and I felt at ease to relax any sense of control. Anticipating that these ‘talks’ could roam into deeper and more personal waters, these second-round interviews were individual and private.

As the study progressed and I became more closely involved with my participants and their stories, I often chose not to audio-record. The dialogue sessions became free-flow conversations and this flow was very natural, as if friends were conversing. These unscripted, unrecorded conversations revealed much. I would then race to furiously transcribe this dialogue before it faded from memory. For the longer, annual, scheduled interviews, I continued to audio-record – as the interviews would often extend to an hour or more (exemplars of which are shown in Appendix D and Appendix E).

In 2015, to further triangulate or crystallize the findings, the decision was made to interview some of the participants’ head teachers; a further ethics application was submitted and approved (Appendix B). These interviews could not rely on the same depth of relationship and rapport, as enjoyed with the participants;

nevertheless, still informal, these interviews did add to the emerging narratives. Typical prompt questions are shown in Appendix F.

Another central method for data collection was the lesson observations and the associated two-way feedback sessions; both discussed below.

4.4.4 The Lesson Observations and Feedback

The lesson observations were another central source for my evidence, and were considered to be of equal significance to the interviews. The importance of observations has been highlighted by Ernest (1989); it has been shown that there can be 'a great disparity between a teacher's espoused and enacted models of teaching mathematics' (1989: 2).

Depending on differing circumstances, the individual participants were observed a varying number of times. The record of observed lessons is shown in Table 4.6 below.

	Lessons observed (LO) in 2013-2014:	**Lessons observed(LO) in 2014-2015:**	**Lessons observed (LO) in 2015-2016:**	**Lessons observed (LO) in 2016-2017:**

Harvey Venue 1	LO1: Year 8 (set 1 out of 3; 11 girls,15 boys)	LO2: Year 10 (set 2 out of 3; 11 girls,15 boys)	LO3: Year 11 (set 2 out of 4; 13 girls,15 boys) LO4: Year 8 (set 1 out of 3; 15 girls,17 boys) LO5: Year 8 (set 1 out of 3; 14 girls,16 boys) LO6: Year 10 (set 3 out of 3; 11 girls, 4 boys) LO7: Year 8 (set 1 out of 3; 15 girls,16 boys)	LO8: Year 10 (set 2 out of 4; 15 girls,10 boys) LO9: Year 9 (set 1 out of 3; 15 girls,16 boys)
Darcy Venue 2	LO1: Year 11 (set 6 out of 8; 9 girls,13 boys)	LO2: Year 9 (set 3 out of 4; 13 girls,10 boys) LO3: Year 9 (set 3 out of 4; 16 girls,13 boys)	LO4: Year 11 (set 1 out of 8; 11 girls,16 boys) LO5: Year 10 (set 5 out of 8; 11 girls, 10 boys) LO6: Year 11 (set 1 out of 8; 11 girls,17 boys) LO7: Year 9 (set 6 out of 6; 4 girls,9 boys)	LO8: Year 11 (set 5 out of 8; 13 girls,6 boys)
Bea Venue 1		LO1: Year 11 (set 3 out of 4; 6 girls, 9 boys) LO2: Year 11 (set 3 out of 4; 6 girls, 9 boys) LO3: Year 11 (set 3 out of 4; 6 girls, 9 boys)	LO4: Year 11 (set 5 out of 6; 9 girls,11 boys) LO5: Year 9 (set 1 out of 4; 12 girls,14 boys) LO6: Year 9 (set 1 out of 4; 14 girls,17 boys)	LO7: Year 11 (set 5 out of 6; 14 girls,5 boys)
Anna Venue 1	LO1: Year 7 (student KS2 levels: 3-5; 12 girls,12 boys)	LO2: Year 7 (set 2 out of 4; 13 girls,14 boys) LO3: Year 7 (set 2 out of 4; 12 girls,16 boys)	LO4: Year 8 (set 1 out of 6) LO5: Year 10 (set 5 out of 6; 10 girls,9 boys) LO6: Year 10 (set 6 out of 7; 8 girls, 6 boys)	
Katy Venue 1		LO1: Post-16-resit group (7 girls)	LO4: Post-16-resit group (10 girls; 1 boy)	LO7: Post-16-resit group (8 girls, 3 boys)

		LO2: Post-16-resit group (8 girls) LO3: Post-16-resit group (10 girls)	LO5: Post-16-resit group (12 girls) LO6: Post-16-resit group (2 girls)	
Cath Venue 1	LO1: Post-16 group (4 girls)	LO2: Post-16 group (3 girls)	LO3: Post-16 group (6 girls)	LO4: Post-16 group (5 girls)
Euan Venue 2	LO1: Year 11 (set 7 out of 7; 5 girls; 9 boys)	LO2: Year 8 (set 2 out of 4; 16 girls; 8 boys) LO3: Year 8 (set 2 out of 4; 16 girls; 8 boys)		
Janet Venue 2	LO1: Year 7 (set 2 out of 3; (set 2 out of 4; 30 girls)			

Table 4.6 Record of Observed Lessons

The initial intent was to simply observe lessons, with reference to the 'Framework to identify effective mathematics teaching' (discussed in Chapter 3), to see whether any differences in subject knowledge, behaviours, attitude or efficacy could be detected over time, and whether any perceived changes appeared to correlate with the teachers' espoused views.

In reality, the need to master the crafts of lesson observations and mentoring, and to be ethically responsible soon became apparent. Using the framework – and relying only on the high inference judgments – appeared not wholly appropriate. Opting to use the critical events technique, promoted by Wragg (2012) - with the idea that the observer looks for 'specific instances of classroom behavior which are judged to be instances of some salient aspects of the teacher's style or strategies' (2012: 64) - a narrative of the lesson was recorded. Aiming to stay as neutral as possible, I documented what preceded an event, what happened and what came next.

Electing to be a non-participant observer, my decision was driven by the desire to capture the essence of the lesson by recording as much input, from both teachers and students, as possible. This approach was commented upon by Katy:

'*The observation itself was slightly different* [to previous experiences of being observed] *in that you didn't get involved with the student's working but rather observed what was going on in the room. I think this yielded different, more detailed information for feedback and gave us specific points to discuss.*'

(Feedback-on-feedback1 (from LO3))

On occasions I did blend the participant and non-participant approaches to observation and moved around the classroom to view students work in an attempt to see whether the student responses mirrored the teachers' expectations - and to capture on camera examples of student work.

The actual observation documents were written as a non-judgmental commentary of what occurred in the lessons. These were used as a stimulus to promote reflections and informal discussion immediately following a lesson. Later each written, real time commentary, was polished and sections were added commenting on the 'strengths' and 'limitations' of the lesson with reference to the 'Framework to identify effective mathematics teaching' (Appendix N); more detail regarding this process is discussed later.

It is common for teachers to feel some trepidation toward being observed and I wanted to minimize anxiety. I wanted the experience to feel, and be, worthwhile.

The purpose of the observations was therefore made explicitly clear to the participants from the outset: this is an emerging study to explore the impact, or otherwise, of this retraining programme on teacher subject knowledge, attitudes, beliefs and practice over a period of time. Wragg (2012) describes the importance of having won 'the confidence and respect of those observed' (Wragg 2012: 142) and the relationships forged through the retraining face-to-face sessions and the preceding interviews (described in detail above) helped enormously in this regard. Teachers welcomed me into their classrooms and appeared to trust and value my presence and the feedback offered – as documented by the overwhelmingly positive comments to myself and to Hedger, the independent evaluator. Relationships based on openness, trust, and honesty were carefully nurtured.

An observer in a classroom will inevitably create impact (Wragg 2012): the dynamics within the classroom and the lesson itself will be altered and this presents further ethical considerations. To what extent a lesson is distorted is impossible to ascertain, but these considerations could at least be explored during the post lesson feedback sessions. And in an attempt to limit my intrusive impact, I determined a typical routine for lesson observations, as shown in Table 4.7.

• Arrive before the class to find a discreet place to sit in the classroom.
• Teacher to decide how, and if, they choose to introduce me.
• Limit interaction with the students; respond only if they are curious.
• Reiterate to teacher that the scribbling of copious notes, throughout the lesson, is part of the process in an effort to record as much of the lesson as possible, focusing on 'critical events' (see above).
• Offer verbal constructive feedback (only if it appears the teacher would welcome it) immediately after lesson.

Table 4.7 Illustration of Lesson Observation Etiquette

A danger of the observer-observee relationship is that the observer can be cast in the more authoritative role; participants can be ‘inescapably locked into a superior- subordinate relationship’ (Wragg 2012: 59). I was keen to downplay this potential dynamic. In an attempt to both diminish this scenario and be sensitive to the observed teachers’ receptivity, I was overly grateful (for their time, and the opportunity to observe); I emphasized the positives of the lesson and tended towards flattery in order to reward and thank the teacher.

Other ethical issues arose when it became obvious teachers sought instant verbal feedback. There are issues with providing feedback, not least that there is no absolute certainty regarding what constitutes teaching effectiveness (this, discussed in detail in Chapter 2). Reflecting on the nature of effectiveness in terms of teaching, has been a recurring and constant theme throughout the entire research project and recognizing there are often several opinions about quality, not (of course!) just one’s own, was of particular relevance in terms of lesson feedback. Other reservations in providing feedback concerned the dangers of appearing judgmental with potential negative consequences for the teachers who had, after all, voluntarily chosen to take part in this research and give up their own free time. These ethical implications certainly suggested it could be ‘easy to settle for saying little’ (Wragg 2012: 62). And yet teachers (as perhaps all performers) anticipate some feedback and some form of evaluation; as Wragg (2012) says: ‘Anyone teaching new subject matter or breaking fresh ground, may be desperate to know what they can do to improve their professional skill’ (2012: 63). Wragg (2012) also suggests that if lessons are ‘worth observing then they are also worth analyzing properly’, and that ‘little purpose is served if, after a lesson, observers simply exude goodwill, mumble vaguely or appear to be uncertain why they are there, or what they should talk about' (2012: 2).

Following the initial lesson observations, and building on the established rapport, the decision was made to offer each case study teacher individual themes on which to focus. The second set of observations, shortly after the completion of the course, were conducted as developmental lesson observations focusing on these themes. With a focus on development, I was aware that the stakes could potentially feel higher for the teachers. Acutely aware that lesson observations can create anxiety for many teachers (discussed in Chapter 2), I attempted to preempt any possible concerns by way of an email missive, conveying the spirit of lesson observation as envisaged by Wragg (2012):

> '…if teaching is to develop to the point where it can display its talents with pride and its frailties without fear, a tall order in a climate where teachers have often been criticised unfairly and blamed for society's ills, then positive steps must be taken...to make lesson observation a high priority, and that may mean ingenuity, and capitalising on what is available like the presence of student teachers and their tutors.' (2012: 131)

Informal developmental verbal feedback was once again offered; and again the participants reported (in interviews, questionnaires and dialogue) on the value of having ongoing support and advice. Being observed, without the spectre of 'performance management' or Ofsted, was considered as very liberating. Although this informal feedback was appreciated, I felt lacking of a firm framework for formal feedback to properly and rigorously address the many misconceptions and limitations being observed within the lessons. I was 'feeling' my way in terms of feedback, as I didn't want to risk damaging the developing relationships; ultimately without my participants I had no project. However in the spirit of 'capitalising on what is available' (Wragg 2012) - and with the support from my supervisor and consent from my participants - I decided to experiment with a more robust form of feedback. Exploring this emerging theory, that more robust developmental lesson observation and feedback is needed for newly retrained teachers, became the next stage of my study.

The lesson observation document continued to be written in real time, and then used as a vehicle for discussion immediately following the lesson. At this juncture, the strengths and limitations of the lesson were discussed and co-constructed by the teacher and myself, with reference to the high inference items from the ‘Framework of effective mathematics teaching’ (see Appendix N). The teacher was always invited to reflect and feedback first, reflecting the ethos of the Japanese Lesson Study model (APEC 2013).

These focused mentoring and coaching sessions became a key feature of the lesson observation process. The difference between mentoring and coaching can be subtle and I use them virtually synonymously (and there is more description of these in Chapter 2) as a continuation to the support given during the retraining programme. Mutual trust and respect were essential, and comments from the participants (outlined in Table 4.8) highlight the significance of these considerations.

Anna:	. *I feel part of the process and not judged…It allowed me time to reflect on my lesson and the discussion with Naomi was along the ‘coaching’ type and therefore I was able to notice areas to improve myself with her guidance.* (Feedback-on-feedback 1)
Bea:	. *I value your opinion - as lecturer/academic - more than that of HT* (Interview 3)
Cath:	. *With you…it is non-judgmental…I don’t know how others are managing without this [feedback and mentoring]* (Interview 3)
Darcy:	. *I really didn’t enjoy that; I found him very harsh [supervisor visit to*

	triangulate results]. It made you seem lovely …(Interview 3)
Euan:	. *It was forward thinking and constructive whilst also being an honest appraisal of the teaching seen.* (Feedback-on-feedback 1)
Harvey:	. *There are not many opportunities to get feedback that is non-judgmental and this is an opportunity to get [that] feedback; The non-judgmental side is very powerful to me* (discussion following Lesson Observation 6)
Janet:	. *It is important to be observed by someone who is a good teacher. The observer needs to be credible. I've had some observers… where I think: Like to see you do this!!* (discussion following Lesson Observation 1)
Katy:	. *Thank YOU! I wish you could come more often. That really was one of the most useful pedagogic discussions I've been able to have in years! I wish lesson observations were more like that (constructive). This is the best observational process - it is developmental and non-judgmental* (email: 15/102015)

Table 4.8 Comments from Participants Highlighting Mutual Trust and Respect

Within a few days of each lesson observation, the participants now received the polished written report, identifying all the strengths of the lesson and with all the observed limitations and misconceptions clearly addressed (see Appendix G for an exemplar lesson observation document). Photographs were incorporated within this document, providing visual cues to the lesson, including board work, pages from students exercise books, activities and exercises. The teachers were always given a right to reply by way of being invited to respond and to edit. None ever did. Two weeks after each observation (when the teacher had had a chance to digest, absorb and reflect on the feedback) a 'feedback-on-feedback' form was sent to the teacher, to explore their thoughts and reactions to this more robust feedback process (see Appendix H). These responses added to the data.

I conducted over 50 lesson observations with each of the eight participants experiencing somewhere between 5 and 9 observations. Some other planned observations were cancelled at short notice by the teachers and the reasons for this varied: tests or examinations, scheduled after the appointment arranged, were considered by the teacher unworthy to observe; sometimes a teacher reconsidered and cancelled if they subsequently felt the observation had, after all, been arranged with too short notice; one teacher felt that, at times, there was just ‘too much on’; family issues impacted on one teacher; illness and absenteeism; and one case study teacher, in his late 40’s, simply stopped teaching - resigning from the profession after 14 years of teaching. During the months of May and June, it was particularly difficult to arrange visits as teachers were very focused on the upcoming examinations and associated revision; perhaps also suggesting teachers felt these lessons unworthy of observation. All of this may suggest that even though great efforts were made to put teachers at ease and to minimize the intrusive nature of the observation, for the teacher an observation may still be a matter of some significance or stress - and that a heightened level of performativity is required - only to be embraced when conditions are favourable. Alternatively it could be, as some teachers commented, that they didn’t want to ‘waste’ an opportunity for feedback and for mentoring when they were not set to gain the most.

To summarise, from 2015 to 2017 participants received (with their consent) rigorous verbal and written feedback highlighting developmental aspects. My role as observer therefore evolved into one of mentor and coach. Exploring this more definitive support role, and considering how this affected teachers both personally and professionally, became another emerging theme from my research.

In addition to capturing feedback, by way of ‘feedback-on-feedback forms’, various other questionnaires were employed throughout the study; these are considered next.

4.4.5 Questionnaires

The questionnaires employed throughout this study were used mainly to service the major instruments of interviewing and observation. All teachers, enrolled on the Plymouth SKE+ course, completed the standard Mathematics Attitude Questionnaire (Appendix I) and Subject Questionnaire for Mathematics (Appendix J) both pre and post the retraining. These questionnaires explored their confidence in subject knowledge as well as their views on the teaching of mathematics and asked teachers to gauge their expertise level (from 1 to 5) on 20 different topics of mathematics; these questionnaires were repeated at the end of the course so the teachers' own perceptions could be compared. The questionnaires also ascertained a few basic teacher beliefs, which provided an ideal entry point for the first interviews with the research participants and a direction in which to probe much deeper into their beliefs, ideas and motivations. Other questionnaires were designed throughout the course of the study for theoretical sampling, to triangulate, to capture shifts in teacher perceptions over time, and to prime teachers prior to an ensuing interview. These questionnaires, influenced by Garet *et al* (2001) and Boyle *et al* (2005), are included in Appendices K, L and M.

Along with these questionnaires, and the lesson observations and interviews previously discussed, reflections, thoughts, observations and ideas were all noted and explored by way of memos; these a key tool for grounded theory methodologists.

4.4.6 Memos

Memos or note-writing are a tool to keep track of ideas, thoughts, connections, queries, hunches and sense-making (Creswell 2012, Watt 2007). Used throughout the entire research process, memos can help shape emerging ideas and 'prevent paralysis from mountains of data' (Creswell 2012: 439).

Throughout the data collection cycles and throughout the whole research study, I was conscious of being as reflexive as possible. Reflexivity, a concept that comes from anthropology, is a process of reflecting on oneself as the researcher, to consciously acknowledge and examine experiences, assumptions and preconceptions which preempt the research and that therefore inevitably influence the process and outcome. By thinking reflexively, my intention was to reduce the risk of being misled by my own assumptions. And any insights or underlying (and revealed) motivation and purpose for the study, can be used to add depth and clarity to the research. Renshaw (2009) refers to this reflexivity as the quality of a person's 'inner listening, attention and awareness' (2009: 6). Learning to be reflexive, and to reflect on one's thoughts and behaviours, 'creates a means for continuously becoming a better researcher' (Watt 2007: 82). Becoming a better researcher, whilst simultaneously aiming to contribute to the field in question, can be considered core aims for this PhD study.

Experience as a teacher and educator, and also as a mentor and manager – will have undoubtedly coloured the lens through which I see. Two decades ago, as a young and relatively inexperienced new head of a mathematics department, I inherited teachers of mathematics who were non-specialists. This experience is still clearly embedded in my memory and will influence my thoughts, ideas and interpretations. As too, will be the constant struggle to recruit effective teachers to a rural comprehensive, questioning even then what it was we really wanted (and needed) teachers of mathematics to be able to do. This study deliberately focuses on one retraining scenario – that of teachers, taught by me under the umbrella of Plymouth University. Nevertheless, visiting and observing other retraining models (for example, in Newcastle), funded similarly by the government, has helped me reflect on my own practice and to think more widely about the process of retraining. Observing and talking to mathematics teachers from other countries and examining other education systems and aspirations, has afforded me the opportunity to step outside the box of England's education system, with its shortage of mathematics specialists, and look from the outside, in – and to explore assumptions, expectations and cultural differences. Meetings, arranged with other training specialists – for example with Murphy from TAM (Teaching A level Mathematics) – have also helped hone and examine my thoughts and emerging themes.

In the style of an online journal, I kept eclectic memos in one document spanning from early 2013 until the end of 2017. I started writing these memos without *knowing* what to write or think, taking inspiration from Laurel Richardson (2010) and her article: Getting Personal: Writing stories. For Richardson, 'Writing is a method of discovery…I write because I want to find something out. I write in order to learn something that I did not know before I wrote it' (2010: 35). Embracing this sentiment, I used memos to help to me think and understand reflexively. Richardson (2010) recognises that we are *in* our research; by engaging with internal dialogue and documenting it by way of memos, the 'process of knowledge construction' can be revealed (Watt 2007: 84). Charmaz and Belgrave (2012) echo this sentiment, believing it is the writing of memos which 'links coding to writing the first draft of the analyses' and that memos keep interpretations close to data and ‘avoids forcing the data into extant theories’ (Charmaz and Belgrave 2012: 357).

In addition to these writings, I also compiled extensive field notes with numerous notebooks taken into the field to capture incidents and events.

4.4.7 Field Notes

Glaser (2001) claims the dictum ‘all is data’ (2001: 145). In other words, everything can be considered as potentially relevant data: interviews, observations, meetings, conferences, lectures, news articles, conversations with colleagues and friends, poems, stories – the list is, by nature, endless. Accordingly, for grounded theorists, the literature review is also viewed as a source of data.

Field notes were used to collate this varied and extensive data. This data comprised: my own personal thoughts; personal reflections and diary entries kept by the participants; email communications; impressions from observing mathematics lessons, and talking to teachers, in other countries (Japan, Hungary and Finland) and of lesson observations and interviews with Shanghai teachers demonstrating in England; the observation of Core Maths colleagues, identified by the Core Maths Support Programme (CMSP) as expert practitioners; conversations with other tutors of retraining programmes; and the emanations from numerous other experiences and sources.

The previous cohort of retrained teachers (and prior to the one from which the research participants were drawn) had provided me the opportunity for informal pilot interviews and lesson observations. Three members of this cohort agreed to attend a 'reunion' and were happy to accede ethical consent and contribute to this study by way of post-course interviews and questionnaires. These contributions have also added to the field study.

Aware that I am 'part of the scene being observed' (Angrosino and Mays de Perez 2000: 676), this may be 'no bad thing' as it is questionable whether 'observational objectivity is either desirable or feasible as a goal' (Watt 2007: 90). Nevertheless, taking account of myself, and my central position within this project, have been significant considerations throughout the study. Maintaining personal reflections, by way of memos and field notes, have helped me maintain reflexivity and to capture the research process as a journey of joint discovery alongside my participants.

Throughout this intimate and intrusive journey, ethical considerations were imperative.

4.4.8 Tackling Ethical Dilemmas/Approach

Protecting my participants was fundamental and an ethical approach to this qualitative research was clearly appropriate and essential.

A sensitivity towards ethical issues has grown over recent decades. In the 1960's, with the birth of grounded theory, there appeared little consideration of potential ethical complexities. Now ethical dimensions are a cornerstone of any research and, it could be argued, are more complex with qualitative methodologies than with quantitative (Yin 2014). Qualitative research studies, such as this, may be more intrusive and probing; examining personal lives may be more likely to risk potential harm. Relationships between researcher and participants, between me and *my* participants, are also likely to pose ethical complexities and will certainly create an impact of one kind or another. Qualitative research is not impact-neutral.

Ethical considerations encompass: privacy, confidentiality, anonymity, betrayal, deception, and harm (Cohen *et al* 2011, Creswell 2012, Yin 2014).

Privacy ensures a person has the right not to take part in the study, or in aspects of the study (Cohen *et al* 2011) – and participation for this project was voluntary and equitable, so that no one was unfairly included or excluded (see details of the recruitment in section 4.4.2). Informed consent was received from all participants, in line with the Plymouth University ethics guidelines and all participants had the right to withdraw up to the point of data collection completion (Appendix A). Participants privacy must also be protected by way of anonymity or confidentiality. For this study, confidentiality was guaranteed; anonymity was not. Anonymity which ensures a researcher cannot know from whom the data has come was clearly not appropriate for my constant comparative data analysis approach. Confidentiality, inferring the connection between the data and the actual person is not made publicly known, was guaranteed by way of each participant being given a pseudonym and avoiding any references to geographical locations. Confidentiality can also imply the intent not to discuss a participant with anybody else (Cohen *et al* 2011). As Cohen *et al* (2011) point out, ‘the more sensitive, intimate, or discrediting the information, the greater is the obligation on the researcher's part'; and 'Promises must be kept.' (Cohen *et al* 2011: 92). Although seemingly straightforward, this vow of relative silence did raise some challenges. With the exceptional, and perhaps surreal, circumstance of two participants from one school swapping hierarchical roles overnight (see sections 5.3 and 5.4), maintaining confidentiality between the two participants became both more significant and more challenging. Maintaining a public veneer of neutrality regarding the unfolding drama was essential.

Betrayal - when data, assumed to be confidential, is disclosed - can potentially inflict damage or harm, by way of stress, embarrassment or anxiety. This is more than a breach of confidentiality; this is also a breach of trust (Cohen *et al* 2011). In this study, issues surrounding potential betrayal or harm may be most prominent in the *weaving* of the summary narratives from the many interview and observation transcripts; the individual transcriptions, less troubling. The transcripts for the lesson observations and feedback sessions were intended to be a negotiated process between myself and the participants; these transcripts, with reflective detail, were returned to the teachers who were then afforded a right-to-reply and were at liberty to edit and return. None ever were. The interview transcriptions, although on offer, were never requested: Having faithfully attempted to accurately transcribe every word - and running to over 6000 words apiece - none of the participants chose to reread the experience. The summary narratives (see Chapter 5), on the other hand, weaved from all the data for each participant were not offered to the participants for their view or input. This was a decision made - a tension held - in regard to revealing the 'truth' and not being inhibited to do so, whilst protecting my participants and not wishing to cause any harm, upset or disappointment. I am nevertheless conscious these narratives will eventually enter a public (if not necessarily wide) arena – with the potential for causing some harm, by way of disappointment or disagreement. Participants, who have readily revealed their day-to-day practice, whilst investing in a valuable relationship with me over an extended period of time, may come to feel vulnerable if - in the final summary - their practice is considered with negative connotations. It could even seem like a ‘betrayal of trust’ (Cohen *et al* 2011: 95).

Deception was obviously never intended but this too may have unexpectedly crept in on occasions. Over emphasizing the positives of a lesson in order to reward or thank a teacher for their time, was something of which I was certainly culpable of at the start of the study. This could be construed as a form of deception, deceiving the teachers into believing their teaching and subject knowledge were stronger than perhaps the evidence suggested. Over time, and with strengthening relationships partly built on this initial positive input, more honest and balanced appraisals were given. Being sensitive whilst being honest was clearly a critical path to follow. Sensitivity was always a significant consideration and was particularly so at times of extreme stress or anxiety on the part of the teacher, examples of which are clearly documented in Chapter 5.

These issues outlined above, certainly created tensions and ethical dilemmas: On the one hand the aim is to capture an honest representation of the observed ‘truth’; on the other, we are ethically bound not to inflict harm. Guillemin and Gillam (2004) describe the need to be ‘alert to and prepared for ways of dealing with the ethical tensions that arise’ (2004: 278). Strike *et al* (2002) offer two principles for guidance in the field, and for dealing with ethical tensions such as mine: the principle of benefit maximization and the principle of equal respect.

The principle of benefit maximization is pragmatic, in terms of promoting the best course of action to be the one which produces the greatest benefit for most people; being uninhibited to reveal full disclosure within the summary narratives may ultimately be seen to benefit more people. These actions, therefore judged by their consequences (Strike *et al* 2002). The principle of equal respect ‘demands that we respect the equal worth of all people’ (Cohen *et al* 2011: 98). Straying into the realms of elevated positive affirmation may be seen in the light of striving for equal respect and the conscious attempt to break down any assumed hierarchy between researcher and researchee. Given that this was only a temporary scenario, which may also have added to the principle of benefit maximization, the effects may be seen to be mitigated.

The multitude of interactions and reciprocal relationships with my participants, with all the associated ethical considerations, created a wealth of data which required coding; considerations surrounding this process are presented next.

4.4.9 Coding the Data

Close and comparative attention to the data was my first analytical step. This immersion in the data, reading and re-reading the interviews and dialogue transcripts, and getting a sense of the whole, preempted the beginning of the coding process. Coding, separating the data into pieces by segmenting and labeling sections of the text, initially using in-vivo codes (derived from the participants' words) before later introducing in-vitro codes (constructed by the researcher to refine terminology), provided a means to organize and make sense of the data. As Charmaz and Belgrave (2012) point out, coding moves the researcher from description towards an understanding, and so to a conceptualization of the research phenomenon. For constructivist grounded theorists coding paradigms (diagrams indicating interrelationships between codes) are unnecessary; descriptions suffice. The advantage of 'in-vivo' codes, at least initially, is that they ensure a close connection to the data and limit the likelihood of bias; they are more likely to reflect the participants' perspectives rather than that of the researcher and of the extant literature (Creswell 2012, Glaser and Strauss 1967). Continuously coding data throughout the research informed my decisions in terms of theoretical sampling. In other words, this helped to suggest what to consider in subsequent interviews and dialogue sessions to explore specific key points, and to extend, refine or confirm coding categories. Theoretical sampling helping, therefore, to gain rich data, identify gaps within the data and develop codes and themes. The interview questions gradually became more probing; this possible as the relationships with the participants strengthened and thrived, enabling more open and intimate conversations. Later the initial codes were examined for overlap or - in the case where they had been barely populated - for redundancy. Codes were subsequently aggregated into broad themes and just as segments of text could contribute to more than one code, some codes contributed to more than one of the inter-related themes. The Nvivo software was employed to manage and support the coding process, enabling efficient and rigorous interrogation of the developing and substantial data base. The initial ‘in-vivo’ and ‘in-vitro’ codes are listed in Table 4.9.

in-vivo codes	**in-vitro codes**
• Confidence (CON)	• Barriers to further development (BD)
• e-learning and online tests (e-L)	• Bring into mathematics from other subject specialisms (BRING)
• Effective mathematics teacher (what is) (EFF)	• Catalysts for development (CAT)
• Exam (GCSE) results (EX)	• Department Practices (PRA)
• Face to face sessions (F-F)	• Immersion (into subject) (IMM)
• Lesson Study and collaboration opportunities (LS/CO)	• Impacts of retraining (IMP)
• Mentoring and coaching (M&C)	• Mathematics teaching observed (MT-Obs)
• Ofsted (OFS)	• Perceptions (PER)
• Pedagogy (PED)	• Pressures (PRESS)
• Professional development opportunities (PD)	• Student attitudes (SA)
• Resources (R)	• Teacher attitudes/Beliefs (TA)
• School support (SSup)	• Teaching style experienced themselves (TStyle-exp)
• Shortage of mathematics teachers (SHORT)	
• Subject knowledge (SK)	
• Teaching mathematics – as described (TM)	

Table 4.9 Initial Codes Emerging from the Research Study

(The abbreviation for each code is given in brackets – and these abbreviations are used throughout the remainder of the text.)

Issues surrounding subject knowledge and ideas relating to the meaning of effective teaching were overtly explored during interviews and questionnaires. It is therefore to be expected that they were frequently referenced by participants and naturally became in-vivo codes.

From these codes, broad themes eventually evolved, as outlined in Table 4.10.

	Theme	Description
1.	**Subject knowledge and Pedagogical Content Knowledge (PCK) issues** (SK) (PED) (EFF) (IMM) (IMP) (e-L) (CON) (TM) (PRA) (SA) (TStyle-exp) (PD) (R) (F-F)	including: the impact of the lack of mathematics subject knowledge; effectiveness; the benefits of being immersed in mathematics; confidence issues related to teaching maths
2.	**Mentoring and coaching** (M&C) (IMP) (PD) (TA) (PED) (TM) (CON) (PER)	the impact of these for the participants
3.	**Collaborative practice including opportunities (and the lack of opportunities)** (LS/CO) (IMP) (PD) (PRA) (MT-Obs) (R) (F-F)	for: collaborative planning; networking; sharing of good practice; peer developmental lesson observations; and Lesson Study
4.	**Senior management influence (support/pressure)** (SSup) (PD) (CAT) (BD) (PER) (PRESS) (EX)	pre, during and post the retraining programme
5.	**The school/department effect** PRA) (BD) (CAT) (PER) (TA) (TM) (MT-Obs) (EFF) (EX) (PED)	the impact of the school or department 'norms' (the department 'mould') on a teacher's style of teaching
6.	**External pressures** (OFS) (EX) (PRESS) (SHORT)	the impact on teaching of: Ofsted; GCSE results; other pressures (for example, financial constraints)

Table 4.10 The Broad Themes from the Research Study

The aim for grounded theorists is to keep seeking data until each theme is saturated, and no new information is unearthed or discovered with regard to the category. In practice, ‘saturation is an elastic category that researchers use to suit their definitions’ (Charmaz and Belgrave 2012: 359). In my case, data collection concluded in 2017, after the final interview with each participant.

Making sense of all the data, grounded theorists tend to present their generated theory in three possible ways: ‘as a visual coding paradigm, as a series of propositions or hypotheses, or as a story written in narrative form’ (Creswell 2012: 437).

For this study, narratives are presented to portray each of the 8 participants (see Chapter 5). Following this, an analysis chapter (Chapter 6) draws upon all the narratives and supporting literature to summarise findings. In Chapter 7, the narrative style is blended with a ‘series of propositions’ (Creswell 2012: 437) - which may have the potential to suggest enhancements for future retraining programmes.

Any findings obviously depend on the quality of the research; ensuring the validity of the study was another significant and essential step to be woven throughout the research – and is discussed in the next section.

4.4.10 Validity and Reliability

Validity and reliability are rooted in the positivist perspective and in quantitative research (Golafshani 2003). Reliability is concerned with replicability and the extent to which results can be reproduced if the study were to be repeated. Validity, depends on reliability, and refers to the degree of accuracy in regard to whether a study measures what it set out to do – whether metaphorically, the results from the study hit the bullseye (Creswell 2012, Golafshani 2003, Yin 2014,). In a qualitative context, it is suggested the concepts of reliability and validity need to be 'viewed differently' and adapted and redefined (Golafshani 2003: 599). Inductive theories technically cannot be valid or invalid but instead strong or weak - or probable or less probable - because the premises and connectives from which such a theory is developed are themselves based purely on probabilities.

In terms of evaluating a grounded theory study, Charmaz (2006) uses the ideas of 'credibility, originality, resonance, and usefulness' to measure whether the theory generated at the end of the study is indeed grounded in the view of the participants (Creswell 2012: 442). This interpretative approach links to the interpretative paradigm and the ideas of reality and truth being constructed from observed human actions and interactions. Any emerging theory from a grounded theory methodology is necessarily and purposefully close to the data – and so will not have wide applicability or scope (Creswell 2012: 436). However, the theory is not a 'minor working hypothesis' but rather a 'middle range' theory drawn from multiple individuals and data sources, which provide an explanation for a substantive topic (Glaser and Strauss 1967: 32/33). For this study, I did not seek generalisations, predictions or patterns but instead understanding, illumination and 'extrapolation to similar situations' (Golafshani 2003: 600). Validity can therefore be seen to be related to credibility and whether the 'theoretical explanation makes sense' and whether it is an 'accurate rendering of events' (Creswell 2012: 442). This links with Glaser and Strauss' (1967) four verification criteria for judging the adequacy of the emerging theory:

fit, relevance, workability and modifiability (with ‘fit’ and ‘workability’ considered to be the two most significant).

The term ‘reliability’ in qualitative contexts may more closely connect to quality, dependability and consistency, with the idea of ‘trustworthiness’ deeply embedded (Golafshani 2003: 600). Seale (1999) states that the ‘trustworthiness of a research report lies at the heart of issues conventionally discussed as validity and reliability’ (1999: 266). Stenbacka (2001) however, argues there is no place for reliability in qualitative research as a lack of measurements renders reliability irrelevant. And it can be argued that intimate, unique, qualitative research such as this, is, by definition, not replicable. This creates a dilemma if it is assumed there can be ‘no validity without reliability’ (Lincoln and Guba 1985: 316). However, if as Lincoln and Guba (1985) suggest, ‘the former [validity] is sufficient to establish the latter [reliability]’, then the definition of reliability in a qualitative context is neatly sidestepped and subsumed in the holistic description of validity; this, assuming the term validity, in a qualitative context, refers to credibility and sense-making (Creswell 2012).

For my grounded theory approach, the process of validation is therefore dependent on credibility and sense-making – coupled with the ideas of the research being original and useful. During the constant comparative process of coding and theoretical sampling, data was continually cross-checked and triangulated with the emerging categories. And as an extension to triangulation, Richardson (2000) advocates crystallisation, with the multifaceted attributes of refraction, reflection and de-fraction, as ‘we do not triangulate; we crystallise’ (Richardson 2000: 934). Richardson (2000) points out that there are ‘far more than three sides from which to approach the world' and that what we see 'depends on our angle of repose' (Richardson 2000: 934). Crystallization creates Richardson's paradox: 'we know more and doubt what we know' (Richardson 2000: 934). In the instance of my participants, data was initially triangulated (or crystallised) from interviews, lesson observations, conversations and questionnaires; each layer, adding to the credibility and resonance of the emerging stories.

The next section summarises the methods, my methodology and the research study as a whole.

4.5 Summary of the Methodology and Methods

The methodology design and development have been fundamental to this study, and *may* prove valuable for future projects. The summary of this design is outlined in Table 4.11.

What is involved?	**Why?**
Preliminary light literature review	As a scoping exercise, to explore initial ideas
Research questions posed	To frame the research study
Constructivist grounded theory (Charmaz 2014) used as the backbone for the design	This builds on an interpretative perspective and assumes that theories are not discovered but are mutually constructed by the researcher and the participants, as a result of interactions within the field (Charmaz and Belgrave 2012)
Regular and frequent access to participants; Researcher to enter, however partially, the participant's world and be affected by it	Enabling interactions within the field and for relationships and friendships to develop
Researcher to display heightened interpersonal skills: empathy; listening skills; friendship; mentoring skills	For the researcher-participant relationships to thrive and become deeper and more meaningful

A determination to limit any potential power hierarchy between researcher and participant	For research methods to be successfully initiated, including interviews and observations.
Time and energy	Relationships and trust take time to build; this can be a slow but intense process
Mutual commitment to project; participants need to *want* to be involved	To ensure the longevity of the project and to gain deep and interesting data; and to limit superficial sentiments
Researcher to be prepared to *give* of themselves, for example: deliver demonstration lessons; offer resource ideas; contemporary research input; guidance (if sought); time to listen	To acknowledge there is no 'intimacy without reciprocity' (Fontana and Frey 2005: 711) To value the not insignificant time commitment from participants by making the experience worthwhile
Being at the heart of the research project, and employing the art of noticing (Mason 2002) with sensitivity	To augment all of the above To access unique, deep and intimate data
Prior experience, perceived wisdom and natural analysis using common sense, invoking Schatzman's (1991) 'common interpretative acts'	Used to frame and interpret the data – with no pretense that prior experience is irrelevant or is to be hidden
Sharing, explaining, reviewing, talking about and experimenting with ideas; necessarily filtered through the perspectives of our personal lives	To help make sense of the participants' unravelling stories Examples: the sense of stress and anxiety, or the burden of workload, can be appreciated through the lens of being a teacher; the struggle to recruit teachers viewed through the lens of being a senior leader
Close and comparative attention to the data, including an extended and ongoing review of literature; theoretical sampling employed	To constantly compare data with data, including the literature; the literature is treated as any other source of data. To look for gaps, overlaps, and emerging themes.
Unavoidable ethical tensions to be dealt with sensitively, invoking Strike *et al*'s (2002) two guiding principles: the principle of benefit maximization and the principle of equal respect	To simultaneously limit any potential 'harm' to participants whilst being uninhibited to expose and reveal the 'full' findings
The writing of detailed narratives for each participant; rich, detailed descriptions built up over time	To capture and present the participants data from multifarious sources, from which a general analysis can be drawn to address the research questions
A list of propositions documented in the conclusion of the study, intended to be credible, original and useful – and to resonate with future readers; thereby 'validating' the study	To summarise the analysis and to make sense of the findings: to suggest enhancements for future provision and 'extrapolation to similar situations' (Golafshani 2003: 600)

Table 4.11 Summary of the Methodology Design for this Research

The research questions have given me clear direction and intent to what I was looking *at*, and the methodology and methods a clear framework for *how* to look and see. It was however, always unclear as to what I would *find* or *discover*. Observing and listening to the participants over a significant period of time, I have attempted to summarise the narratives simply and clearly. Richardson (2001) describes much academic writing to be 'simply not interesting to read' (2001: 35) and Cockcroft (1982) identified the reduced relevance of research when the reports are 'written in a technical style which is not always easy to follow' (1982: 228), as too did Tooley and Darby (1998). In the telling of these stories, and in the subsequent analysis and drawing of conclusions, I have attempted to portray the writing in in an engaging and accessible way, and to promote the original voice of the participants. From a rich patchwork of narratives, an important story with the beginnings of new knowledge is manifest; this without 'pretence that by some methodological alchemy it will be transformed to something more secure in its epistemic status' (Thomas and James 2006: 29). The findings, this new knowledge, although not generalizable is anticipated to be transferable in terms of being useful for future research studies and for the design of future retraining programmes.

Each of the participant's stories, weaved together from the various research instruments employed throughout the course of this longitudinal study, are described in detail in the following chapter.

Chapter 5: The Participants

5.0 Introduction

This chapter captures the stories of my participants, all of whom volunteered to take part in this research project. Being willing to volunteer is a significant factor to ventilate: Teachers prepared to participate in an intrusive study *may* be more reflective and effective than those who choose not to do so (Browne 2006).

Conforming with constructivist grounded theory principles, the narratives were weaved together, with depth being added over time, from the data collected using various research instruments (detailed in Chapter 4). Each narrative varies slightly – in terms of structure – and this is influenced by the longevity of involvement by some participants and by the varying depth of engagement with the research instruments. Three participants (Katy, Janet and Euan) gave incredibly detailed accounts in their personal reflective journals, and this has been capitalized upon.

Direct quotes and questionnaire responses are included in italics, and the codes assigned to these segments of text are recorded in brackets (see Table 4.9 in section 4.5.4 for the list of codes and abbreviations).

Table 5.1 presents a brief overview of each of the participants, prior to each profile being presented in turn, each following a broadly chronological sequence of events.

Participant and Venue	**Original subject**	**Highest previous mathematics qualification**	**Number of years teaching in total (as of September 2017)**	**Number of years teaching mathematics (as of September 2017)**	**SKE+ Course Award**
Harvey Venue 1	PE	GCSE, grade A	10	4	Merit (82%)
Darcy Venue 2	PE	A level, grade D	14	5	Distinction (100%)
Bea Venue 1	Science	A level, grade C	28	4, no longer teaching maths, as of September 2017	Distinction (94%)
Anna Venue 1	Science	A level, grade C	7	3, no longer teaching maths, as of September 2016	Merit (84%)
Katy Venue 1	Childcare	GCSE, grade C, after resitting		5	Merit (86%)
Cath Venue 1	Science	A level Statistics, grade B	15	8	Distinction (96%)
Euan Venue 2	IT/Computing	A level, grade B	14, resigned from teaching in July 2015	2 no longer teaching maths, as of September 2015	Distinction (100%)
Janet Venue 2	Music; English; Business Studies	GCSE, grade A	6	1 no longer teaching maths, as of September 2014	Merit (86%)

Table 5.1 An Overview of Each Participant

5.1 A Profile of Harvey

5.1.1 Introduction to Harvey

In 2013, Harvey's school was struggling to recruit mathematics teachers. As a consequence, Harvey was offered the opportunity to transfer from the PE department to the mathematics department and he keenly embraced this opportunity, enthusiastic to retrain. Harvey decided to enrol on a Subject Knowledge Enhancement Plus (SKE+) retraining course. (The SKE+ programme is discussed in detail in Chapter 3.)

Harvey was one of 14 teachers being retrained at Venue 1, in 2013-2014. Harvey is a qualified PE teacher with 10 years teaching experience, four of which he has taught mathematics. All of his teaching experience is within 11-18, mixed, comprehensive schools. Prior to completing the SKE+ course, and achieving a merit for his Certificate in Mathematical Mastery, his highest mathematics qualification was a GCSE grade 'A'.

This section pieces together a story of Harvey's '*transformation*' (Reflections on Course, December 2014) from PE teacher to mathematics teacher. Table 5.2 illustrates at which points Harvey was involved with the various research instruments during the course of this longitudinal study.

	Year 1 2013-2014	Year 2 2014-2015	Year 3 2015-2016	Year 4 2016-2017
September		Personal reflections – throughout year	Personal reflections – throughout year Lesson Observation3: Year 11 (set 2 out of 4; 13 girls,15 boys)	Personal reflections – throughout year
October		Reflections on Course Questionnaire Visit and notes from external evaluator: Keith Hedger	Feedback-on-feedback1(from LO3)	
November				
December	**Course commences** Mathematics Attitude Questionnaire 1 Subject Questionnaire for Mathematics SKE+ Evaluation 1	Mathematics Attitude Questionnaire 2 Subject Questionnaire for Mathematics SKE+ Evaluation 2 **Course concludes**		
January	Interview 1	Pre-Interview 2 Questionnaire Lesson Observation2: Year 10 (set 2 out of 3; 11 girls,15 boys Interview 2		Lesson Observation8: Year 10 (set 2 out of 4; 15 girls,10 boys) Lesson Observation9: Year 9 (set 1 out of 3; 15 girls,16 boys) Final Questionnaire Interview 3
February	Lesson Observation1: Year 8 (set 1 out of 3; 11 girls,15 boys)		Lesson Observation4: Year 8 (set 1 out of 3; 15 girls,17 boys) Feedback-on-feedback2 (from LO4)	
March			Lesson Observation5: also with Ted Graham (research supervisor) Year 8 (set 1 out of 3; 14 girls,16 boys)	
April			Feedback-on-feedback3 (from LO5)	
May				
June	Personal reflections – throughout year		Lesson Observation6: Year 10 (set 3 out of 3; 11 girls, 4 boys) Lesson Observation7: Year 8 (set 1 out of 3; 15 girls,16 boys)	
July				
	Mathematics teaching commitment: Full-time	**Mathematics teaching commitment: Full-time**	**Mathematics teaching commitment: Full-time**	**Mathematics teaching commitment: Full-time**

Table 5.2 Schedule Illustrating Harvey's Participation with the Various Research Instruments

5.1.2 A Narrative of Harvey as a New Mathematics Teacher

On the Mathematics Attitude Questionnaire 1 (December 2013), Harvey ticked '*yes*' to the question: 'Are you confident you can be a good teacher of mathematics?' (SK; PED; TA). Towards the end of the course Harvey also believes that his students are getting a good deal in terms of their teaching, and ticked the option: '*Good - probably about as good as they've ever had'* (Reflections on Course Questionnaire) (SK; CON; PED; TA).

From both the Mathematics Attitude Questionnaires, it is clear Harvey ranks '*excellent subject knowledge*' as highly significant in being an effective mathematics teacher (SK). Harvey regularly referred to the need to improve his subject knowledge and to build connections, recognising he did not yet have the understanding of '*how topics seem to relate to each other*' (Interview 1). Harvey linked his practice and pedagogy to his subject knowledge levels: '*As I get more comfortable with a subject I fell freer to let them go…but with my [older] Year 9 and 10's I can't let them go so I do more chalk and talk'* (Interview 1) (SK; PED).

Notes I made after the first lesson observation (at the start of the course) record a very clear rapport between teacher and students with some subject knowledge weaknesses. The second lesson observation - and the first one after the completion of the course - highlighted some interesting issues. Harvey was delighted with the lesson, feeling that he now had the confidence to *'let the students go'* (CON; SK; PED) and enact teaching in the style promoted by the retraining programme. But he appeared oblivious to the students' lack of mathematical focus and key connections and teaching points were missed.

There were very few instances of the interweaving of mathematical content and pedagogy, and subject knowledge weaknesses were still apparent. Harvey was keen for me to comment and make suggestions. It was at this point in the research project that the idea for more formal developmental feedback with the associated mentoring and coaching was formulated; there was a need to be able to comment honestly and constructively and not to simply settle for giving pointless platitudes (Wragg 2012). Providing participants with the opportunity to comment on this more formal analysis, by way of a feedback-on-feedback form, was also an idea developed at this time.

Harvey credits the course for his improved subject knowledge: '*If I hadn't done the course, I really don't think I would have such an in-depth knowledge… and without that subject knowledge there is no way that I would have been able to teach that [Higher GCSE]'* (Interview 2, January 2015) (SK; F-F). Linking this strengthened subject knowledge with pedagogy, Harvey said: '*As I have become more secure in my subject knowledge I have grown in confidence',* feeling more competent to spot and avoid common misconceptions (Reflections on Course, September 2014) (SK; PED). Harvey picks up this point again in Interview 2 (January 2015): '*I know about misconceptions, knowledge that I have gained from the course'* (SK; PED); '*as my subject knowledge has improved I feel more confident in doing different types of activities whereas it would have been before out of the book'* (SK; CON; PED). Harvey also felt more comfortable offering *'extensions because of my increased subject knowledge'* (Interview 2) (SK).

Harvey believed his teaching style was '*changing from chalk and talk towards a more discovery method'* (Reflections on Course) (PED). Without improved subject knowledge and confidence, Harvey believes he would have continued to teach in a predominantly didactic manner.

> *Harvey:* '*In the past when I've done a topic that I have found quite challenging then it got to the point where I would revert back to - chalk and talk and book method and I hated it - um - they got bored and then they started misbehaving'*
> (Interview 2, January 2015) (SK; PED)

During the feedback session after Lesson Observation 4, Harvey referred again to improved subject knowledge enabling his practice: '*Subject Knowledge has gone up, confidence has gone up - so I can try things - and I am willing to let them [students] try*' (SK; PED). During the feedback after Lesson Observation 5, Harvey suggested more connections between topics were starting to develop: '*The bigger picture is coming*' (SK; PED).

Referring to more active teaching and learning style, Harvey said: '*It was the confidence of the course that made me think I could do that sort of thing [discovery] otherwise – because none of the other teachers are - so how could I?'* (Interview 3) (CON; PED; TM; PRA).

Acknowledging the craft involved in the style of teaching being advocated, Harvey decided to continue his retraining and enrolled for the 2015-2016 pilot Core Maths TSST (GOV.UK 2018a); he achieved a merit at the end of the course. Harvey pointed out: '*it was very much that style and I enjoy that style - put more emphasis on the kids rather than me - and I do really like that so…it is the style that I learned'* (Interview 3) (PED). Although Harvey appeared to be noticing more about the style – and what was involved – he still needed to gain more experience appreciating the '*big picture'* (Interview 3) of mathematics and the multitude of connections to be made; for this, greater subject knowledge and a considerable commitment to lesson-planning may still be needed.

A committed and engaged participant throughout the whole year of the course (with 100% attendance), Harvey positively relished lesson observations with the associated mentoring and coaching; his motivation was clear: '*I want to develop; I want to get better*' (Lesson Observation 5) (PD; M&C). Feeling that there were '*not many opportunities to get feedback that is non-judgmental'* (M&C; SSup), Harvey believed that mentoring and coaching was an '*extremely good use of my time*.' Not only does Harvey believe that he has developed his teaching skills as a result of mentoring and coaching, but he feels he has also appreciated how best he could mentor others: '*If I have to do observations - I will do it this way - now less judgmental and more about the feedback'* (Lesson Observation 4) (M&C). This awareness - perhaps an extremely fortuitous, if unintended, outcome of the study.

During the course of several lesson observations it was possible to see the development of Harvey as a teacher of mathematics. Lesson Observations 3 through to 7 showed a clear trajectory of a teacher developing and honing their practice. Harvey regularly described the period of his retraining as a '*transformation*' - from PE teacher to mathematics teacher - and believes that this would not have been possible without significant support from the school and department (SSup; PRA). This support was evident pre, during, and post the retraining course. Examples of such support include: a 5-day residential subject knowledge programme (in Spring 2013); regular mentoring and team teaching sessions with an ex-Head of Department; no quibble release time;

mileage expenses for attending all sessions; and a sense of the mathematics department being 'on-side'.

In September 2016, Harvey changed schools for a promotion to Assistant Head of House. The levels of senior management support were now much reduced and Harvey believed that this was right, '*it should be less'* (Interview 3) (SSup). There is evidence however that further subject knowledge support and development would have been beneficial. Notes made during the final two lesson observations (Lesson Observation 8 and Lesson Observation 9) show students being taught to rely on procedures and memorise formula, no whole class teaching and obvious teaching opportunities missed. This appeared to illustrate a backward step in the development of his mathematics teaching. I was particularly interested in whether any difference in outlook between the two schools had affected Harvey's style of teaching so I asked Harvey about the difference between his two schools:

Harvey*: 'I think the main difference is the emphasis on the amount of marking and the testing here - there is a big emphasis on number crunching - where are the kids?…it's just all too much, … I am working until nine or 10 o'clock every night - it is unsustainable - and for not much benefit.'*
(Interview 3) (PED; PRA: PRESS)

It appears that the school's ethos is having a strong impact on Harvey's teaching approach and as other influences fade, the school itself maybe the stronger force in determining teaching styles. With more emphasis on marking and testing, Harvey's time to plan lessons has been reduced. This is proving to be especially problematic for Harvey as, whilst his own subject knowledge is not secure or comprehensive, he believes: '*I think my time would be better spent planning good lessons than marking the work.'* (Interview 3) (PED; SSup). In terms of planning lessons and sourcing resources, Harvey said: '*it is phenomenal how much you can get off twitter'* (Interview 3) (R).

Without expansive subject knowledge teachers may feel the need to keep control over the lesson by imparting information and limiting student discussion (Wragg 2012). This approach (of being dependent on, and limited by, numerous prepared slides) was apparent during the early lesson observations, and then again in later lessons at his new school (documented in notes from Lesson Observations 8 and 9).

The school in which Harvey is currently teaching is the only school (in this study) where collaborative planning, approximating the style of Lesson Study, is actually taking place. In reality, although the teachers are working in small groups to plan and observe lessons together, the aim is about resource provision and consistent practice and not about research, so is only very loosely related to Lesson Study. Nevertheless, Harvey is clearly enthused by this practice and delighted to have been able to contribute some of his own Lesson Study experience from the SKE+ course, encouraging the teacher who had taught the lesson to reflect first: '*we did it that way but it was only because I have done it on the course*' (Interview 3) (LS/CO; F-F).

5.1.3 Summary

Harvey presented himself at the start of the SKE+ course as a teacher with strong pedagogical skills, well-liked by pupils, bringing some PE type rapport and presence into the classroom - who was really enthusiastic about teaching mathematics and very keen and motivated to learn. This character summary was corroborated by the external evaluator of the course (Hedger 2014).

Harvey certainly perceives that the retraining and all its associations has had an impact.

Harvey: 'for me the impact was massive … you learnt so much and you came away with such good ideas and stuff to try and I am still using those ideas, I literally took the ideas - and a lot of the other maths teachers who had the maths degrees used to say - how do you get these ideas? I got [the ideas] from the course; and the other teachers are like [wow!!]…and they [students] used to love it and find it more fun and accessible…So yeah the impact on me with massive, I think therefore that's impacted a lot of the kids… and now the impact on here [his new school] is that they've got a good maths teacher'. (Interview 3, January 2017) (IMP; SK; PED; CON; PRA; TA)	

The impact of the training may not have been deeply embedded. In very little time – in a new school setting – Harvey appeared to revert back to the 'chalk and talk' style he claimed to dislike so much. With limited planning time this may have been his only course of action. Harvey regularly referred to wanting to teach by enabling the students the opportunity to 'discover'. Harvey showed overtures in this direction in years 2 and 3 of the study, but was constantly compromised by limiting subject knowledge. Harvey appeared to be impeded throughout his retraining and beyond, by his limited prior attainment in mathematics (GCSE is his highest mathematics qualification). Further subject knowledge enhancement may have enabled him to develop his practice. Previously Harvey has appeared to recognise the link between less engaging lessons and poor behaviour. Nevertheless, at his new school, with Harvey's reversion to a more didactic approach, student behaviours appear to show boredom, loss of focus and disengagement (Lesson Observations 8 and 9). Harvey's school and the team within which he now works appears to be the most dominating influence on his approach to teaching mathematics.

Harvey's priorities may have shifted and the zeal he demonstrated towards becoming a mathematics teacher may have faded. With his promotion to Assistant Head of House, his pastoral duties now seem to be his passion. It is possible that the ethos of the new school – with so much emphasis on marking and testing – has dampened his appetite, and indeed his opportunity, to develop as a mathematics teacher.

The narratives of other participants now follow – after which reflective analysis will draw upon these summary profiles.

5.2 A Profile of Darcy

5.2.1 Introduction

Darcy is a qualified PE teacher with 14 years teaching experience. In September 2012, Darcy was appointed to teach mathematics full time, having previously taught PE at the school for four years; the school is an 11-18 mixed comprehensive.

Darcy was one of 10 teachers being retrained at Venue 2, in 2013-2014. Prior to completing the course and achieving a distinction for her Certificate in Mathematical Mastery, her highest mathematics qualification was an A level grade 'D'. Having not studied the Higher level at GCSE, Darcy felt she needed to study the A/A* grade GCSE material from the SKE+ course carefully '*because I haven't done that stuff myself because I only did the Intermediate'* (Interview 1) (SK). For her initial teacher training, Darcy embarked on a B.Ed. degree in PE *with* mathematics but dropped the mathematics after year 1.

Darcy's current school has some interesting characteristics worthy of note. At Key Stage 4, all students were, until very recently, assigned to be in either the J or K 'half' of the school with approximately 150 and 50 students respectively. The 'halves' were decided by student prior attainment with the J 'half' students aiming for GCSE grades A* – C and the K 'half' students mainly aiming for grades D – G. This system has only very recently been reviewed, apparently following advice form an education consultant: '*This chap that came in - he has obviously left an impression*' and '*we scrapped that now*' (Interview 3). The school has now recently adopted a three-year Key Stage 4, with students making their option choices at the end of Year 8. When students arrive in Year 7, they are informed - from their benchmark test levels - their flight path to GCSE grades. The focus on Key Stage 4 is further emphasised with teachers receiving the message to prioritise Key Stage 4, and to create additional opportunities for revision sessions for Year 11 students, by reducing time for planning and marking at Key Stage 3.

This section pieces together a story of Darcy's transformation from PE teacher to mathematics teacher, over a period of 4 years. Table 5.3 illustrates at which points Darcy was involved with these various research instruments during the course of this longitudinal study.

	Year 1 **2013-2014**	**Year 2** **2014-2015**	**Year 3** **2015-2016**	**Year 4** **2016-2017**
September		Personal reflections – throughout year	Personal reflections – throughout year Lesson Observation4: Year 11 (set 1 out of 8; 11 girls,16 boys)	Personal reflections – throughout year
October		Reflections on Course Questionnaire Visit and notes from external evaluator: Keith Hedger	Feedback-on-feedback2 (from LO4)	Lesson Observation8: Year 11 (set 5 out of 8; 13 girls,6 boys)
November				
December	**Course commences** Mathematics Attitude Questionnaire 1 Subject Questionnaire for Mathematics SKE+ Evaluation 1	Mathematics Attitude Questionnaire 2 Subject Questionnaire for Mathematics SKE+ Evaluation 2 **Course concludes**		Final Questionnaire Interview 3
January	Interview 1 Lesson Observation1: Year 11 (set 6 out of 8; 9 girls,13 boys)	Lesson Observation2: Year 9 (set 3 out of 4; 13 girls,10 boys) Pre-Interview 2 Questionnaire Interview 2		

February			Lesson Observation5: Year 10 (set 5 out of 8; 11 girls, 10 boys) Lesson Observation6: Year 11 (set 1 out of 8; 11 girls,17 boys)	
March			Lesson Observation 7(also with Ted Graham (research supervisor)): Year 9 (set 6 out of 6; 4 girls,9 boys)	
April				
May				
June	Personal reflections – throughout year	Lesson Observation3: Year 9 (set 3 out of 4; 16 girls,13 boys) Feedback-on-feedback1 (from LO3)		
July				
	Mathematics teaching commitment: Full-time	**Mathematics teaching commitment: Full-time**	**Mathematics teaching commitment: Full-time**	**Mathematics teaching commitment: Full-time**

Table 5.3 Schedule Illustrating Darcy's Participation with the Various Research Instruments

5.2.2 A Narrative of Darcy as a New Mathematics Teacher

Darcy appears to be a very confident teacher. She seems to enjoy a venerated position within the school and enjoys a lot of freedom and little intervention. In 2012 Darcy was sent on an 'outstanding teacher course' (unrelated to mathematics teaching). A desire to be outstanding and to be the best appeared to be evident during the SKE+ course. Darcy was driven to succeed in all the online tests and engaged in regular humorous banter with other 'high attaining' participants on the course – all vying to achieve the top marks. Darcy did so, scoring 100% on each of the 37 tests. Darcy really enjoyed doing the tests.

Acknowledging the distinction between being able to do maths and being able to teach maths, Darcy said: '*my maths knowledge was very - I could do it but I couldn't necessarily teach it'* (Interview 3) (SK; PED). To develop her mathematical pedagogy Darcy commented: '*the course was a bit of a must for me*' (Interview 3) (SK; PED).

Darcy was described by another participant, as: '*obviously outstanding – she has it all – can do the tests and teach well*' (SKE+ session, April 2014). Curious to know how this opinion had been realised, it became apparent that it was Darcy's own musings.

> Darcy: *'Really mix it up. I wouldn't ever say any two lessons are the same so sometimes there is that occasion where you just have to say here's the example on the board and you just have to practice but I always try and get the kids up and around the room I always try and get them teaching each other, helping each other and if they're stuck I always say ask before you ask me. And I try and encourage them to take more responsibility for their learning um so that they can try and find out for themselves rather than just being told the answer.'*
> (Interview 1, January 2014) (PED)

The first lesson observed, at the start of the course, felt fast and possibly a bit frantic, with missed opportunities for deep thinking. Subject knowledge issues were highlighted with Darcy teaching incorrect knowledge in regard to statistical averages. Active participation and engagement from students were not observed, or encouraged, and the lesson delivery was from the front, didactic and rather 'scatter-gun' like. It was a Year 11 revision lesson and Darcy was determined to cover a lot of ground. Darcy made several comments relating to test scores, GCSE exams and marks. Whilst trying to establish who got the question correct, Darcy commented: '*Again in exams - we hate them but we have to do them*…'. This was interesting because Darcy clearly puts a lot of emphasis on exams (and she herself enjoys doing tests: *'I have really enjoyed them…I really enjoyed them*' (Interview 2) (TA) (PER) (PED)).The classroom environment speaks of the high profile of tests and exams – boxes of exam papers fill every available shelf and space.

Darcy is clearly driven by GCSE results and works incredibly hard describing herself as *'a really competitive person'* (Interview 3) (TA). Regularly delivering extra-curricular revision sessions, Darcy was proud of her results: *'I always want my exam results to be the best but - yeah and they were this year - I always want my results to be the best and I was really pleased with my results - they were very good. Um very very good*' (Interview 3, with regard to top set Year 11) (EX) (TA) (PER) (PRA). With the increased demands on her time – sometimes teaching 8 sessions a day – Darcy, on occasions, appeared exhausted; this approach to getting Year 11's through their GCSEs may not be sustainable.

A didactic and superficial approach to teaching was shown in Lesson Observation 2, with equivalent fractions. One student observed that they '*had done this before*' (SA) and there appeared very little challenge or context to the lesson. There was no big picture awareness and no evidence of the style of teaching advocated on the course.

Lesson Observation 3 was the first with the more formal feedback. Darcy did employ some strategies garnered from the SKE+ course, for engaging students in mathematical thinking and for widening participation. Aware that I am at the heart of this research project, I acknowledge I may have been predisposed to credit these particular strategies – because I myself had previously endorsed and enacted them during the retraining. However, active participation throughout the lesson was limited, as too were opportunities to develop deeper understanding. Opportunities for discovery or creativity were not encouraged, as evident from one boy who deserved (but did not receive) credit for an ingenious (but unanticipated) approach to a problem.

Darcy completed a feedback-on-feedback form and selected the ‘strongly positive’ option in every single category, indicating that she found the mentoring and coaching useful and worthwhile. Darcy did add the comment ‘*but disappointing to see so many things I could do to improve*’ (Feedback-on feedback form) (M&C) (TA) (PER).

Feedback after Lesson Observation 4 again highlighted that deep thinking had not been developed. The point, discussed with Darcy, was that although the teaching was aspirational in terms of talking about exam grades and exam success, the teaching itself was not challenging for - or of - students.

The start of Lesson 5 appeared to emulate some features modelled on SKE+ course. Following an engaging YouTube clip as students entered the room, the lesson was well planned and set in context, with use of real data. There was an obvious commitment to include as many students as possible in class discussion and a concerted effort to demonstrate a positive attitude to all students. However, I highlighted the clerical nature of the work and asked whether the students could ‘*be pushed to think a little more for themselves?*’ (Feedback from Lesson Observation 5).

Lesson 6 appeared to show a significant shift and students had to think for themselves throughout the lesson, having been asked deep-thinking questions. They were guided to see how they could construct their own knowledge (surrounding sine, cosine and tangent), work things out for themselves and not to, necessarily, rely on memory. It may be worth noting that this was with Darcy's favourite group, a top set Year 11, and the positive attitude directed toward the students appeared natural and reciprocated.

Lesson 7, a lesson that Ted Graham (supervisor) co-observed, did not showcase similar pedagogical development. Ted viewed the 'combination of ice-cream scoops' as a good *idea* for the starter but believed a poor resource had been chosen. Ted also identified that the students did not work collaboratively, instead they worked on their own for a lot of the time. During feedback, Darcy was offered guidance to encourage more student engagement – getting them up out of their seats and to the board, for example. Ted highlighted some missing details in the board work and shared his opinion about disliking worksheets. 'Probability' is perhaps a perfect opportunity for students to play and experiment – and I reflected that this was an opportunity missed. The poor choice of resource (with a muddle between combinations and permutations and confusion about the ice creams being 'different') and a reluctance to let students experiment, may have exposed subject knowledge weaknesses and a lack of confidence with the material. Darcy commented: '*It wasn't a normal lesson I changed it because of being observed. I changed it because NS was less impressed with 'bread and butter' type lessons' (*Lesson Observation 7) (TA) (TM) (PED)(M&C). This appeared to suggest that Darcy was not wholly engaged with the developmental aspect of the feedback.

In conversation a week or so later, Darcy revealed that she did not enjoy the feedback from the '*scary tutor*' (Ted). She referred to this again during Interview 3, whilst talking about mentoring and coaching:

> Darcy: '*everyone likes to be told that what they're doing is right and is good - and while it's often hard to be told 'I wouldn't do that' - for example your scary mentor [laughter] …you can only ever learn from coaching and feedback…'* (Interview 3) (M&C) (TA)

Darcy's main goal from the mentoring and coaching feedback sessions, may have been to receive affirmation for the job she was doing. I feel Darcy was less able to engage with the developmental aspect – other than to please me personally. There is very little evidence (apart from the occasional 'performance' lesson) to show that Darcy was able to enact the developmental feedback.

Darcy often employs a didactic approach with a spiral style of delivery – believing she will have to reteach students again and again, as '*they can't retain stuff from one day to the next*' *(*Lesson Observation 7) (TM) (TA) (PRA). Darcy pointed out that her mid-to-lower attaining students '*often only score only 15/80'* in tests and she acknowledges the '*confidence of the kids is low';* so not to baffle or '*confuse the students'* further, Darcy believes in not using '*too formal language' (*Lesson Observation 7) (TM) (PRA). During interviews Darcy often referred to the idea of mathematical language and terminology with comments such as:

- *'my terminology wouldn't be as good as somebody who had done their qualification'* (Interview 1)
- *'my terminology isn't there'* (Interview 2)
- *'one of my targets was to ensure I was using the correct terminology'* (Interview 2)
- *'I go to my head of department [for subject knowledge support] … for key words and definitions'* (Interview 3)

Darcy's reluctance to use the correct terminology with her students may be closely linked with her own lack of proficiency, and could in fact be hindering her students' progress, not helping it.

5.2.3 Summary

From the lessons I have observed, there appears to be a disparity in terms of how Darcy suggests she is teaching and how she is actually teaching. Her rhetoric is convincing and she may even have convinced herself that she is teaching more effectively than she is. Darcy points out '*there is that occasion where you just have to say here's the example on the board and you just have to practice'* (Interview 1) (TM) (PRA), but I would avouch from what I have observed, this practice is the usual rather than the occasional.

The driver for Darcy's approach to teaching appears to be pressure for exam grades. This comment during Interview 1 is very revealing:

> *Darcy: 'ultimately your head and your HOD telling you must get grade C's, you must get grade B's, you must get grade A's, and more often than not the way you're going to get them is [doing] exam papers - you know doing a lot of didactic teaching and here's your exam questions, here's your textbook…'*
> (Interview 1) (EX) (PRA) (PED)

Darcy did make several comments suggesting she would like to teach using the activities encountered on the SKE+ course, but that there simply wasn't the time or the appetite from senior management, to engage in such frivolities.

> *Darcy: 'my priority is to get from D's to C's whilst I would love to take them out on the tennis courts and do you shaving foam with string which I know would sit in their head … I just feel there isn't that time and even in the Key Stage 3 lessons - you know we have the scheme of learning where you are told - do this in three weeks, do this in four weeks...'*
> (Interview 2) (SSup) (PRA) (EX)

As ‘*the time pressures are so tight’* (Interview 2) (PRESS), Darcy believes she has no alternative to a superficial approach to teaching and learning. Darcy asserts that her senior leadership would not approve of her doing otherwise: *‘if SLT walk into the room and ask what are the kids learning and well they are doing an investigation I think a lot of them would be ‘oooh not sure…’* (Interview 2) (PER) (SSup) (PRA).

In principle Darcy suggests she would prefer to teach differently but Darcy has developed a strategy that successfully secures her higher-attaining students good GCSE results. And it is this, Darcy believes, which defines an effective teacher: ‘*an effective maths teacher is someone who gets the kids that exam in Year 11’* (Interview 2) (EX; TA). It may be exhausting for her and a less than satisfactory experience for the students, but teaching and learning ‘*to the test*’ (Interview 2) (EX; PED) is the style Darcy has adopted and is a style she is reluctant to relinquish. This form of delivery allows her to maintain control of the lesson content and does not leave her exposed to unexpected subject knowledge scenarios. Although Darcy has acknowledged that all but the higher attaining students struggle with retention, I believe she will continue to teach in a superficial, didactic manner, dependent on a repetitive tight spiral curriculum. This style is the antithesis to the one Darcy frequently espoused: *‘Kids coming in enthused about lesson, engaging in starter from the off, discussing ideas and concepts. Topic for lesson explained, kids helping one another, discussing and moving onto more challenging questions’* (Reflections on Course) (PER; TA; PED).

Darcy does feel valued, '*I'm more valued than I ever was as a PE teacher'* (TA) (PER) (SSup) (Interview 2) and with a reputation for strong discipline and good general pedagogical and classroom management skills, little intervention or interest is affected from the Senior Leadership Team. Subject specific professional support appears to be woefully limited. Significantly, in 2017, Darcy was promoted to Head of Key Stage 4 in the mathematics department, with responsibility for data analysis (to identify where students could improve their GCSE performance). Darcy is also now supervising a young PE teacher who has recently enrolled on the 2017-2018 TSST retaining programme.

Darcy has carved out a role as a mathematics teacher who delivers successful GCSE results.

5.3 A Profile of Bea

5.3.1 Introduction

Bea started teaching in 1989 and has taught in several co-educational state comprehensive schools. In 2004, Bea became an Assistant Head teacher at her current school; prior to this she was a Head of Science. In her role as an Assistant Head, Bea continued to teach Science and line manage several departments including mathematics. In 2013 the school failed to find a Head of Mathematics or indeed a mathematics teacher at all. However, according to Bea, there was '*an embarrassment of riches*' (Interview 1) in the science department. So the decision was made to merge the mathematics and science departments: five science teachers '*volunteered*' to each teach one mathematics group, thereby negating the need to recruit a mathematics teacher. Two of these science teachers (Bea and Anna) enrolled on the SKE+ course. Interestingly - a year later - of the five science teachers who had agreed to teach mathematics, the only two still remaining to do so were Bea and Anna.

From the initial questionnaires and interviews it is clear that some of the key factors driving Bea to enroll on the course, were: to be able to '*address students' misconceptions in mathematics, link mathematical topics and boost student confidence'* (Mathematics Attitude Questionnaire 1) (SK; PED; TA). Bea believes the course addressed these needs and now feels able to teach mathematics as she would science: deliberately challenging students' misconceptions to provoke deeper thinking.

For the 2014-2015 academic year, having failed again to appoint a Head of Mathematics, Bea suggested she took on the role in addition to being an Assistant Head. Bea credits the SKE+ course for giving her the confidence to transform the mathematics department. Another participant (Anna) is within this same department so I have been able to consider two different perspectives.

In May 2015, Bea was involved with an unfortunate incident which appeared to reveal a lack of loyalty to the headteacher. Under pressure, Bea resigned from her role as Assistant Head; she did however retain (on a temporary basis) her position as Head of Mathematics. A year later Bea moved '*sideways*' into a permanent position teaching mathematics full time and in charge of whole school development of 'Teaching and Learning'. In a twist of fate, Anna who had until now been Bea's underling, enjoyed an almost meteoric rise to be promoted as the new Assistant Head, and in doing so became Bea's line manager.

Table 5.4 illustrates at which points Bea was involved with the various research instruments during the course of this longitudinal study.

	Year 1 2013-2014	Year 2 2014-2015	Year 3 2015-2016	Year 4 2016-2017
September		Personal reflections – throughout year*	Personal reflections – throughout year*	Personal reflections – throughout year*
October		Reflections on Course Questionnaire Visit and notes from external evaluator: Keith Hedger	Lesson Observation4: Year 11 (set 5 out of 6; 9 girls,11 boys)	Lesson Observation7: Year 11 (set 5 out of 6; 14 girls,5 boys)
November				
December	**Course commences** Mathematics Attitude Questionnaire 1 Subject Questionnaire for Mathematics SKE+ Evaluation 1	Mathematics Attitude Questionnaire 2 Subject Questionnaire for Mathematics SKE+ Evaluation 2 **Course concludes**		
January	Interview 1	Lesson Observation1: Year 11 (set 3 out of 4; 6 girls, 9 boys) Pre-Interview 2 Questionnaire Interview 2		Final Questionnaire Interview 4
February		Lesson Observation2: Year 11 (set 3 out of 4; 6 girls, 9 boys)	Lesson Observation5: Year 9 (set 1 out of 4; 12 girls,14 boys)	
March			Feedback-on-feedback1 (from LO5)	
April		Lesson Observation3: Year 11 (set 3 out of 4; 6 girls, 9 boys)		
May				
June	Personal reflections – throughout year*			
July			Lesson Observation6: Year 9 (set 1 out of 4; 14 girls,17 boys) Feedback-on-feedback2 (from LO6) Interview 3	
	Mathematics teaching commitment: Full-time	**Mathematics teaching commitment: Full-time**	**Mathematics teaching commitment: Full-time**	**Mathematics teaching commitment: Full-time**

*including extensive email correspondence from Bea, numbering in excess of 100

Table 5.4 Schedule Illustrating Bea's Participation with the Various Research Instruments

5.3.2 A Narrative of Bea as a Mathematics Teacher and as a Head of Maths

Bea believes it is the SKE+ course which gave her the confidence to take on the role of Head of Mathematics and determinedly reshape the department: *'This course has genuinely changed my life…I would never have had the confidence to take on my Maths department and challenge them to understand that they (the qualified ones) are wrong and I (the physicist) am right'* (email 5/11/14) (CON; TA; PED; PRA; BRING; IMP).

Bea was keen to consider a bigger vision and look to plan for a five-year programme of study based on understanding and collaboration.

In November 2014, two years after the school had been identified as 'requires improvement', the school was once again inspected by Ofsted and was deemed to be 'good'; all the teaching in mathematics was judged to be good or better. Two outstanding lessons were seen in the course of the inspection - both were mathematics lessons (Bea was one of these teachers). Bea, when asked whether she could have taught mathematics this successfully without the course, said '*yes - but now with added confidence and knowledge surrounding common misconceptions.'* She then added: *'BUT now [I have] the confidence to transform the whole department in this SKE+ image*' (Interview 2) (F-F; CON: PED; TA; PRA; BRING; CAT). There seems no doubt that Bea has felt confident to make major changes to the department as a direct consequence of the retraining provision; as a senior manager, teaching relatively few mathematics lessons, Bea had the time and space to do so.

Combining pedagogical skill and mathematical wherewithal, Bea was keen to introduce teaching and learning by 'problem solving'. It was interesting to see whether her department would be able to follow suit. I was curious to know whether she felt she had teachers within the department who could embrace the style of teaching she envisaged. Referring to the Japanese Level 3 type teachers (see 2.2.2), we considered whether she had any Level 3 type teachers and if not how to best to develop teachers in such a way. Questioning how often she observed others, Bea responded: '*Not as much as I should*...*There just isn't the time to do peer observations. I could do a lot more with my department if there was more time'* (Interview 1) (LS/CO; SSup; BD; PRA). Over the years the department make-up varied from an assortment of experienced teachers drafted in from various other disciplines, to a collection of various inexperienced teachers including NQTs and TeachFirst teachers. In 2017, a Head of Mathematics was finally recruited - an ex-primary teacher who had never previously taught in secondary school. At no point during my study was the department staffed by a significant complement of specialists. From several comments from colleagues, Bea was aware that some were less than comfortable about incorporating a '*guided rediscovery*' approach, recognizing that: '*Not everyone can do it this way - deep thinking, the engagement…Other things need to be nailed [first] - relationships, subject knowledge - you need to be able to make connections between all maths topics*' (Interview 3) (SK; PED; PRA; BD). Bea certainly had her work cut out to transform the direction and mindset of the department but she remained a stalwart provocateur, insisting her way was the right way, believing children are taught best by *'putting them in real life situations where maths is used to solve real problems' (*Reflections on

Course) (PED; TA). To do this, Bea believes a set of tools and skills should be taught along the way: *'I think of it like a treasure chest of mathematical skills that the children should acquire really quickly and then use to solve real problems' (*Reflections on Course) (PED; TA).

When asked to describe a good mathematics lesson, Bea replied: *'A hard question on the board that challenges the kids to think, to make links. Students then tackle that problem with courage and tenacity; making mistakes, pushing the boundaries…' (*Reflections on Course) (PED; TA). And this was typical of what I observed. There were other common themes in the observed lessons: a strong student-teacher rapport with students appearing relaxed but ready to work, was commonplace; students were deliberately provoked to think by way of interesting questions and scenarios; mathematical language was used as a matter of course; with an emphasis on understanding most students were involved in interactive 'questioning and answering' in most lessons. Bea always had complete control of the class with a non-confrontational ethos in classroom: *'I think teaching like I teach, you have to have certain things absolutely nailed. You can't be doing this and arsing around with behaviour management…' (*Interview 3) (PED; TA).

At the end of the Lesson Observation 2, Bea asked her students some questions about what they thought and felt, regarding mathematics lessons. When asked if they have to '*think in maths'* (SA) they all responded emphatically and almost in unison, that yes they have to think a lot, more than in other subjects and more than in previous years - and that this was most definitely a good thing. Other pupil comments are illustrated in Table 5.5.

• *There are harder, more challenging questions this year…[previously in mathematics] it was too easy*
• *We can ask each other when we get stuck*
• *We are mentally engaged*
• *It depends on your teacher. Didn't get on with the teacher last year - so we just mucked about…*
• *There is no negativity - we don't feel judged…*
• *Somebody might get something wrong but nobody laughs [like would have happened last year]*
• *We don't use text books …not being told to get textbooks out and turn to page…'cos then it's as if the teacher doesn't really care…*
• *She [the teacher] knows what she is talking about …[the teacher] mixes it up… you remember much more …*

Table 5.5 Comments from Year 11 Students, after Bea's Lesson Observation 2

Having observed Bea several times, and from interviews and other conversations, I know Bea is keen to promote cognitive autonomy. This is clear from several of her comments and her own personal research surrounding autonomy, believing: *'we have to teach in a way that allows for mastery and fluency' (email, December 2014)* (SK; PED; TA).

Our post-lesson discussions were wide and varied, encompassing but also moving far beyond the parameters of the lesson feedback. One such discussion was along the lines of: Who is responsible for the students' lack of success in a test when they have only recently been taught the topic? Bea's response was that she was coming to the conclusion that they, the students, have to start taking more responsibility. But she qualified this by saying '*that you can never eliminate previous poor experience and teaching*' (reflecting Smith's (2017b) findings) (Interview 4) (TA). This chimed with something Bea had said during the third interview: '*We need more specialist teaching in primary schools*' (reflecting Williams (2008) recommendation) (SK; PED). Bea had recently been on visits to feeder primary schools and had returned with tales of incorrect mathematics being ‘taught’. Often our discussions would feel like a genuine exchange of ideas and one of co-mentoring and coaching (Renshaw 2009). This response from Bea was typical: *‘I feel you are open to what you see and judge it for what it is, not against a tick list of criteria to make it good/outstanding whatever...it’s a two-way thing…’ (*Feedback-on-feedback2) (M&C; TA)*.*

During the final lesson observation (October 2016), the headteacher and two other senior teachers entered the room with clipboards in hand, on one of their routine ‘learning walks’. There was a tangible and immediate change in atmosphere. Students who had previously been articulate and working collaboratively, went silent. One student, when asked by a senior teacher what he was doing, stared at the desk, appeared frozen with embarrassment and mumbled that he ‘*didn’t know*’. Later that week, Bea asked me if I could forward my observation notes as *‘someone is seeing that lesson from rather a different perspective and I would like to counter their opinion by using that of someone who was actually in the lesson…’ (email from Bea, 7/10/16)* (PER; BD; SSup)*.*

Bea is an advocate for ‘*real-time teaching*’ and dislikes the use of pre-prepared PowerPoints, suggesting that she cannot always know what is going to happen in a lesson ‘*because - you know what if, what if, what if - I would need an infinite number of hyperlinks’* (Interview 3) (TA; TM). Bea noted ‘*I probably hate them more than I realise’* but she does think that ‘*they are very useful for people who are trying to establish themselves’* as they can be used as a behaviour management tool: ‘*let’s have a slide with eight simple steps …let’s write down these 8 steps people in silence’* (Interview 3) (TA; PED). To Bea, an effective mathematics teacher is ‘*engaged and interested in the subject…lessening the* *needs for props [pretty penguins or cake on board]*'; someone who has the subject knowledge '*nailed*' (discussion following Lesson Observation 3) (EFF; SK; PED; TA). Bea referenced the impact of the school culture: '*the heads of department in this school are pressured to do nothing but concentrate on outcomes – and If I'm really honest I don't think that plays to my strengths'* (Interview 3) (PED; PER; SSup; PRESS; TA; EX).

To summarise my own observations: The students believe in Bea and believe she knows her stuff. In Bea's words: '*it's about having confidence in your subject knowledge and confidence in your relationships with the kids*' (Interview 4) (SK) (PED). Students are engaged and behaviour is exemplary. The work is challenging and students feel safe; safe to get things wrong without ridicule. Bea 'gives' of herself by telling little stories; by so doing Bea models how to be open to posing questions, to think about how to solve these problems and to enjoy the process whilst doing so. And there appears to be a shared sense of purpose - for all to succeed.

Bea believed retraining gave her the confidence to promote her pedagogical stance, allowing students to struggle with mathematics in context, and to offer something different to the way in which she was taught. Bea: *'the course gave me some backup … it's okay to go with your instincts, it's not the way that you were taught maths but it's alright to teach it like that' (*Interview 3) (F-F; CON; PED; CAT; TSyle-exp).

Bea seems to have been able to embrace a different script, a different script from the one from which she was taught. In terms of Bea's lasting impression of the impact of the SKE+ course: *'I remember more of it than other courses I* *have done more recently - possibly because [of the number of] sessions we went to. I am actually using the stuff … pretty much all the time' (*Interview 3) (IMP; F-F; TA; PD). Bea went on to say: '*I am immersed in it because I teach maths full time' (*Interview 3) (IMM; TM).

Exploring the pros and cons of retrained teachers teaching mathematics fulltime, Bea commented: '*I guess for me there is a direct parallel with the language analogy – and you learn best by immersion*'; '*For me it's knowing the whole spectrum, its knowing where it starts and where it finishes*' (Interview 4) (IMM; SK). This echoed Bea's earlier comments: *'I think you should just chuck them in – because there will be little lessons that you learn and can put into practice immediately' (*Interview 3) (IMM; CAT; PER). Bea also pointed out the advantages of simultaneously teaching two parallel groups, acknowledging that *'the second time I teach something is loads better than the first' (*Interview 4) (PER; CAT).

However, Bea did offer a 'con' in terms of fulltime mathematics teaching: '*If you're not very good at it you will affect a lot of children - and a lot of children with possibly some quite disastrous effects'* (Interview 4) (PER). In this scenario, Bea suggested that some newly retrained teachers may not have '*enough headspace during lesson*' (Interview 4) (PER) to focus on the interweaving of the pedagogical subject knowledge required to elicit deep understanding; teaching fewer lessons may give them more time to prepare.

Bea suggested it takes '*longer to plan in a new subject*' and that it '*would be a very good idea*' (Interview 3) (PER; BD) for retrained teachers to have a reduced timetable similar to that of NQTs. Sourcing relevant resources also took significant time: 'I think – uh – I can't find it, I haven't got time' (Interview 3) (R). A version of collaborative planning was introduced to her department by senior management, with '*everyone having one period [a week] for shared planning with an experienced teacher'*; whilst Bea valued the idea she doesn't think '*it was as effective as it could have been'* (Interview 4) (LS/CO; SSup). Reasons for this included: it was a top-down directive with little thought for the outcomes; '*it wasn't the right people in the right pairs*'; it was intended to '*spontaneously grow*' but failed with lack of interest and motivation (Interview 4) (SSup; PRA). In effect, Bea believed there was a lack of wisdom and mathematical structure. I contrasted this to the Japanese style of Lesson Study and pondered why this appears to be so rarely emulated in the UK. Bea countered with: *'I think that possibly because people would think it is an enormous fuss for a drop in the ocean';* pointing out the number of lessons taught in any one year, Bea added: '*we [would] need to do 1000 of these to make it worthwhile'* (Interview 4) (LS&CO; PER). However, whilst talking, Bea revised her opinion stating that a realistic aim could be '*for the initial lesson in each topic to be polished, something that we have planned together, somebody's taught, we've all observed*' (LS&CO). Bea also suggested: '*possibly because education is so political'*, that as a country, unlike Japan, we are not prepared to invest in long-term outcomes and that *'most people here would just roar with laughter and say in three governments time the whole national curriculum would've changed - education doesn't get left alone - it's just permanently tinkered with'* (Interview 4) (PER; BD).

Enquiring about senior management support pre, during and after the course, Bea said: '*Nobody has enquired about my progress… no one has enquired how I got on or asked how it was or how much hard work*' (Interview 4) (SSup). Bea also made the point: '*You know if you sign up to be a moderator here you get a day off in lieu. No one said you know all that work you're doing at the weekend, those hundreds of hours … you know could we give you half a day...*' (Interview 4) (SSup).

Bea does believe there should be ongoing support post retraining, along the lines of mentoring and coaching, and suggested that course providers should be explicit and say to head teachers '*and this is how you support your participants at the end*' (Interview 4) (SSup; M&C; LS/CO). In this way, Bea suggests, '*all that finesse*' that has been developed during the year of the course would not be lost (BD). Bea goes further: '*Actually what was the point of the 12 days of the course if it is all going to be forgotten*' (Interview 4) (SSup; BD). In terms of who would pay for this support, Bea was sure it should be built '*into the contract for schools';* schools should be told '*we are giving you this for free but you need to pay so much for the next two years for training'* (Interview 4) (SSup).

Bea's preference for mentoring and coaching, over and above Lesson Study, was clear but she acknowledged it to be an expensive option. However, Bea did see a drawback, in that the expense only impacted on the one person being mentored; '*no one else benefits from conversations that you and I have'* (Interview 4) (M&C; BD; IMP). I suggested this may not be wholly true as others may be impacted indirectly.

5.3.3 Summary

The merger of the mathematics and science departments was, according to Bea, a promising vision but ultimately unsustainable: '*It was a spectacular failure*' (Interview 2) (PER). It operated only in 2013-2014. A personal toll on the Head of Science, overseeing two departments, and a mathematics department which continued to stagnate were reasons cited for its failure.

Transforming a stagnating department was key for Bea. And participating on the course was, for Bea, more than being able to improve her own mathematics teaching. Bea wanted to have the confidence to transform the whole department, in the *'image*' championed on the SKE+ course, believing without the course '*the department wouldn't be as it is'* (Interview 4) (IMP; PRA; TA).

The final question I put to Bea, was whether she thought the retraining to be good value for money. She countered my question with: '*what price would you put on two people [herself and Anna] who are now trained to teach maths?*' Bea also added: '*But I think you could get more impact out of it if you had some form of sustained approach in the years to come'* (Interview 4) (IMP; SSup).

Anna, the next participant to be profiled, no longer teaches mathematics. (And as of September 2018, Bea no longer teaches any mathematics.)

5.4 A Profile of Anna

5.4.1 Introduction

Anna has taught in one school, an 11-16 city comprehensive; she had been a science teacher, alongside Bea, for 3 years when the SKE+ course commenced. During the year of the retraining programme, Anna taught one mathematics group. In the subsequent two years her mathematics commitment doubled. By September 2016, Anna had been appointed as the new Assistant Head, and with a reduced teaching commitment she no longer taught mathematics.

Following the 2012 Ofsted report, stating the mathematics teaching needed to be '*more conceptual*', the schools' senior management initiated Anna's enrolment on the SKE+ course in order to help '*improve the maths teaching'* (Interview 1) (SSup; PRA)*.* Anna was apprehensive about being roped in to teach mathematics and about being retrained to do so: '*it has been nearly 10 years since I had done any maths and the thought of teaching it was scary*' (Reflections on Course) (CON; PER). Anna did however also add: '*I love maths*' (Reflections on Course) (TA). Anna came to thoroughly enjoy the sessions; '*I am so gutted we missed the last bit of the last session [for Ofsted], it really has been the best course I have ever been on* (email, 4/11/14) (F-F; TA).

During the first interview, I asked Anna what she hoped to achieve from the course. She attempted to suggest 'pedagogy' but could not recall the term, knowing only that it was something to do with '*peda-*'. By the end of the course, Anna did feel it had fulfilled the objective: '*I am much more confident in my own ability, the new skills that I have gained … I feel my students are getting a much* *better deal from me having been on the course*' (Reflections on Course) (CON; SK; PED; TA; IMP).

Anna was happy to volunteer to participate in my research, but expressed concern about being observed. I worked hard to annul any fears and Anna came to openly welcome me into her lessons. Anna did however remain anxious about being observed by others and although previously '*never seen*' by Ofsted was daunted by the prospect: '*It terrifies me'* (Interview 1) (TA; OFS; PRESS). With the outcome of the school's 2012 Ofsted report being 'requires improvement' and with the school under pressure to be 'good', Anna said she was '*nearly sick'* (Lesson Observation 2) (PRESS; CON; OFS)) when Ofsted arrived in the Autumn of 2014. Discussing her '*massive*' lack of confidence whilst being observed Anna explained that she doesn't want to let the department down and in particular did not want to let Bea (as Head of Department) down (Interview 2) (CON; TA; PRA; PRESS). Anna's loyalty to Bea and to Bea's vision for the department was absolute. In November 2014, the school achieved the coveted 'good' from Ofsted; immediately the head teacher retrained his sights for a future 'outstanding', with the mathematics department at the heart of these new plans.

A hard working and dedicated young professional, Anna commands both respect and loyalty from students. With a strong pastoral presence and with polished classroom management skills, Anna experiences few behaviour management issues. In 2016, with only 6 years teaching experience, Anna was promoted to her new role as Assistant Head. Prior to this Anna's sole role of responsibility had been for 'Teaching and Learning' in mathematics. In effect, Bea and Anna's roles had reversed, with Anna now the line manager for the mathematics department.

The focus of this section is on Anna as both a mathematics teacher and as a manager of the mathematics department. It also draws together both Anna's and Bea's stories.

Table 5.6 illustrates at which points Anna was involved with the various research instruments during the course of this longitudinal study.

	Year 1 2013-2014	**Year 2 2014-2015**	**Year 3 2015-2016**	**Year 4 2016-2017**
September		Personal reflections – throughout year	Personal reflections – throughout year	Personal reflections – throughout year Final Questionnaire
October		Reflections on Course Questionnaire Visit and notes from external evaluator: Keith Hedger	Lesson Observation 4: Year 8 (set 1 out of 6)	Interview 3
November				
December	**Course commences** Mathematics Attitude Questionnaire1 Subject Questionnaire for Mathematics SKE+ Evaluation1	Mathematics Attitude Questionnaire2 Subject Questionnaire for Mathematics SKE+ Evaluation2 **Course concludes** Pre-Interview 2 Questionnaire Interview 2		
January	Interview 1	Lesson Observation2: Year 7 (set 2 out of 4; 13 girls,14 boys)		
February	Lesson Observation1: Year 7 (student KS2 levels: 3-5; 12 girls,12 boys)		Lesson Observation5: Year 10 (set 5 out of 6; 10 girls,9 boys)	
March			Feedback-on-feedback1(from LO5)	
April		Lesson Observation 3: Year 7 (set 2 out of 4; 12 girls,16 boys)		
May				

June	Personal reflections – throughout year			
July			Lesson Observation6: Year 10 (set 6 out of 7; 8 girls, 6 boys) Feedback-on-feedback2(from LO6)	
	Mathematics teaching commitment: 1 x Year 7	**Mathematics teaching commitment: 2 x Year 8**	**Mathematics teaching: 1 x Year 10 + 1 x Year 11**	**Mathematics teaching: No longer teaching mathematics**

Table 5.6 Schedule Illustrating Anna's Participation with the Various Research Instruments

5.4.2 A Narrative of Anna as a Mathematics Teacher and as a New Assistant Head (Line Manging the Mathematics Department)

I first observed Anna teach - with a Year 7 class - at the very beginning of the course. Anna exuded a bright, energetic and enthusiastic aura. She was extremely well organised and made regular use of visual displays on the interactive whiteboard – with a 'starter' ready to engage the students as soon as they entered the room. Whilst the main activity was enticing (pushing tables together and being invited to write on them whilst calculating compound areas) the problems posed were not particularly taxing. Student interaction was limited and students were not expected to articulate their thinking to the class or at the board.

Prior to my next lesson observation and soon after the course had completed, Anna sent me an email expressing she was '*a little nervous'* and apologising in case '*it is awful'* but concluded by saying she would '*love to hear'* my feedback (email 18/1/2015) (CON; M&C; PRESS; TA). Under Bea's guidance the teaching of mathematics at Key Stage 3 was now largely by way of projects. Of this, Anna said she was: '*LOVING IT!!!!*' but that she was '*still not really sure how to best structure my lessons, I'm letting the students take the lead and it seems to be working so far*' (email 18/1/2015) (TA; PED; CON; PRA). This sentiment seemed to sum up my evaluations of the next few lessons. Anna was an enthusiastic advocate of teaching by 'guided discovery' and for allowing the students to think more deeply, but appeared ill-equipped to structure the lessons so they had any meaningful direction or outcomes. Anna's rhetoric would sometimes suggest otherwise: *'I am a lot more adventurous with my lessons and trying to get the kids to explore … I also get the students to work more independently … I have guided and suggested ...'* (Reflections on Course) (PED; TA; PER; PRA; BD).

Whereas it appeared typical for Year 7 and 8 students to be left to experiment (be it without a sense of direction or purpose), lessons for the lower attaining Year 10 students were often limited and procedural, with students expected to do significant clerical 'work'. Anna genuinely believed in Bea's vision and aspired to teach in a way that promoted deep understanding but had yet to master how to do so. Anna tended to use lots of prepared PowerPoint slides, the use of 'penguins' for a starter was one such sequence I observed. (Was Bea referring to this when she was so dismissive of PowerPoint lessons? See 5.3.2) Anna was keen to be creative and to incorporate her experience of teaching science to make mathematics feel like an experiment. Anna had successfully done this with one group, with ice and boiling water, and the students could recall this enhanced experience (and the mathematics involved) over a year later. Anna struggled to find further opportunities to do likewise.

In spite of Anna's enthusiasm for Bea's vision I wondered whether Anna knew there was something missing in her lessons. After Lesson Observation 4 (Year 8), this was in fact exactly what Anna voiced: '*I felt like the lesson missed something'* (TA; TM; M&C; PED; CON). We talked about what that might be. After shared reflection, Anna concluded that the lesson lacked challenge and that she spent too long on the basics. She began to question whether, in fact, some of her students could already competently and confidently do what was being asked of them. Following this discussion, we agreed that Anna had answered her questions. In summary, in spite of Anna's enthusiasm, her teaching lacked rigour; Anna*: 'I know it sounds awful but there is a lack of confidence - in my maths. I need to try and stay one step ahead'* (during feedback after Lesson Observation 4) (CON; SK; M&C; TA).

Anna knew it important to provoke deeper thinking by asking 'why' questions – and attempted to do so. But the 'why' questions I heard were often relating to relatively trivial matters that did not enhance mathematical sense making and may in fact have detracted from it. Recognising that on some occasions a lesson did not develop as Anna had been hoping, I asked Anna whether she would ever consider adapting the lesson and engage in 'real-time' teaching (an activity Bea promotes). Anna commented that it was *'a confidence thing. At times I have scrapped the lesson plan and gone off task - but that is when I feel more confident*.' During this same feedback session, Anna came to the conclusion that: '*I need to think what is in a GCSE question - the end point'* (during feedback after Lesson Observation 4*)* (CON; SK; TA)*.*

During the feedback session following Lesson Observation 5, Anna said: '*It felt slow and draggy*' (PER; M&C). Confusion stemmed from the very first slide – a poor choice of resource had been selected; mathematical meaning and mathematical sense making were lost. Anna recognised it was the loyalty of her students that had kept this lesson afloat, '*If I had tried that with a different group - could've run into problems*' (TA; R). I flagged up the issue of resources and Anna described how she cobbles together her own from various sources on the internet. I suggested she consider searching for high quality published material rather than endlessly having to create her own. Anna wrote: '*I feel part of the process and not judged…' (*Feedback-on-feedback1 (from LO5)) and that she could now see how to move forward in the next lesson (M&C; TA; CAT).

During the final lesson observation, Anna had embraced the idea of students using their own data for the purpose of the lesson. Unfortunately, another poor choice of resource led to confusion; Anna: '*I think I have confused some of you…'* (Lesson Observation 6) (R). The students spent significant time copying from the board, an activity Anna discovered to be a surprisingly difficult and time consuming task. The lesson was reduced to a list of rules, with Anna telling her students: '*we have to come up with 5 rules to drawing a bar chart…*' (Lesson Observation 6) (PED). Suggesting a golden opportunity for relating mathematics to real life had been missed, we discussed the Japanese way of setting problems in context to make them meaningful and to avoid mathematical tasks being procedural, reduced to the trivial and administrative. We agreed that requiring ‘rules’ does suggest to students that this is something (else) to be remembered. Even with the lesson limited to a series of steps and rules, for students to copy, many mistakes were made by students. Anna did not pick up on, or address these during the lesson.

After the lesson, Anna lamented the loss of having two parallel groups so as to be able to learn from one to benefit the other. During the feedback we also discussed how tricky it is to concentrate on a task whilst a ‘teacher’ continues to talk, constantly firing off new instructions and information. Anna immediately recognised that this is her tendency, ‘*to try and maintain concentration amongst students’* because she is *‘wary of silence in the class*’ (Lesson Observation 6) (TA; CON; PED); Anna was keen to reconsider her practice. And during the final interview, whilst espousing the value of coaching and mentoring, Anna refers to having indeed attempted to address this habit. Anna’s comments on the feedback-on-feedback forms were, without exception, positive and refer to the coaching as allowing her to improve her practice.

During this final feedback session, Anna noted that ‘*it was harder to teach maths the further away from the course we got’* (Lesson Observation 6) (PED; PD; BD; SSup). Nevertheless, Anna maintained her belief in Bea’s vision for mathematics, in terms of developing understanding: ‘*the way Bea does it - is better for kids*’ (Interview 2) (PED; TA). And Anna appeared to echo Bea’s very words: *‘in the lower years it should be about exploring, it should be about understanding the basic concepts…’* (Interview 2) (PED; TA).

Anna's view of an effective teacher also appeared to echo that of Bea's: someone who can engage and inspire students; someone who is less interested in simply disseminating methods and procedures but more interested in promoting resilience tackling tough problems. This approach was obviously something Anna admired but found difficult to promote. Right at the outset, Anna had said she had wanted to improve her pedagogical skills for teaching mathematics, as she '*didn't have the knowledge of how to teach things'* (Interview 1) (PED; TA). After the course had concluded I wanted to know whether she felt she had developed those skills; Anna believed so '*and they're exploring things, playing with things, exactly how we do it on the course*' (Interview 2) (TA; PED; F-F; IMP). This comment struck me as significant. Having observed and interviewed Anna several times since the completion of the course, this is exactly how I see how Anna would *like* to be teaching. She would like to replicate for her students, the sense of enjoyment and exploration that she herself experienced and valued so highly. She has in fact allowed her younger students to explore and play, worthy activities in their own right, but without knowing where she wanted herself or her students to go; what the end point was. Anna thought the retraining to be one of the main adjuvants in confirming to her what she believed mathematics teaching should and could be: '*I'm really enjoying it, I'm really, really enjoying teaching maths*; And that '*I don't think I'll change the way I teach it no definitely not*' (Interview 2) (TA; PED; CAT; PRA; IMP). Anna also thought the retraining had the potential to develop *'more normal*' or '*more rounded'* mathematics teachers, by drawing from a diverse group of teachers (Interview 3) (BRING; TA; EFF). This, Anna believes could add to, rather than detract from, the effectiveness in teaching mathematics.

Anna believes '*you definitely need the support from up above, definitely'* (Interview 2) (SSup; TA; CAT) and so feels fortunate to have been on the course with Bea, who was line managing mathematics at the time. And as Anna points out, with two of them having been on the course, changes are easier to implement. Another benefit from the shared experience was of being more open to sharing and popping in and out of each other's classroom, and encouraging others in the department to do likewise. Anna also added that she now felt more comfortable about '*Taking risks*' in her teaching '*especially because we [her and Bea] both started at the same point'* (Interview 2) (CON; CAT; PED; LS/CO).

In 2016, and in her role as an Assistant Head, Anna was involved in trying to recruit mathematics teachers. Having failed to secure visas for two overseas candidates and struggling to find anyone else of any '*calibre'*, Anna described recruitment as '*really, really tough*' (Interview 3) (SHORT). Anna reported that, on more than one occasion, a prospective teacher was '*stolen*' or '*poached*' from them by another school – by way of being offered a more attractive package (Interview 3) (SHORT; PRESS). As a result, Anna found herself with a cohort of largely inexperienced mathematics teachers with a significant complement of NQTs, TeachFirst, and non-specialist teachers, including the Head of Department who is a primary specialist. Anna said, of a department of 12 teachers, '*the only specialists we have - one [an unqualified teacher] teaches 12 lessons a fortnight to Year 11s, the other is an NQT'* (Interview 3) (SHORT; PRESS).

Back in 2013, with a shortage of mathematics teachers and an Ofsted inspection looming, the decision was made to merge the science and mathematics departments. That initiative failed and in 2016, the mathematics department continued to face a struggle to be fully staffed. Given that Anna was now in a position to influence and implement such decisions, I was keen to know whether she considered retraining teachers to be a solution for their current predicament. Teachers had in fact been sent each year on the more local and truncated Teacher Subject Specialism Training (TSST) retraining courses but this had proved '*even a struggle'* (Interview 3) (PD; SSup) for which to release teachers. An interesting observation from Anna was that for those teachers who have been drafted in to teach mathematics but had yet to experience any TSST, the task of teaching mathematics was proving to be more challenging than these teachers had anticipated. In the light of this, Anna said about retraining programmes: '*So we do see it as a beneficial thing'* (Interview 3) (TA; IMP).

As an Assistant Head, Anna has also been instrumental in setting up some collaborative practice amongst colleagues. Anna had been particularly impressed with this on the course and had frequently wished there was more time for this type of activity: *'I would love for us to do like that at school…it's not happening at the moment 'cos Ofsted and things... But I think that in the future would be fantastic to do …' (*Interview 2) (LS/CO; OFS). Pleased to finally be able to do so, the driver for initiating collaborative practice stemmed from a combination of factors: the move towards to a five-year scheme of work; the inexperience in the department; an apparent lack of outstanding teaching amongst the more experienced colleagues (garnered from the 'learning walks'). Anna was pleased to have launched this initiative and now felt the maths department to be working far more collaboratively: *'it definitely feels more* *collaborative, definitely'* (PER). Anna cited an example where the new head of department had insisted on consistency of the classroom display boards and that this '*is forcing the agenda - of collaboration'* (Interview 3) (PER; LS&CO). The idea Anna espoused was that by requiring this consistency: *'we're going to collaborate because we are all doing it'* (Interview 3) (PER; LS&CO). Anna appeared oblivious that the administrative nature of the examples given (of having consistent display boards and of jointly planning a five-year scheme of work) did not embody the spirit of collaborative planning. This may in part explain why Bea's perspective of this 'collaboration' was rather different to that of Anna's, and also as to why it has subsequently petered out.

In 2016, with a much reduced timetable, Anna was no longer assigned to teach mathematics, because in her words*:' it was easier to put me into science for 12 lessons and take a [different] science teacher out for 24 lessons so he could have two classes of the same year …whereas if you put me back in maths we would still be 12 short in maths'* (Interview 3) (SSup; PER; BD). So the decision was made for Anna, the retrained teacher, to teach no maths and a non-specialist with no retraining to teach 24 periods a fortnight.

Anna has undoubtedly benefited from the mentoring and coaching sessions, arising as a result of this research. Describing the sessions as '*really, really supportive',* Anna found the feedback *'really, really beneficial',* particularly appreciating that it *'wasn't judgemental'* (Interview 3) (M&C; CON; CAT). One conversation Anna recollected related to '*why am I talking so much?'* (mentoring session after Lesson Observation 6)*;* of this, she said it felt like a *'light bulb moment'* (Interview 3) (TA). Asked whether she thinks colleagues would similarly benefit from mentoring and coaching, Anna agreed wholeheartedly but wondered aloud who 'in house' could do it. Anna felt the head of department '*wouldn't feel comfortable with the subject knowledge'* (SK; PRA; BD) and that the one teacher with very good subject knowledge, is himself unqualified and also '*on SLT [Senior Leadership Team] so he has got other responsibilities*' and that '*everyone else is new, so* – [laughter]' (Interview 3) (SHORT; BD; PRESS).

5.4.3 Summary

The early Key Stage 3 lessons I observed Anna teach, showed signs of developing along the lines advocated by the retraining course. But Anna found this ethos much more difficult to enact with the later Key Stage 4 lessons (with lower attainers); this in part because for Anna, the retraining now seemed somewhat distant. This 'distance' from the course was compounded by Anna's relatively little mathematics teaching. Asked whether she felt it would be better to have a greater mathematics teaching commitment, Anna suggested that the planning required would be huge and feared that the quality of the lessons would deteriorate. On reflection she did then add *'I think if you are thrown in at the deep end then you just have to suck it up and you do get immersed … but I think initially it would be - oh my god'* (Interview 3) (IMM; CON; SK; PED: CAT; BD). In theory, Anna felt wedded to the idea of teaching with the ethos advocated on the course, and of that being promoted by her then head of department, Bea. In practice, Anna had yet to master teaching in this way before she was promoted to Assistant Head and had other issues to consider.

To improve the retraining experience Anna suggested two things: for the group to stay in touch and act as a support network so as '*to know I am not alone'*;

and to be '*more immersed in the maths'* (email 2/9/2016) (IMM; LS&CO; IMP). In particular Anna felt having two parallel classes would have helped her to '*reflect on my practice and implement changes quickly';* this in turn *'would have improved my confidence massively'* (email 2/9/2016) (CON; IMP; CAT: BD).

Perhaps if Anna's confidence had continued to grow and she had felt more connected to a collaborative support programme, she would have been less inclined to relinquish the role of '*maths teacher*' (email 2/9/2016).

5.5 A Profile of Katy

5.5.1 Introduction

Katy was a child-education teacher in an FE college when she first started teaching some mathematics. She had discovered that her students had very poor numeracy skills so offered to teach a little basic maths to support her child-care students (Functional Skills, level 1). During the second year of this arrangement, Katy saw the SKE+ course advertised and decided to enrol to upskill her own mathematical skills. By the time the course commenced, Katy was ironically no longer teaching any mathematics; the college had made an executive decision to reorganise the delivery of all mathematics provision. Katy decided to continue with the training regardless. For the 2014-2015 academic year, Katy was once again teaching mathematics; she had been asked to teach a blend of both Functional Skills and Foundation GCSE mathematics for 3 hours a week whilst she also continued to teach child-education. It was at this time I first started to observe Katy teach. Two years later, still at the same college - which Ofsted rated as a 4 in February 2016 - Katy was teaching only mathematics (to GCSE resit groups) for 18 hours a week.

At the outset of the course, Katy was anxious her mathematical skills would be inadequate. Her highest attainment to date had been - after one failed attempt - GCSE maths grade C on a Foundation tier. Katy sought reassurance regarding the appropriateness of the course; I encouraged her to continue as she was *so* keen and *so* determined to improve the life chances of her students by improving her own mathematical skills. Later when reflecting on the sessions

Katy said: '*They were good. I always came away thinking GOD I've learnt a lot today*' (mentoring session after Lesson Observation 6) (TA; IMP; CON; F-F; SK; PED).

This section pieces together a story of Katy's training and teaching mathematics. Table 5.7 illustrates at which points Katy was involved with the various research instruments during and following the course.

	Year 1 **2013-2014**	**Year 2** **2014-2015**	**Year 3** **2015-2016**	**Year 4** **2016-2017**
September		Personal reflections – throughout year	Personal reflections – throughout year Lesson Observation4: Post-16-resit group (10 girls; 1 boy)	Personal reflections – throughout year
October		Reflections on Course Questionnaire Visit and notes from external evaluator: Keith Hedger	Feedback-on-feedback2 (from LO4)	Lesson Observation 7: Post-16-resit group (8 girls, 3 boys)
November		Pre-Interview 2 Questionnaire		
December	**Course commences** Mathematics Attitude Questionnaire 1 Subject Questionnaire for Mathematics SKE+ Evaluation 1 Interview 1 (informal, not audio recorded)	Mathematics Attitude Questionnaire 2 Subject Questionnaire for Mathematics SKE+ Evaluation 2 **Course concludes** Interview 2		Final Questionnaire Interview 3
January		Lesson Observation1: Post-16-resit group (7 girls)		
February		Lesson Observation2: Post-16-resit group (8 girls)	Lesson Observation5: Post-16-resit group (12 girls)	
March		Lesson Observation3: Post-16-resit group (10 girls)	Feedback-on-feedback3 (from LO5)	
April		Feedback-on-feedback1 (from LO3)		

May			Lesson Observation6: Post-16-resit group (2 girls)	
June	Personal reflections – throughout year		Feedback-on-feedback4 (from LO6)	
July				
	Mathematics teaching commitment: None	**Mathematics teaching commitment: 3 hours a week teaching:** **Functional Skills/Foundation (mixed group) GCSE maths**	**Mathematics teaching commitment: 9 hours a week teaching:** **Foundation GCSE resit maths**	**Mathematics teaching commitment: 18 hours a week teaching:** **Foundation/Higher (mixed groups) GCSE resit maths**

Table 5.7 Schedule Illustrating Katy's Participation with the Various Research Instruments

5.5.2 Notes and Comments from Katy's Diary of Personal Reflections

Katy is a reflective, articulate and insightful teacher. During the year of retraining she kept detailed recordings of her own self development and emotional state. Anxious about being out of her depth, Katy wrote (after the first session): *'I didn't feel as bad about my mathematical skills as I thought I might…I saw that most people had misconceptions and/or were making mistakes.'* Katy found this *'quite liberating'* (Personal Reflections, December 2013) (TA; SK; CON; F-F).

As the sessions progressed, Katy realised that she was struggling to remember everything and she wished she had written down and recorded more material. Katy felt the issue to be exacerbated because she was not actually teaching any maths, and therefore not using and revising the material. She did however, very much want to keep *'the great ideas afloat'* (Personal Reflections, February

2014) (TA) – so she could use them in subsequent years. Excited and enthusiastic about learning the mathematics for herself, Katy felt a sense of satisfaction she did not experience in her '*vocational area';* in Katy's words: '*satisfied that I had really learnt something that I could share and feeling a bit special'* (Personal Reflections, April 2014) (SK; TA; CON; IMP). On occasions Katy did feel '*embarrassed*' about not understanding everything but recorded that '*everyone is so helpful'* (Personal Reflections, May 2014) (TA; CON).

Unable to make a particular session at Venue 1, Katy travelled to Venue 2 for the equivalent session so as not to miss one. Here she observed a demonstration lesson and thought this to be '*one of the most useful parts of the day'* (Personal Reflections, May 2014) (LS/CO; F-F; PED). She particularly appreciated the way the lesson was organised and how concepts were developed with the students and how the students' own ideas were incorporated into the teaching and learning. Katy was attuned to the fact that this was a skill and one to which she wished to aspire.

As some of the topics became more in-depth, Katy did struggle and she found herself '*just writing down what was on the board*', unable to engage with the activity and feeling '*fearful*' of '*getting it wrong'*. Katy described this '*fear*' as '*when your mind is whirring, hoping not to be asked a follow on question because you're barely grasping the concept'* (Personal Reflections, June 2014) (F-F; TA; BD; PRESS). On occasions Katy felt she needed more time than the sessions allowed to '*digest what has been covered'*; she pondered whether her time would be better spent '*concentrating on consolidating the essentials for the foundation paper before really challenging myself with the higher level stuff'* (Personal Reflections, July 2014) (BD; SK; F-F; TA; PRESS).

Katy appreciated the introduction to Lesson Study and the mini-teach sessions. Although she approached the teaching with some trepidation, Katy was a willing partaker. Being in a supportive and '*very safe environment*' where no one felt *'judged'* was key for Katy and she describes everyone as being '*really respectful and encouraging of each other's ideas'* (Personal Reflections, July 2014) (TA; LS/CO; CAT). The independent evaluator, Hedger (2014), in his interview with Katy recorded that: *'She finds the group lesson-planning sessions particularly valuable, and gained considerably in confidence from a well-received presentation she did'* (Hedger, 2014) (CON; CAT).

On the occasion Katy attended the other venue, her experience of the mini-teach was very different. She felt uncomfortable, less able to contribute ideas in the planning stage and acutely anxious about being selected to 'teach'. This suggests successful collaborative planning relies on a good group dynamic - within which there is some level of expertise. For Katy - on this occasion - she felt the group had been dominated by one character and that the end result was poor: '*Luckily I didn't have to teach it and, as I suspected when we were planning it, it wasn't particularly engaging or clear'* (Personal Reflections, May 2014) (TA; BD; F-F).

5.5.3 A Narrative of Katy as a New Mathematics Teacher

I first observed Katy teaching a Functional Skills group. She commented that she felt very nervous teaching maths and that it was like experiencing '*white-noise*' (Lesson Observation 1) (TA; TM; CON; BD) whilst standing in front of the class as she couldn't think and teach at the same time. She felt she couldn't ‘*think on her feet*’ (Lesson Observation 1) (TA). Without secure and embedded subject knowledge, Katy felt exposed. Katy felt fortunate to have only one mathematics class at this time.

Good relationships with students is something Katy considers key for effective teaching and she believes that this ‘*human connection’* (Lesson Observation 2) (TA; EFF) is especially important for mathematics. Echoing Anna’s comments, Katy thought retraining teachers may diversify the pool of personality types teaching mathematics, and that this could only be a good thing. Katy also thought that her own experience struggling with mathematics (and failing her GCSE the first time) helps her empathise with students who are also struggling and have previously ‘*failed*’ (Lesson Observation 2) (TA; BRING; PER).

Katy was excited and delighted by her own new found skills and confidence. She felt empowered by being in a position to be able to ‘*explain’* misconceptions and she believes this ability to be able to understand is ‘*one of the strengths of the SKE+*’; Katy was appalled when a colleague at her college said ‘*oh I tell them to just accept that’s the way it is’* (Interview 2) (TA; CON; SK; PED; PRA). Believing there is a better way to teach, Katy’s approach to teaching began to change, moving away from ‘*just telling*’ which she felt was just ‘*not right*’ and towards a more interactive approach; At first ‘*the students were like - don’t know, just give us the answer*’ but slowly some of the students began to become more engaged with the process of learning (Interview 2) (TA; PED; SA; PRA; TM).

As Katy continued to teach more mathematics at the college, she said: '*I am absolutely loving teaching maths… for me it's new, it's fresh, it's so different, it's engaging.*' She also believed that it had reinvigorated her teaching career: '*It's made me want to teach again. I had been thinking may be move on, get a cafe, a campsite - but this year – no, I definitely want to teach*' (Lesson Observation 1) (TA; BRING; TM).

Katy did recognise the constraints that her limited subject knowledge created. And this, coupled with a lack of time for planning, did result in anxieties. The way forward for Katy was to aim to teach more mathematics, and at GCSE level, so she could '*focus more time and effort on it'* (Lesson Observation 1) (TA; IMM; SK). The students' own anxieties surrounding the subject meant '*they really don't like it if I don't know whether something is right or wrong, which happens only occasionally - but does happen'* (Lesson Observation 1) (SA; TA). And for this reason Katy was even more determined to upskill – putting many more hours into reading and researching around mathematics education.

By coincidence, around the time of the third lesson observation, Katy conducted a questionnaire with her students to explore their feelings and experiences surrounding maths. She found to her surprise (and dismay) that several students '*clearly think having a maths expert to teach them is important!!*' (discussed following Lesson Observation 3 and in email, 14/3/2016) (SA; TA; PER).

When Katy's teaching commitment for maths increased to 9 hours (in 2015-2016) she was now in the position of being able to teach the same lesson to two different groups, tweaking and polishing the plan for the repeat lesson. For Katy this was ideal as her inexperience often led to her underestimate or overestimate what the students could achieve. After one such lesson, and following our mentoring and coaching session, Katy believed she could significantly improve the experience for the repeat-lesson: '*Probably would not have repeated this - but now with this guidance I will give it another go. Really, really useful. Really, really helpful*' (discussed following Lesson Observation 4) (M&C; TA; CAT).

Another issue faced by Katy was the huge variation in prior attainment amongst her re-take GCSE students; some had failed their first attempt by 1 mark, others had struggled to achieve 1 mark. Creating a 'safe' experience for those she felt were the most vulnerable in the class was something we often considered – and resonated with Katy's own experience on the course.

After the fifth lesson observation, we discussed the limited conceptual leaps some of her students were making and that they may benefit from coming to the board to articulate to others. Katy tended to dominate the board and maintain control of the dialogue. Katy felt her lack of confidence in the subject was inhibiting her doing otherwise, as she did *'not want to get it wrong'* (feedback-session following Lesson 5) (M&C; CON; SK; PED). Katy also had a habit of insisting her students copy out a question - before attempting it - so as to have something to revise from. I questioned the value of such tedious clerical tasks. A lot of lesson time was routinely wasted and we felt more could be expected from, and more achieved by, the students; constant disruptions throughout the lessons (toilet breaks, phone calls) typical. Katy, having never observed another mathematics teacher, was unsure of what she could expect from these disillusioned and sometimes disaffected students; students who knew they needed their maths '*GCSE ticket'* (feedback session following Lesson Observation 5) (M&C; SA) but often felt doomed to fail again.

Katy responded incredibly positively to the rigorous feedback sessions, even when the lessons observed had not gone as she had hoped. Katy commented that she was comfortable '*discussing all the negative points',* that she did not feel *'judged'* and that the discussions were the *'most constructive'* she'd had with regard to teaching (Feedback-on-feedback1(LO3)) (M&C; PER; CAT). Katy made the point that it was good to teach an '*everyday*' lesson whilst being observed – without the hours of thinking and prep and stress required for a '*performance*' Ofsted-style lesson (Feedback-on-feedback1(LO3)) (PER; OFS; PRESS; CAT). Reading what was actually said during the lesson, Katy remarked 'I was *shocked at how vague my instructions were and that helped me see the lesson from the students' perspective'* (Feedback-on-feedback1(LO3)) (TA; PER; CAT). Finding it '*refreshing*' to discuss all aspects of the lesson, including the negative points, Katy pointed out she would not feel similarly so in a '*graded observation'* (Feedback-on-feedback1 (LO3)) (TA; PRESS). But then again, she points out, she wouldn't have taught such a lesson in a graded observation: '*I would have played safe'*. Katy was keen to be observed again: '*definitely want to be observed again. I have told all my colleagues how useful it was as a process*' (Feedback-on-feedback1 (LO3)) (M&C; TA; CAT).

Following Lesson Observation 4, Katy again commented that she continued to feel comfortable despite her being '*disappointed in [her] teaching'* (Feedback-on-feedback2 (LO4)). In fact, she thought that was why it was so useful: '*If I'd done a really good lesson I'm not sure I would have gained as much from the experience. It was interactive and therefore an opportunity to share my thoughts and to gain specific knowledge on how to improve*' (Feedback-on-feedback 2 (LO4)). In an email sent shortly after this feedback, Katy said: '*I am so glad we had our discussion, because I would not have gone near this again [with other group] if we hadn't';* Katie reported the 'repeat' lesson to be much more *'focused and productive*' (email, February 2016). Katy made similar positive remarks following Lesson Observation 5: '*always a good use of my time to discuss what I'm doing in my teaching*' (Feedback-on-feedback3 (LO5) (M&C; TA).

After Lesson 6, Katy said of the lesson: '*I just knew it wasn't good and was disappointed in myself'* (feedback following Lesson Observation 6). Katie later revealed that on this occasion, she had felt uncomfortable, as she didn't feel her teaching practice had improved despite the previous '*excellent feedback*' (email, May 2016).

> *Katy: 'I was embarrassed because throughout the lesson I was aware of the lack of effective teaching and learning - the limited stretch and challenge and almost chaotic feel to the whole session with people coming and going all the time.'* (email correspondence, May 2016) (TA; EFF)

Disappointed with herself, and feeling less than enamoured engaging with verbal feedback, Katy did however embrace the written form of feedback and, having had time to digest the feedback, felt it to be '*constructive and helpful'* (Feedback-on-feedback4 (LO6), May 2016) (M&C; TA; CAT). Katy was keen to point out that although on this occasion she had felt despondent, there was nothing in the verbal feedback that compounded that, saying: '*the feedback was still non-judgemental and developmental'*. Katy did point out: '*The further away from the SKE course I become, the harder it is to continue to use the more* *active methods'* (Feedback-on-feedback4 (LO6), May 2016) (BD). Recording her progress, Katy *describes her experience as like a 'roller coaster ride, with ups and downs'* (email correspondence, May 2016) (TA).

During the final mentoring session, following Lesson 7 (January 2017) Katy said that she didn't want '*this [my visits] to finish'* as she had little opportunity to discuss and develop ideas outside of these meetings. Clearly grateful for the mentoring and coaching, Katy continued to ponder how other participants managed without this opportunity for feedback and mentoring: '*Just leave the course with no support or contact….!!!???*'; Katie often expressed her gratitude: *'Really appreciate this'* (feedback following Lesson 7) (M&C; TA; CAT).

Katy's lack of opportunity to share or collaborate with colleagues was a recurring theme: '*we don't share practice'* (feedback following Lesson 6) (LS/CO; PRA). Her only other lesson observations had been along the lines of Ofsted style practice observations and she felt this process had not been a good experience and that she had felt anxiety at being judged (and graded). She felt the power dynamic in these scenarios to be significant and that the feedback lacked quality or purpose.

Katy recognised the norm for her department was '*being didactic and just getting them to do it – which is what I have done*'; and believed the retraining to be an opportunity to explore '*more active methods'* (Interview 2) (PRA; PED; F-F).

Katy is isolated at her college. Although she considers her colleagues '*nice*' there is no sharing of practice - in fact the opposite is true with a very '*closed door'* approach (Interview 3) (PRA). This is an almost astonishing scenario when there is the opportunity for doing otherwise: '*We have a whole morning [together as a department] - and it's all admin stuff - we have three hours a week*' (Interview 3) (PRA). The department's only collaborative project was to pull together a scheme of work. Questioned as to why Katy thought this case, she believed it was lack of vision and direction '*from the top'*. The '*maths manager'* manages a huge area of the college including a diverse range of subjects. And apart from investing money in textbooks, Katy felt there '*is nothing, no support, nothing'* from the senior management (Interview 3) (SSup; BD). Being proactive Katy had asked a colleague if she could attend his Higher tier mathematics classes. The rest of the department all laughed as if she were joking; she managed to persuade them she was serious but the opportunity didn't materialise.

With no senior management support, no opportunities to observe others teach mathematics and a passive department, I wanted to know where Katy got her leads from in terms of how to teach. Katy was very clear: '*Twitter, I just google things… follow blogs*' (Interview 3) (SK; PED). Katy however, did regularly refer to needing further training: '*I really need to do the course again… I am now scrabbling around in my memory and notes… there has to be more support after the course*' (Interview 3) (PD; SSup: BD).

During the 2017-2018 academic year, Katy did indeed repeat the retraining year; Katy believed that she was finally ready to engage with the course in its entirety.

5.5.4 Summary

Katy initiated the teaching of mathematics herself, to better help her child-education students. Soon after, Katy found herself teaching GCSE mathematics when the college belatedly realised the need for greater provision. Fortunately for the college, Katy had been proactive in reskilling herself and pursuing opportunities. Finding the face-to-face sessions '*the best thing*' because she 'struggled' when working on her own (Interview 2) (SK; CAT; BD), Katy also embraced the mentoring and coaching, stemming from this study. The college is seemingly oblivious to the commitment Katy has made over the years, refusing to pay travel expenses for professional development events undertaken in her own time. Ironically, Katy believes she was only released for SKE+ because, as a child-education teacher, she could be '*spared*'; whereas now as a teacher of mathematics she cannot be released for any day-time training. In effect the college has got for '*free*' a part-trained mathematics teacher; they are now not prepared to continue the development. Katy has some sympathy as '*professional development is just not a priority; I don't think it's even on the agenda… they [the college] are so strapped for cash'* (Interview 3) (PRESS; SSup; PD; BD).

On the face of it, Katy would not have appeared the most likely candidate for successful retraining. Her limited prior knowledge could have proved an insurmountable obstacle. But her determination to learn, develop and reflect is remarkable. Katy has spent significant time immersing herself in the subject, reading related books, watching YouTube, doing the students activities ahead of them, networking and attending any professional development she could find, whilst encouraging colleagues to do likewise. And although there remain significant subject knowledge weaknesses, Katy is continuing to develop. Katy is aware she struggles to see the '*bigger picture'* and link concepts together; she also believes she lacks confidence in '*problem solving'* and wonders whether she is '*too traditional'* (discussion following Lesson Observation 6) (SK; PED: CON; TSyle-exp; TM). These concerns most likely stem from subject knowledge limitations, and in the final interview with Katy, she perceptively said the problem that underlies it all '*is my lack of subject knowledge'* (SK; TA). Katy identified her '*transition into maths'* as an enjoyable experience but appreciated the gradual increase in the amount of maths teaching: '*I think I would have been overwhelmed if I had just been teaching all the maths straight away - um - especially GCSE because I will be honest - I was a bit out of my depth when I first started - um - but I think the transition has been perfect for me'* (Interview 3) (TA; TM; PRESS; CAT).

In a sector which acutely struggles to recruit effective mathematics teachers, Katy is a respected and well liked lecturer doing a reasonable job. With continued development opportunities, alongside her willingness to invest her own time, Katy could become an effective practitioner. Mentoring and coaching have proved particularly effective for Katy as she is so reflective and willing to be challenged.

In the Summer of 2016, with the college struggling financially, Katy found herself facing redundancy. Almost half of the child-education teachers were made redundant. Katy retained her job but in a new role as a fulltime teacher of mathematics.

5.6 A Profile of Cath

5.6.1 Introduction

Cath is a qualified Science teacher, with Biology as her specialism; she had 12 years teaching experience at the start of the SKE+ course, five of which were teaching mathematics. Cath teaches at a school for teenage mums; previously she has also taught in a Secondary Modern and in a Catholic Comprehensive. Cath works four days a week and teachers mostly maths, with the exception of one morning for science; she teaches very small groups. Prior to teaching, Cath worked in industry for several years. In September 2016, the school for teenage mums - having been under constant threat of closure for many years - merged with hospital education; Cath describes how much is changing under this new arrangement.

Cath, having previously been very '*comfortable*' teaching science at the school (Interview 1) (CON), was suddenly asked to teach mathematics (to fill the vacant position). Cath describes finding this a daunting prospect because not only had she never previously - as a teacher - '*been in any maths lessons'*, she was without any immediate support as there was no mathematics department, *'it's just me, it's all on me*' (Interview 2) (LS/CO; SSup; PRA). Cath, a softly spoken teacher who exudes a caring and nurturing nature, appears to be wracked with confidence issues and frequently worries that: *'I am doing something wrong and letting them down'* (after Lesson Observation 1) (CON; TA).

Cath described her motivation for embarking on the course as '*massive'* because although she '*loves maths*' she had felt '*rusty on the higher stuff*' and felt like she was failing the girls: *'I feel like I'm failing …I'm failing the girls and I just cannot find why'* (Interview 1) (SK; CON; TA; PRESS). Cath attended the SKE+ course with a colleague from the same school, an art teacher. A year after the end of the course this teacher was no longer teaching mathematics; another colleague, inspired by Cath, has recently enrolled for a TSST retraining course.

This section pieces together a story of Cath's growing confidence and her development as a mathematics teacher. Table 5.8 illustrates at which points Cath was involved with these various research instruments during the course of this longitudinal study.

	Year 1 2013-2014	**Year 2 2014-2015**	**Year 3 2015-2016**	**Year 4 2016-2017**
September		Personal reflections – throughout year	Personal reflections – throughout year	Personal reflections – throughout year
October		Reflections on Course Questionnaire Visit and notes from external evaluator: Keith Hedger		Lesson Observation4: Post-16 group (5 girls)
November				Feedback-on-feedback2 (from LO4)
December	**Course commences** Mathematics Attitude Questionnaire 1 Subject Questionnaire for Mathematics SKE+ Evaluation 1 Interview 1	Mathematics Attitude Questionnaire 2 Subject Questionnaire for Mathematics SKE+ Evaluation 2 **Course concludes** Pre-Interview 2 Questionnaire Interview 2		Final Questionnaire Interview 3
January		Lesson Observation2: Post-16 group (3 girls)		

February	Lesson Observation1: Post-16 group (4 girls)			
March			Lesson Observation3: Post-16 group (6 girls)	
April			Feedback-on-feedback1 (from LO3)	
May				
June	Personal reflections – throughout year			
July				
	Mathematics teaching commitment: Full-time	**Mathematics teaching commitment: Full-time**	**Mathematics teaching commitment: Full-time**	**Mathematics teaching commitment: Full-time**

Table 5.8 Schedule Illustrating Cath's Participation with the Various Research Instruments

5.6.2 A Narrative of Cath as a Newly Upskilled Mathematics Teacher

Cath appears to be a teacher lacking in confidence. On the Mathematics Attitude questionnaires, Cath responded to the question: 'Are you confident that you can be a good teacher of mathematics?' with a '*No*' at the start of the course and with a '*Not sure*' by the end (CON; EFF; TA). Cath herself had been afraid of her own mathematics teacher, '*we had a terrifying Irish teacher at a convent school… I was terrified*' (Interview 1) (TStyle-exp). For her own students, Cath would like them: '*Not to be afraid*' and to have '*More confidence'* (Mathematics Attitude Questionnaire 1) (TA). Cath reiterated this on the second Mathematics Attitude questionnaire, saying: '*I would like them to start to enjoy maths and have confidence using it*' (TA).

Cath frequently worries she is not being an effective teacher of mathematics. As to what Cath thinks being effective is, she elucidates: someone who can '*build* *confidence'* in all learners and make '*everyone feel safe'* (Interview 2) (TA; CON; EFF). From the various questionnaires and reflections, it is clear Cath also rates having '*excellent subject knowledge'*, being able to '*explain clearly'* and being '*supportive'* as key attributes for an effective mathematics teacher *(*Mathematics Attitude Questionnaire 1 and 2, Reflections on Course, Personal Reflections, respectively) (SK; PED; TA).

Until 2016, the school was solely for teenage mums – for those who were pregnant and for those who had their babies with them. Group sizes were small and were split into two groups for pre-16 and post-16 students. Cath found paired working and group work difficult to orchestrate, in part because the group sizes were so small and also because '*there is a very wide range of ability within the same class that can be a challenge*' (Interview 1) (TM). Cath also found that the girls' skills at being able to work with each other '*quite poor'* (Interview 1) (TA). Limited social and inter-personal skills did appear to have an effect on learning but Cath believed other issues impacted more, namely negative experiences in earlier mathematics lessons damaging self-esteem, limiting their willingness and ability to learn (Smith 2017b). Consequently Cath appears to shoulder the weight of responsibility for their prospects of engagement and future success; this likely to be the root of her confidence issues.

Cath contrasted a typical lesson prior to the course with one after the training had been completed. Prior to training the lessons ran along the lines: '*Stick objectives in book; starter of the day; PowerPoint presentation to introduce topic; exercise from text book; plenary*' (Personal Reflections, December 2013) (PED). And after the course: '*Set the scene - a meaty relevant problem at* *beginning of lesson; more playful experimenting with games and activities; maths books becoming more untidy!; link topics; exploration of students wrong answers; more confidence (me)'* (Personal Reflections, December 2014) (PED; CON).

I observed Cath on four occasions and I was informed prior to my first visit that the girls (especially pre-16) can be hostile to visitors. I chose to use a very informal 'non-observing' participatory approach: I chatted to the girls about themselves and their babies and became involved in the lesson, taking part in the same activities. The classroom setting was vibrant and warm and the classroom displays were informative, relevant and recent. During the first lesson observation it became clear that the girls were desperate to pass their GCSE maths - to get their 'ticket' - and were eager for help, including mine. The lesson finished promptly; the girls went to collect their babies from the nursery and take them for lunch.

During the post lesson feedback session, Cath commented that the girls '*often get D's*' at GCSE and that she was really struggling to help them get '*their C's*' (discussion following Lesson Observation 1) (TA; PER). Again she said: '*I am concerned I am doing something wrong and letting them down*' (TA; PER; PRESS). Cath expressed her eagerness for any advice and support and once again pointed out that this '*is quite an isolating role'* (discussion following Lesson Observation 1) (PRA; SSup; LS/CO; CON).

Cath reiterated her sense of isolation during Interview 2: '*suddenly I am asked to teach maths - there is no department it's just me, it's all on me. Was a bit of a* *poisoned chalice*' (TA; PRA; SSup). And with regard to exams, Cath: 'I wish that could go away, that pressure' (Interview 2) (EX; PRESS; TA). Nevertheless, having taken on the role, Cath felt she had to '*unpick what I know and how I learned*' in order to be able to teach mathematics to others (Interview 2) (PER; PED).

The atmosphere during the second observation was again cosy and warm. Cath started the lesson with a YouTube clip showing the annual winter construction of the London Ice Rink (at Somerset House). It showed barriers being used for the perimeter. Cath, having modelled how to simplify the scenario, posed the questions of how many barriers would be needed for the perimeter and what would be the area of the ice rink. The big spread in prior attainment was clearly apparent amongst the five girls, with one student quick to calculate and call out, whilst others were not at all comfortable contributing ideas. We talked about this during the post-lesson discussion and wondered whether the approach advocated on the course is in fact the 'best fit' for these girls. Although Cath believed the SKE+ course was allowing her to grow in confidence as a mathematics teacher, she felt it had yet to translate to an increase in student performance. We questioned whether collaborative work was possible with so few in a group, some of whom exhibit limited inter-personal skills; the situation was compounded by attendance issues and limited teaching time. But Cath was desperate to do something differently as '*many girls keep just missing their C grades'* (discussion following Lesson Observation 2) (TA).

Arriving for the third observation, the girls' work was evident everywhere with vibrant wall and ceiling displays. After a recap on 'solids', several area and volume activities were orchestrated along the lines of a carousel (but with the Cath moving the activities rather than the girls moving around). The six girls were asked to work in pairs and to collaborate; some did. As misconceptions with regard to 'volume' came to light, Cath asked valuable, probing questions. Cath then introduced the '*max box'* activity, maintaining a steady stream of further information as the girls attempted to tackle the problem. During the post lesson feedback, I suggested that insisting on correct terminology would aid mathematical sense making for students; Cath was very open and appreciative of all advice. We also talked about the idea of a 'launch' for an activity – allowing students to 'get on', without the disturbance of any further information or instructions. The need for a 'launch and then leave' approach resonated with Cath. On the feedback-on-feedback form Cath highlighted that she had had a tendency to talk over the girls whilst they tried to work: '*I fear I may do this regularly and talked to colleagues at school about this …'* (Feedback-on feedback form1 (LO3)) (M&C; PER).

Having left out chunks of the planned lesson so as to be able to showcase what she really wanted me to see, we talked about issues stemming from lesson observations. Cath said she was far more relaxed now, both in terms of teaching maths and being observed teaching maths, but did wish again that '*she could observe other maths lessons: We never, ever get the opportunity to observe'* (discussion following Lesson Observation 3) (M&C; LS/CO; SSup; BD). Cath also commented that she missed the network and support of the SKE+ group.

When I arrived for the final lesson observation, the school had (in order to ensure survival) been merged with the hospital school. Very vulnerable students, with significant mental health issues of both (and cross) genders, were now on roll. The change in atmosphere was apparent and Cath appeared under enormous stress trying to teach a hugely diverse group of students. Again keen to showcase the main aspects of her planning, Cath rushed the lesson and skipped various activities. Several PowerPoints were hastily flipped through and one or two students expressed frustration. One girl refused to do the mini activities threaded throughout the lesson 'script'; she simply wanted to '*get on with the maths'*. Later this girl explained that she had spent all her maths lessons at school just making stuff and not doing enough maths; she simply wanted to get on and do questions from a text book.

With tensions in the room between the different 'types' of students and with two of the 'new-comers' appearing openly hostile, Cath felt under pressure. Later she said: '*I think, probably, if I had been on my own I would have done a better job… it wasn't how I planned… so it was disappointing'* (discussion following Lesson Observation 4) (PRESS; TM). Cath acknowledged that she simply ploughed on and included '*too much'* because '*I wanted to carry on with what I had planned, I wanted you to see these things*…*I had some good stuff…*' (discussion following Lesson Observation 4) (PRESS; TM). Together we agreed the more demanding and interesting questions had been left a little too late, and some of the earlier material could have been dealt with more efficiently. When asked how she would have done things differently without me there, Cath said she would have done far more '*live teaching*', adding '*I do a lot more of that when I am not being observed*' (discussion following Lesson Observation 4)

(PRA). Cath believes that you are less likely to '*live teach'* during an observation, because *'you don't know what they [the students] are going to come up with';* whereas if everything is '*planned and prepared…you think nothing can go wrong'* (Interview 3, November 2016) (TA; CON; SK; PED). *'Live teaching'*, according to Cath, *'is a bit braver'* because you have to be confident to deal with the unexpected (TA; CON). Generally, Cath believes that since completing the course, her confidence with delivering the subject has increased and so too has her time spent '*live teaching'* (Interview 3) (CON; PED).

During the final interview, whilst acknowledging the value of being observed, Cath questioned where was *her* opportunity to observe others. She pointed out that an observer is '*learning loads watching me, good and bad*' (Interview 3) (TA; LS/CO), but that she wanted a similar opportunity for her own self-development as she is the one who should be learning. I thought that to be a really reflective point and one identified in the literature regarding the least experienced teachers having the least opportunities to observe and the most experienced teachers observing the most (Wragg 2012). Cath linked this lack of opportunity with the absence of support (and '*working completely in isolation*' (Interview 3) (SSup; PRA)), both limiting her prospects to develop her own practice. Sharing good practice and observing others teach are, according to Cath, '*the best professional development you could ever get'* (Interview 3) (TA; PRA) and she believes this is something all teachers '*deserve*' (TA). Cath had also referred to this during the first interview: '*we never get the chance to escape from our classrooms ...I would like to go in more lessons*' (SSup; LS/CO).

Along with having more opportunities to see others teach, Cath struggles to find the time to plan her mathematics lessons: '*Just want some time to plan, just sometime…*' (Interview 3) (BD). During the final interview Cath confided that often her '*confidence dips*' and that she had to work extra hard, '*doing more work at home'*, in order to prepare and to avoid feeling like she was failing '*because I do have high expectations of myself*' (Interview 3) (CON; BD; SSup). Cath went on to describe her frustration that despite her best efforts and hard work – and her attempts to employ all the techniques learnt from the course - the students struggled to learn or retain the knowledge '*and I think that's when I feel I have let them down'* (Interview 3) (TA; CON; PRESS). When Cath went on to detail exactly how much time each week she dedicates to planning, she simply broke down in tears. Immediately moving to suspend the interview, Cath dismissed the idea, saying '*its reality isn't it?'* (TA). Still sobbing, Cath continued uttering '*it's partly my fault really',* suggesting that as she wasn't '*good enough*' she had to work harder (Interview 3) (CON; TA; SSup). Cath's students have immense problems and issues; she does a really tough job. I wondered aloud if anyone – using her terms of reference – could ever be 'good enough'.

There appears no doubt Cath feels isolated and that feelings of insecurity have led to anxiety. Cath has had no one with whom to share ideas and no opportunity for collaborative planning. Cath's previous experience of collaborative planning, on the SKE+ course, had been very positive and she had thought *'they were brilliant, I really enjoyed those'* (Interview 3) (LS/CO; F-F). With strong personal subject knowledge, Cath found the collaborative practice one of the most valuable aspects of the training: *'I wanted more of that actually…the bits I was learning the most'* (Interview 3) (CAT). Cath also observed a whole demonstration lesson when she visited Venue 2 on one occasion: *'I remember the lesson you did on statistics…I loved that'* (Interview 3) (F-F; LS/CO; CAT). Cath then suggested the idea of packaging together, in one place, all the mini-teach sessions and all the demonstration lessons for *'teachers who were not specialists'*, believing this would be a '*brilliant way'* of exploring the curriculum (Interview 3) (LS/CO; PD).

No longer having any opportunities to collaborate, Cath also receives no mentoring or coaching (other than from me). I asked Cath whether, since the course, she feels supported in any way by her senior management; her response: '*not really*' and that there isn't the '*awareness that it is needed actually'* (Interview 3) (SSup; Per; BD). With typical self-depreciation, Cath now questions whether she herself should have been more proactive seeking support: '*that is my fault - I need to tell them that I needed it maybe'* (Interview 3) (SSup; TA; BD). To the idea that course providers could provide the script as to what participants should ask for next, Cath's response: '*I think that is brilliant. I think that could be really useful. I think you should do that, definitely*' (Interview 3) (SSup).

Taking time to search for reliable resources has also been a strain on Cath's reserves, with an '*increased work load'* (Interview 1) (PER; R). She feels she has found some better quality mathematics resources now - to add to those from the course - by simply spending hours '*trawling*' (Interview 3) (R). During the course participants readily supported one another and freely shared resources and ideas. Cath again lamented the loss of this network, and thought it would be great to have '*a bit of a reunion'* as '*I am back floundering on my* *own really*' (Interview 3) (LS/CO). Perhaps course providers should consider supporting the longevity of such informal networks.

5.6.3 Summary

Cath is a reflective and caring practitioner with a keen sense of wanting to 'give' of herself, to help improve the life chances of others. She desperately wants to do a good job but is unsure she is doing so. Undoubtedly the retraining programme gave her a much needed opportunity to share experiences and collaborate with others. Knowing her subject knowledge was secure and experiencing new approaches and activities, gave Cath a huge boost to her professional self-esteem.

Cath believes the essence of the SKE+ course was to demonstrate that '*you can play around and explore [with maths]'* and that it *'does relate to real-life'* (Interview 2) (F-F; PED). It is questionable whether the style of teaching modelled during the course, and one which Cath found very appealing, is wholly the right approach for her students. Cath is however '*really trying'* to make maths '*far more relevant'*; Cath believes she has moved away from simply believing you have to '*tick off a list of objectives'* (Interview 2) (PED).

Cath's cohort of students is becoming increasingly diverse and – seemingly – increasingly vulnerable, with a number of students '*in care, they have had a dark life, there is so much hostility they are not ready to learn'* (Interview 3) (PER). Given these circumstances, it is difficult to employ all that was endorsed on the course. Nevertheless, retraining could have been a bit of a lifeline for

Cath, and her students will undoubtedly benefit from the support Cath received. Ongoing support is, without doubt, still needed especially as her role becomes even more demanding with the increasing needs of her students.

Cath continues to seek opportunities for self-development. In 2017 she enjoyed an opportunity, supported by Plymouth University, to travel to Finland to observe mathematics teaching of which she described as '*an amazing opportunity'* (email, May 2017) (TA; PD).

5.7 A Profile of Euan

5.7.1 Introduction

Euan has worked in just one school - for a period of 14 years - a mixed, 11 to 18 comprehensive school. Euan taught some mathematics during most of his time teaching. During the period of retraining, Euan taught one mathematics class - a lower-attaining Year 11 group. In the subsequent year he also taught one group only - a top set Year 8. At the end of that year, Euan left teaching altogether. Having a degree in computing, Euan had worked in the IT industry for about 15 years prior to teaching. Asked whether he had ever had any regrets about switching careers, Euan replied: '*only when it comes to money, that is the only thing… [salary] about halving*' (Interview 1) (TA).

In the school, Year 7 are streamed into two populations – a '*more able*' and '*less able*' population; Years 8 to 11 are placed into two '*equal*' populations with five mathematics sets in each (Interview 1) (PRA). In 2014, Euan commented that although the mathematics department was fully staffed, '*there is still a question mark over the quality of some of the teachers'* (Reflections on Course, December 2014) (EFF). The schools' senior management seemed to agree and so had decided to send a teacher on the SKE+ course, with the intent of injecting some new ideas into the mathematics department: the way it is taught; the way it is approached; resources used. Euan was selected as someone who would be able to successfully disseminate and share best practice with the rest of the department. Euan considered this to be a '*boost*' ('*nice to be sent on a course')* because he felt he had been '*treated really badly at school for two* *years'* (Reflections on Course) (SSup; PD; TA). His feelings of ill-ease had arisen from the sense that he was being '*eased out'* of computing and into mathematics. Euan was keen to point out that this was not an '*anti-maths thing*' - and that he enjoyed teaching mathematics - but rather a concern about being moved away from his area of expertise (Reflections on Course) (TA).

One of Euan's long-standing frustrations - both during and after the course - was that even though he felt the course had offered all that his senior management had hoped, and he himself was inspired and enthused, he was given no time nor opportunity to disseminate his experiences: *'haven't had opportunity to share them, that is the biggest drawback …'* (Interview 2, January 2015) (PRA; LS/CO; SSup; BD) .

At this time, Euan's school was in 'special measures' and there was a palpable sense of the significance of the next Ofsted inspection. Consistency was the school's watchword and this impacted on Euan's practice. Preferring a freer style, Euan felt compelled to tow the line because he wanted to support his colleagues: '*they will look around and see that the pages of my books are perfectly folded in half, with kids writing in columns I have written in red pen each week and they respond in green pen every week and with a blue stamp on it*' (Interview 2) (OFS; PRA; TA; PRESS).

This section pieces together a story of Euan's training and teaching mathematics. Table 5.9 illustrates at which points Euan was involved with the various research instruments during the course and the following and final year of his teaching.

	Year 1 2013-2014	Year 2 2014-2015	Year 3 2015-2016	Year 4 2016-2017
September		Personal reflections – throughout year	Euan left the profession	
October		Reflections on Course Questionnaire Visit and notes from external evaluator: Keith Hedger		
November				
December	**Course commences** Mathematics Attitude Questionnaire 1 Subject Questionnaire for Mathematics SKE+ Evaluation 1	Mathematics Attitude Questionnaire 2 Subject Questionnaire for Mathematics SKE+ Evaluation 2 **Course concludes**		
January	Interview 1	Interview 2 Lesson Observation2: Year 8 (set 2 out of 4; 16 girls; 8 boys)		
February	Lesson Observation1: Year 11 (set 7 out of 7; 5 girls; 9 boys)			
March				
April				
May				
June	Personal reflections – throughout year	Lesson Observation3: Year 8 (set 2 out of 4; 16 girls; 8 boys) Feedback-on-feedback1 (from LO3) Interview 3		
July				
	Mathematics teaching commitment: 1 x Year 11	**Mathematics teaching commitment: 1 x Year 8**	**Mathematics teaching commitment: None**	

Table 5.9 Schedule Illustrating Euan's Participation with the Various Research Instruments

5.7.2 A Narrative of Euan as a Mathematics Teacher

Notes I made after the first lesson observation (at the start of the course) record good rapport with the students with a largely tension-free atmosphere – but that Euan had had to work hard to maintain this portrayal of a relaxed and calm environment; the students mostly uninterested and disengaged with mathematics. A really good introduction to the lesson (imitated from that seen on the SKE+ course) was set up with video, music and a challenging introductory problem. But in spite of Euan's efforts, it seemed evident that the students were '*not really up for it*' (discussion following Lesson Observation 1) (SA). With limited interpersonal skills amongst the group, collaborative group work proved challenging. The starter was swiftly discarded in favour of a mundane activity of writing very simplistic questionnaires; the task 'allowed' to be very undemanding. Euan and I spent some time discussing whether a much 'richer' experience for the students - the starter activity with some appropriate scaffolding for example - may have made the task of '*controlling the class*' that little bit easier (discussion following Lesson Observation 1) (M&C; PED).

During the first interview, Euan had said that his teaching style needed to improve and that he had '*fallen into some bad habits*' (PED; TA). He was '*afraid the default mode'* he used with his Year 11's was *'to get didactic'* (PED). Wishing it be otherwise he cited *'behaviour management'* for why that was so. This seemed to sum up and be a true reflection of the Year 11 lesson I had observed. Euan reiterated that a reason for coming on the course was to explore different ways to teach and to observe mathematics lessons; he had never previously observed anyone else teach mathematics.

The second lesson observation – and the first one after the completion of the course – was with a very different set of students, a Year 8 (set 2 out of 4). The class entered keen and ready to work, in a clearly familiar, collaborative and interactive, modus operandi. The students were engaged and happy. Euan exuded enthusiasm and his gentle humour was appreciated by all. Euan made links and connections to other areas of mathematics and to material from previous lessons – which the students clearly remembered. Euan told me he was keen to challenge the students and was clear in his belief of '*doing it this way'* pointing out that '*if the pupils are challenged they will be engrossed*' (discussion following Lesson Observation 2) (PED; TA). This was interesting to hear and see – because this was the essence of the post Year 11 discussion.

The third observation, a few months later, was with the same Year 8 class - a revision lesson on transformations. The lesson had a fun start with an interactive computer game Euan had seen used on the SKE+ course. The students enjoyed the calling out of the algebraic rules but some students were overheard saying how easy it was; it *is* a very simple game. This activity was unfortunately not extended - as it easily could have been - and instead Euan offered a very brief comment informing the students to expect '*harder*' two-step rules in the test; some students expressed concern and confusion. The lesson moved onto 'reflection' with a good warm-up activity which engaged all. Then the students moved onto an activity for which they had to spend considerable time copying axes and images from the projected slide, a time consuming clerical task. Some very good interactive questioning followed. Translation was then very briefly mentioned but so superficially so that no student who did not already have a grasp of this topic was likely to do so. For rotation, the advantages of using tracing paper were highlighted by Euan – but none was available to use in the lesson. Enlargement was very briefly discussed in haste toward the end of the lesson – with some inaccurate suggestions of how best to do. The apparent aim of the lesson was to prepare the students for an upcoming test; on the whole it appeared to do a poor job of this.

During the feedback at the end of this lesson, I floated the suggestion that too much time may have been spent on simple and clerical tasks and not enough time on the more challenging activities; Euan agreed. Euan also agreed that he had been hindered because he was '*not 100% sure on terminology*' (for example, '*translation versus transformation'*) (Feedback following Lesson 3) (M&C; SK; PED). I suggested that this may be more indicative of subject knowledge gaps rather than language limitations. Teaching and learning opportunities were also missed when students posed some of their own interesting questions which were not pursued. Previously, during Interview 2, Euan had mentioned that he thought this Year 8 class should be aiming for more advanced topics. Exploring reasons for why this was not possible, Euan explained it is '*because of what we've got to cover for the tests',* and expressed frustration at the repetitive nature of the spiral-style scheme of work, suggesting that if it were otherwise he would not have to '*re-teach*' so often (feedback following Lesson Observation 3) (PED; PRA; TA). Euan appeared unaware that the time used for his superficial revision lesson, could have in fact been used to extend and advance their knowledge *whilst* revising the basics, perhaps using the idea of 'recursive elaboration' (Davis and Simmt, 2006: 308), to extend and elaborate upon the original knowledge.

Euan's responses on the feedback-on-feedback form after this lesson, were all positive and he made the comment: '*It ranged beyond just the lesson, was forward thinking and was constructive whilst also being an honest appraisal of the teaching seen*' (June 2015) (M&C; PED).

During Interview 3 (June 2015), Euan pointed out that he teaches only one mathematics group a year and that this provides limited opportunity to lay down layers of experience and expertise; he thought it could take him 5 or 6 years to achieve the same level of experience a full time teacher of mathematics would accumulate in one year. This is an accurate analysis but one that varied significantly from his comments in Interview 2, where he felt having only one maths class was of significant benefit because he could focus all his new found learning and ideas on this one class; clearly his thinking had developed over time.

Shortly after this interview, Euan resigned from teaching (leaving in July 2015). He listed work-load, stress and wanting to spend more time with his family as reasons for leaving the profession. Euan had previously said (during Interview 2): '*we just literally do not have time to breathe - that is why everyone is working three hours after school every day*' (PRESS; SSup; PRA; TA).

Euan spent relatively little time as a newly retrained mathematics teacher. He did however make some very interesting observations during his training year which may help shed light on the value of retraining for others.

5.7.3 Notes and Comments from Euan's Diary of Personal Reflections (December 2013 - December 2014)

Euan felt the opening session to be friendly and that all were *'made to feel welcome'*. Euan observed that there were '*different levels of maths ability*' and queried whether all should be in the same group (SK); This, something

Cockcroft (1982) had also identified as being potentially problematic. Euan referred to the '*good resources*' (R) on several occasions and was keen, right from the start, for a facility to be set up - a blog or Pinterest page - for the sharing of these resources. Towards the end of the course, Euan did in fact set up a blog and invited members to join, '*hopefully people will update*' (R). This blog was updated for a while but without a permanent overseer, the venture didn't continue.

Observing demonstration lessons, Euan was impressed by the idea of starting a lesson with a problem. He noted to himself that he needed to allow his students more opportunities to *'discover solutions*' (PED). In a similar vein, whilst observing a Year 7 lesson he began to realise that he likes to be in control and that he needs '*to let the students take control more*' (PED). Euan did make the familiar (if perhaps false) observation that the types of resources and interactive activities observed during the various demonstration lessons would be unsuitable for his own class because his class was '*not the same'* (PED; TA; R) - not the same ability or age-group or group-dynamic. Like many non-specialist participants, Euan was unable to see that a lesson or a resource or an idea, can be adapted and developed to suit many different audiences. One of the lessons Euan *did* find particularly useful was to a lower attaining year 11 group. Euan was teaching a similar group at the time, and so replicated this exact lesson. He proudly sent me photos of the lesson; he had considered it a real success. Euan embraced the opportunity to teach during the SKE+ course and taught part of a Year 8 lesson on simultaneous equations with a World Cup theme. He noted in his diary that he felt this '*went well and good to deliver in non-*

threatening environment' and that during the feedback the group was *'very supportive'* (LS/CO; TA).

At the start of the course, Euan described his typical mathematics lessons as '*a bit shambolic'* with *'demotivated'* students (PED; SA). Although with very a different set of students, Euan contrasted this with a typical lesson at the end of the course, saying he now teaches: *'challenging but fun lessons'* (PED). Euan felt that the students were now *'enjoying their maths lessons'* (SA) and he himself felt *'more confident in my delivery*' (PED; CON).

Euan, keen to perform well for his certification, found the on-line tests to be '*quite frustrating'* (e-L) in terms of keying in answers. Euan did however achieve highly, scoring maximum marks on all of the tests, completing them all halfway through the year. Interestingly, during the final session Euan noted he had forgotten some of the more advanced topics *'since doing the on-line tests*' (SK; e-L). This raises the question regarding the role of the online tests in terms of retention and comprehension.

5.7.4 Summary

Euan, clearly a competent mathematician, enjoyed the retraining course and in particular enjoyed the lessons and the sharing of resources. He became much more enthused about teaching mathematics as a result of the retraining and had reached a point of looking forward to teaching his mathematics class whereas in previous years he had felt '*like oh god*' (Interview 2) (TA). Euan even said he would now like a to teach more mathematics as he wanted to test and hone his new found skills: '*I would actually love to teach some year 10 and year 11*' (Interview 2) (TA; CON; PED; SK).

By the end of the course Euan pointed out that he had not had any feedback from his Senior Leadership: '*no one has come to see me, no one has checked my marking yet, no one has observed me, no nothing yet*' (Interview 2) (SSup). But in spite of this apparent lack of interest from the Senior Leadership, Euan was determined to carry on teaching in the '*new*' interactive and engaging style: '*It will last definitely'* (Interview 2) (TA). Euan had however, had lots of positive anecdotal feedback from students and parents, including: '*I really get it with my teacher this year, he makes it interesting*' (SA). And making it interesting and enthusing students was important for Euan; for him, this is one of the biggest indicators of an effective mathematics teacher: '*in simple terms [an effective mathematics teacher], is someone who can get children enthused in the subject*' (Interview 2) (EFF).

Acknowledging that student behaviour is affected by what and how they are taught, Euan noted that when particularly busy or in times of stress he may *'fall back to the old method of teaching and then yes behaviour deteriorates*' (Interview 2) (PRESS; PED; EFF). The inference here is that lack of time prevents better teaching. I had observed two very different scenarios with Euan teaching: a disaffected and uninterested Year 11 class where the teaching offered was mostly dull and mundane, and an enthusiastic Year 8 class engaging in some rich and interesting interactive activities. It is difficult to say whether the approach taken with the Year 8 class was as a direct result of the retraining or with the dynamics of the students involved. The typically English system of setting students into 'ability' groups can result in the more motivated students being grouped together. This then facilitates a more collaborative and creative style of delivery. I can only surmise – because Euan said so – that it was both. The fact that, by the end of the course, Euan was keen to teach a variety of different age and 'ability' groups, does lend weight to the impact of the retraining.

Euan has clearly expressed his opinion that a didactic, chalk and talk manner (as he himself was taught) is not the best strategy for the '*many*', even if it could still work for the '*few*'. Interestingly then, Euan said he would revert to a more didactic style '*when inspections are looming*' (Interview 2) (OFS; PED; PRESS; TA; PRA). I was curious about this as I suggested that this could be a good time to showcase best-practice. Euan countered with his belief that Ofsted was still looking for certain things, all of which had to be demonstrated within the short segment of time an inspector remained in the classroom. Euan was sure that he would '*never take the kids outside during an Ofsted lesson'* (OFS: TA; PED) nor spend time setting the scene or risking an activity which potentially could go wrong*;* instead he would *'fall back on here's a concept, right everyone understands that, here's an exercise, we'll check that, right let's move on, they see the kids learning something in 10 minutes, wow, tick'* (Interview 2) (TA; PRA; PED).

One of the final comments Euan made was that he '*would love to have sort of refresher every now and again … this course or a variant of this course*' (Interview 3) (TA; PD; R) and to be able to share new resources and ideas. He was very enthusiastic about everything to do with the retraining and thought that those who have been similarly enthused would benefit from staying in touch and from sharing what they were doing with others.

Euan did feel '*knocked*' back when his Senior Leadership team did eventually observe him teaching mathematics (SSup). He sent an email to me early March 2015, expressing his frustration; the observer had suggested the lesson would have been graded *'requires improvement'* (BD) if anyone else other than Euan had delivered it. The observer summed up their concerns by explaining the lesson would be inappropriate for an NQT or trainee to observe as they, themselves, would '*fail in delivering it'* (SSup; BD). As it was, the observer decided to grade the lesson 'good' but qualified this by saying it was dependent on the relationship Euan had with the class. Euan told me he was astonished that views regarding teaching could still be *'so backward' but* was determined to '*persevere*' in teaching with his new approach (email, March 2015) (TA; PED). The irony is, of course, that Euan was sent on the SKE+ course to inject some new ideas into the department. The Senior Leadership team clearly had the insight to realise they needed this but not the wherewithal to follow through; Euan was not supported by his senior teachers.

Two weeks later, Euan sent me another email saying he had decided to leave teaching at the end of the school year: '*I feel really guilty resigning so soon after attending the course, but it is something that I need to do*' (email, April 2015) (TA; SSup; BD).

Euan has not returned to teaching.

5.8 A Profile of Janet

5.8.1 Introduction

Janet had been working as a supply teacher at her current school when the head teacher approached her and offered a permanent position from the September of 2013. At the time it was not clear what subject she would be required to teach; the head teacher was simply keen to '*fill holes'*. Later the head teacher asked her how good she was at mathematics and Janet thought she '*could do Key Stage 3'* (Interview 1). Janet taught Year 7 and Year 8 - for 12 hours a week - throughout the 2013-2014 academic year. Janet was self-motivated enough to sign up for the SKE+ course, as in her words: '*now that I've landed in it [maths teaching] I want to do it as well as I can*' (Interview 1) (TA). And, at the time, it appeared it would be a long-term commitment to the subject switch, as the school had recently lost two mathematics teachers and the school was '*struggling to recruit*' (Interview 1) (SHORT). In fact, Janet only taught mathematics for that one year.

The headteacher supported Janet's decision to participate with SKE+ and was *'very keen for me to come on this, very keen for me to do any kind of CPD'* (Interview 1) (SSup; PD; EFF). This may have been particularly so, as there was a definite lack of expertise within the department on which Janet could draw. The head of mathematics was not a mathematician and the department relied heavily on textbooks which '*come as part of a package with tests and levels*' (discussion following Lesson Observation 1) (PRA; EFF; PED).

This section pieces together a story of Janet's one year of training and teaching mathematics. Table 5.10 illustrates at which points Janet was involved with these various research instruments during the course of this longitudinal study.

	Year 1 2013-2014	**Year 2 2014-2015**	**Year 3 2015-2016**	**Year 4 2016-2017**
September		Personal reflections – throughout year (by way of personal diary)		
October		Reflections on Course Questionnaire Visit and notes from external evaluator: Keith Hedger		
November				
December	**Course commences** Mathematics Attitude Questionnaire 1 Subject Questionnaire for Mathematics SKE+ Evaluation 1	Mathematics Attitude Questionnaire 2 Subject Questionnaire for Mathematics SKE+ Evaluation 2 Interview 2 **Course concludes**		
January	Interview 1			
February				
March	Lesson Observation1: Year 7 (set 2 out of 3; (set 2 out of 4; 30 girls)			
April				
May				
June	Personal reflections – throughout year (by way of personal diary)			
July				
	Mathematics teaching commitment: 12 hours (Year 7 and 8)	**Mathematics teaching commitment: None**		

Table 5.10 Schedule Illustrating Janet's Participation with the Various Research Instruments

5.8.2 A Narrative of Janet as a New Mathematics Teacher

Janet teaches in an all-girls non-selective school, which is in close proximity to a grammar school. I observed Janet teach mathematics three months after the start of the course (with a Year 7 mid-set group). The classroom was a big bright room with interesting and well maintained wall displays. Many features of the interactive whiteboard were used at the start of the lesson. The lesson was highly structured and Janet demonstrated superb and extremely efficient organisational skills. The girls were ‘drilled’ in classroom procedures, including self-marking, finding the day’s learning-objective sticker from a sheet, and completing self-evaluation of the lesson. The girls were all cooperative. A ‘starter’ was explored with the whole class, led by Janet, before the main task of the lesson (questions from a text book) was indicated on the board, split into 4 levels: ‘Not sure’; ‘Core’; ‘Challenge’; and ‘Extension’. The girls were told to start on the questions from level they felt most appropriate. Janet then moved around the room – helping individuals and encouraging others. The girls self-checked their work by going to the back of the room where the answers were available in the teacher book. Quite a queue formed at one point. The mathematical material offered to the girls was fairly mundane and uninspiring. The lesson was unambitious and pedestrian. But perhaps most significantly, mistakes and errors were not picked up – and the opportunity to use them as teaching points missed. No mathematical connections were made and there were very limited opportunities for deep thinking.

Janet appeared to be aware of some of the limiting aspects of her teaching. Prior to observing Janet, I had asked her (during Interview 1) about her style of teaching. She had talked about the importance of setting a subject in a real world context, but that she was finding this difficult with mathematics and was as poor at it '*as the rest of the department to be honest'* (PRA; PED)*.* Janet believed this to be *'because I don't know my subject knowledge well enough to start creating exciting stuff which is why I'm really enjoying this [course]'* (Interview 1) (PED). Janet thought that until *'you know your subject knowledge really well'* (SK) the only option was to teach by *'sticking to the tried and tested, speaking at the front, chalk and talk, work out of the text book kind of thing'* (PED)*.* Janet went on to say that this '*isn't the way I want to teach … it's not where I want to end up'* (Interview 1) (TA). This precis proved to be an accurate description of what I subsequently observed.

Janet believes that a good way to develop and improve as a practitioner is to observe expert teachers in their field. Unfortunately, Janet did not think there were any in her department: '*our department just teaches to the text book and it is just so dull and boring, so I'm not experiencing what I think is outstanding teaching'* (Interview 1) (PRA; PER; PED; TA). Another explanation for why Janet sticks to using questions from text book, is the time she believes it takes to plan and prepare '*new ways of doing things'* (Interview 1) (PRESS; R)*.* And '*time*', she believes is in short supply especially because time, energy and focus were being directed toward preparations for the imminent arrival of Ofsted. Janet: '*because we are pre-Ofsted…we are in initiative over load… in an effort to be outstanding'* (Interview 1) (OFS; PRESS). Janet viewed these preparations for Ofsted as having *'a big impact'* and felt that *'staff well-being* *has gone out the window'.* Pointedly, Janet also added: *'and it's not necessarily where we can see the benefit for the children'* (Interview 1) (TA; PRESS; OFS).

Although Janet did not teach mathematics for long, she kept a detailed diary of personal reflections during her retraining year and some of her observations are particularly insightful and could well prove useful for developing retraining provision.

5.8.3 Notes and Comments from Janet's Diary of Personal Reflections (December 2013 – December 2014)

Janet observed that a friendly supportive atmosphere was established almost immediately and the environment was one where '*no question asked will be seem as a silly one'* (PER). This was important for Janet. Particularly keen on the practical ideas provided, Janet noted that this was because - without guidance of this kind - it is difficult to incorporate these types of activities into your teaching in a subject for which you have not had training. The highlighting of common misconceptions was '*very helpful'* (PED); being able to recognise them as such, and use them to enhance teaching opportunities, is something Janet pin-pointed as usually taking years of practice. Looking at the subject from the point of view of the student, and anticipating student responses, were also identified by Janet as being extremely useful – and gleaned from both the demonstration lessons observed and reflected upon, and the in-session Lesson Study style of collaborative practice. Perry and Lewis (2009) highlight that prior to experiencing Lesson Study, 'few teachers considered the issue of anticipating student thinking' (2009: 378). Watching demonstration lessons (by me) both impressed and concerned Janet. Impressed by *‘how a hook can be used effectively to keep a class engaged and learning throughout’* (PED; SA), Janet expressed her concern that the lesson did not adhere to the still populist (if somewhat outdated) idea of the three-part Ofsted model lesson with plenty of writing (by students in exercise books) to record ‘progress’. Janet documented that she found the post-lesson discussion and reflection, interesting and *‘exceptionally useful*’ (TA) challenging her (and other participants’) views about what constitutes ‘progress’. Having observed me teach several times, Janet said ‘*I would like to teach like you’* (Interview 2) (TA; PED; CAT; SK; CON). Unpacking this a little, Janet clarified that she would like the confidence and subject knowledge to engage students.

As the sessions progressed, Janet noted that all participants were now beginning to contribute to the sessions and that they were learning from each other as well as from the tutor. Janet did reflect that the course moved into mathematical areas in which she felt less than comfortable: ‘*Beginning to find some learning at higher GCSE is of limited use – it is highly unlikely that I will ever teach at this level’* (SK). Janet goes on to question the suitability of the course: *‘this is more a mismatch between me and the course’* (IMP). Janet reaches the conclusion that a degree in mathematics isn’t necessary but that a good A level is essential to be able to teach GCSE and hence ‘*why it is unlikely I will ever feel comfortable doing this*’ (TA; SK). Feeling that a lot of the subject knowledge is beginning to move beyond her reach Janet records that ‘*without either a) exceptional subject knowledge at GCSE or b) some knowledge above GCSE level in order to ‘look back’ at these concepts, I cannot begin to comprehend them by ‘learning up’ to A* GCSE*’ (SK). This is an astute observation and one which *could* underpin how we select teachers for retraining in the future. Janet has articulated her 'truth' – which is you need to have mastered the content for yourself before you can master how to teach it. Janet managed this situation as best she could, by recognising that the *'key is to do some pre-learning before the sessions if subject knowledge is lower than required*' (SK; TA; CAT; BD). Nevertheless, it remained the case for Janet that sometimes the subject knowledge was *'completely outside my sphere'* (SK; BD).

Janet also identified that she has limited opportunities to consolidate her new knowledge and that this was significant: '*the hard learning is likely to be lost as there is no ability for me to put it into practice'* (PER; IMM; BD). Again this seems to be an astute observation, that the advantages offered by retraining may be wasted if opportunities to practice, reflect and hone new skills are not immediately forthcoming. Janet *is* teaching mathematics at the point she makes these observations but she believes she doesn't have '*pupils of the right calibre'* to '*practice on'* back at her own school, and that she finds this '*somewhat frustrating'* (TA; IMM). This a familiar echo to comments made by Euan and other participants; the suggestion being that unless there is a perfect correlation between the cohorts of students (those being observed, and those to be taught), then the value of the resources or the lesson observations are somewhat diminished.

Janet noted that her teaching practice was improving and she attributed this largely to SKE+. She also records that during a recent 'in-house' lesson observation she received a *'good with outstanding'* (PER). I imagine her organisational skills aided enormously with this evaluation of her teaching; in discussion with Janet it was clear that opportunities for deep thinking remained elusive for her students.

5.8.4 Summary

Towards the end of the retraining, Janet discovered she would no longer be teaching mathematics; this, as a result of being redeployed to teach A-level Business Studies in the new 6th form. Her redeployment created a vacancy for a mathematics teacher, one which was apparently '*not easy to fill*' (Interview 2) (SHORT). Understandably, this development had a significant and immediate impact on Janet's dedication to the retraining. To tackle the sessions with embedded higher level content '*realistically required a lot more work outside the sessions'* (Personal Reflections) (TA; e-L; SK), which Janet no longer felt inclined to do. Without a '*passion for the subject'* and now '*without the impetus of teaching it next year*' concepts which are '*clearly beyond my knowledge'* remained so and Janet no longer had the drive and determination to conquer new (to her) challenging material (Personal Reflections) (SK; TA).

Janet questioned the value of discussions surrounding research and the worth of viewing TED talks, as though whilst interesting '*this is not something that will take my practice forward'* (Personal Reflections) (TA). Viewing such activities as '*like more of a filler and less useful than working through examples'* (Personal Reflections) (TA) perhaps highlights a participant's position in terms of training development needs: Where subject knowledge is the key issue, working through mathematics problems is the key priority; looking 'up and out' is for later.

Janet chose not to teach the students at any point but reflected that the lesson observations *'are brilliant to watch and show great creativity, stimulating discussion and enhancements'* (Personal Reflections) (PED). Janet also noted, and recognised, the value of post-lesson discussions and feedback: *'Well-structured feedback system which Naomi gently insists on is good for ensuring usefulness of criticism'.* Janet noted again the significance of the group dynamics: *'the group is friendly and non-judgemental and all is taken in a spirit of constructive criticism'* (Personal Reflections) (LS/CO; PED; TA).

To summarise, Janet appeared to have found the sessions demanding and challenging but of value (certainly before she discovers she is no longer to teach mathematics): '*Brain aches at the end of the day but worthwhile!*' (Personal Reflections) (TA). Janet completed the SKE+ course, in spite of knowing she would no longer teach mathematics, and was awarded a Merit, achieving 86% in the tests.

5.9 Summary of Profiles

These narratives are necessarily condensed versions of the unfolding stories of eight very different teachers, who have experienced retraining and subsequently a number of years teaching. Themes extracted from the participants' stories are summarised and analysed in the following chapter.

Chapter 6: Analysis

6.0 Introduction

Underpinning my research is the idea that we in England have too few effective mathematics teachers. Issues surrounding the *shortage of mathematics teachers* in their schools, and perceptions regarding *effective practice* (as construed by the participants), were highlighted throughout the previous profiles – and are summarised below (in 6.1 and 6.2).

This longitudinal research study has delved deeply into the professional lives of eight teachers. Perhaps inevitably, the explorative nature of this study has also tapped into areas of their personal lives and I have been witness to, and sometimes a confidant of, many facets of life including promotions, demotions, resignations, break-downs, marriages and miscarriages. The intimate nature of this study, with close relationships forged, has helped reveal a rich vein of data; the significance of such was explored in Chapters 2 and 4 (Charmaz and Belgrave 2012, Fontana and Frey 2005, Renshaw 2008).

The major themes developing and emerging from this longitudinal study, and threaded throughout the narratives, are:

- **Subject knowledge issues**, including: the impact of the lack of mathematical subject knowledge; the benefits of being immersed in mathematics; confidence issues related to teaching mathematics
- **Mentoring and coaching:** the impact of these for the participants

- **Collaborative practice,** including opportunities (and the lack of opportunities) for: collaborative planning; networking; sharing of good practice; peer and developmental lesson observations; Lesson Study
- **Senior management influence (support/pressure)** pre, during and post the retraining programme
- **The school/department effect**: the impact of the school or department ‘norms’ (the department ‘mould’) on a teacher’s style of teaching
- **External pressures (i.e. Ofsted; GCSE results; financial constraints)** and the impact on teaching

The table below (Table 6.1) captures some pertinent points from the narratives, which reflect and exemplify these themes; the corresponding codes are included alongside the text (see Table 4.9 for the list of codes and associated abbreviations).

	Subject knowledge (SK) (PED) (e-L)) (IMM) (CON) (TM) (MT-Obs) (PER) (R) (IMP)	**Mentoring and coaching** (M&C) (IMP) (TA) (PED) (TM)	**Collaborative practice** (LS/CO) (IMP) (TA) (PED) (MT-Obs) (PRA) (BD) (R)	**Senior management influence** (SSup) (CAT) (BD) (PER) (PRESS) (EX) (PD) (TA) (SHORT) (PED)	**The school/department effect** (PRA) (BD) (CAT) (PER) (TA) (TM) (MT-Obs) (EFF) (EX) (PED) (CON)	**External pressures** (OFS) (EX) (PRESS) (SHORT) (PRA) (PED) (TA) (TM) (BD)
Harvey	Harvey reports developing subject knowledge enables him to start moving away from predominantly didactic teaching (SK) (PED) (CON) Subject knowledge weaknesses remain evident (SK) (MT-Obs) Clerical/admin type activities employed (R) (MT-Obs)	Harvey believes his teaching skills have developed as a direct consequence of mentoring and coaching (M&C) (PED) Coaching and mentoring enabled Harvey to further develop a different teaching 'script' (M&C) (PED) (TA) (TM) Non-judgmental feedback - considered to be a particularly profitable use of time (M&C) (CON) (PER) (TA) No similar opportunities provided by 'new' school (M&C)	In original school: Harvey encouraged to work with others and observe maths lessons (LS/CO) (PRA) Harvey enthused by the introduction to Lesson Study encountered on the SKE+ course (LS/CO) (TA) An approximation (concerned with resource provision and consistent practice) of Lesson Study noted at his 'new' school; no other collaborative opportunities apparent (LS/CO) (R) Regrets lack of post-course support network (TA)	Significant senior management/departmental support at 'old' school, evident pre, during, and post the retraining course; all associated expenses covered (SSup) (CAT) Harvey promoted to pastoral management position in a 'new' school; senior management support now very limited. (SSup)	Harvey recognises the difficulties of learning to teach in a different way to those with whom he is surrounded (PED) (PRA) (PER) The course gives him confidence to try to embrace a more active teaching and learning model (CON) (PED) Two years after completing the course – and in a 'new' school - it appears the school itself is exerting the stronger force in determining teaching styles; Harvey appears to revert back to procedural style teaching (PED) (BD)(PRA)	Harvey believed his 'new' school was more traditional and less likely to take 'risks' (with teaching styles) so as not to endanger their high Ofsted status(TA) (OFS)
Darcy	Darcy reports being very motivated by tests - scores 100% on all online tests (SK) (e-L) Subject knowledge limitations observed in lessons; Limited challenge for students; Limited linking of topics (SK) (MT-Obs) (PED) Lack of confidence in subject knowledge appears to lead Darcy to prefer to stay in 'control' often exhibiting didactic teaching style; Darcy refers to not knowing the 'terminology' (SK) (CON) (PED) Poor choice of resources appears to limit learning opportunities; Clerical/admin type activities employed (SK) (PED) (R) (MO-Obs)	Motivation, to engage with mentoring and coaching, may have been for self-affirmation (M&C) Direct advice from Ted not appreciated nor adhered to (M&C) No mentoring and coaching offered by school (M&C)	No opportunities for collaborative practice at the school (LS/CO) No opportunity to observe other maths teachers; Prior to course, Darcy had never observed another maths lesson (LS/CO)	No evidence of senior management support or involvement (SSup) Belief that senior management would be unsupportive of anything other than a didactic, teach-to-the-test approach (TA)	Heavily influenced by the culture of the school, determined by senior management, Key Stage 4 GCSE results appear to dominate the agenda - and Darcy's vision (PRA) (EX) (PRESS) The drive for exam results manifests itself as a preference for didactic teaching – to '*get through*' the curriculum (PED) (PER) (PRA) (EX) (TM) A belief that senior management would be uninterested in more active approaches to learning (TA)(PED)	Darcy driven solely by GCSE exam success (EX) Academy status 'allows' maths teachers to teach a greater number of hours than previously (PRESS) (PRA)(TM)

Bea	Bea claims being immersed in teaching maths helps to reinforce ideas from retraining programme; Advocate of real-time teaching (IMM) (SK) (PED) Believes pedagogical 'support' from course has helped her to transform the maths department (PED) (IMP) Advocate of 'safe' environment for students (PER) (PED) Bea keen to address student misconceptions and to make connections between mathematical areas; Mathematical language used as matter of course (SK) (PED) Realises advantages of teaching parallel groups(IMM)(PED) (SK) (PER) (TM)	Mentoring sessions used as a sounding board to *'bounce ideas off'* – in her drive to effect far reaching changes in the department (M&C) No similar opportunities provided by school (M&C)	Bea's and Anna's shared experience leads to a more 'open door' arrangement at school, with increased informal sharing of planning and ideas; provides catalyst for open door policy for whole department (Advantage of two on course.) (LS/CO) (PRA) The collaborative project (introduced by Anna, whilst Assistant Head) is deemed unsuccessful (LS/CO) (SSup) No opportunities for peer observations (LS/CO)	Senior management orchestrated retraining to address the shortage of maths teachers; Bea, confident in her maths skills, happy to engage (SSup) (SHORT) (TA) Experienced no interest or involvement from senior management, during or post retraining (SSup) Belief that there should be more ongoing support post retraining; suggests this should be in the contract with schools (TA) Believes course would have more sustainable impact if support continued in subsequent years. (TA) SMT engage in learning walks which can be stressful for both teachers and students (SSup)	Bea determined to 'mould' her department in the style of teaching promoted on the retraining course (PED) (PRA)	Ofsted dominates school policies and planning (OFS) Academy status 'allows' maths teachers to teach a greater number of hours than previously – deemed necessary for KS4 results to improve (PRESS) (PRA) (TM)
Anna	Anna believes limited teaching opportunities curbed her development as a maths teacher (IMM) (SK) (PED) Poor choice of resources can limit learning opportunities; Clerical/admin type activities sometimes employed(SK) (R) Realises advantages of teaching parallel groups (IMM) (PED) (SK) (PER) (TM) Poor choice of resources appeared to limit learning opportunities; Clerical/admin type activities employed(SK) (Ped) (R) (MT-Obs)	A strong advocate for mentoring and coaching – Anna keen to develop her practice and engage with dialogue (M&C) Limited maths teaching - inhibited opportunities to enact ideas arising from mentoring and coaching (M&C) Found it more difficult to embed ideas discussed, as the training course became more distant (M&C) Appreciated sense of being part of process and not feeling judged (M&C) No similar opportunities provided by school (M&C)	Enthused by the introduction to Lesson Study encountered on the SKE+ course, Anna unsuccessfully attempts to introduce similar at school; Possible cause of collapse: collaborative initiative is based on administrative tasks not 'teaching and learning' (LS/CO) (SSup) (TA) Anna identifies advantages of two on course – sharing ideas/resources – an organic collaboration – encourages risk taking (LS/CO)(R) Regrets lack of post-course support network (TA) Prior to joining the senior management team - no opportunity to observe other maths teachers (LS/CO)	Senior management orchestrated retraining to address the shortage of maths teachers; Anna anxious at outset (SSup) (PER) (SHORT) Experienced no interest or involvement from senior management, during or post retraining (SSup) In 2016, SMT redirected Anna away from teaching maths (SSUp) (BD)	Anna noted it was harder to teach maths the further away from course (PED) (PRA)	Terrified by the thought of being observed by Ofsted (OFS)

Katy	Katy describes her limited prior subject knowledge; Struggled with higher level content on course(SK) Limited teaching opportunities curbed Katy's opportunity to revise/embed ideas(SK)(PED) (IMM)(IMP) Lack of secure subject knowledge led to anxiety whilst in front of a class(SK) (CON) (PED) Realises advantages of teaching parallel groups (IMM) (PED) (SK) (PER) (TM) Embraces all opportunities for further development; Immerses herself in the subject at home(SK) (IMM) (TA) Poor choice of resources appeared to limit learning opportunities; Clerical/admin type activities employed(SK) (Ped) (R) (MT-Obs)	Belief she would have been unable to 'progress' without mentoring and coaching; unsure how other participants without such, have coped (M&C) Believes mentoring has had direct impact on students' experience (M&C) Appreciated sense of being part of process and not feeling judged (M&C) Expressed regret at loss of this support (M&C) No similar opportunities provided by school (M&C)	Good group dynamics highlighted – as essential for successful collaborative practice; as too a level of expertise required within group (LS/CO) (TA) A safe, non-judgmental and respectful environment deemed essential for development through collaborative practice (LS/CO) (TA) No opportunities for collaborative practice at the college - even though logistics would allow it (LS/CO) Katy feels very isolated (TA) No opportunity to observe other maths teachers; Prior to course, Katy had never observed another maths lesson (LS/CO) The network and support of the group is greatly missed (TA)	Senior management appear far removed - with little awareness of Katie's retraining; no support offered (SSup) Lack of vision and direction from senior management - 'allows' the maths department to be very passive in terms of professional development (SSup) (BD) Katy believes that there needs to be more support after the course (TA) (SSup) Katy pays own travel expenses for professional development events (BD)	Katy attempts to move away from the department norm believing there must be a better way to teach than *'just telling'* (PRA) (PED) (TA) Efforts made to embrace all possible professional development opportunities in attempt to move away from the typical department approach (PD)	Ofsted sets agenda for the style of 'graded' lesson observations conducted by college; Katie believes these to be unproductive with feedback lacking quality or purpose (OFS) (TA) (BD) Anxious about being graded and 'judged'(TA) (PER) (OFS) College left scrabbling for maths teachers when graded 4 by Ofsted and required to increase their hours of GCSE maths resit lessons; Katy hastily recruited to teach more maths (OFS) (SHORT) Budgetary pressures lead to a deficit of professional development opportunities (PD) (PRESS) (TA)
Cath	With secure personal subject knowledge, Cath worked hard to '*deconstruct*' (Interview 2) what and how she knew – in order to help others; Pedagogical influence of course critical for Cath (SK) (PED) (PER) (TA) Prefers to avoid dealing with the '*unexpected*' during lesson observations – as this would require her to be '*a bit braver*' (Interview 3) and more confident with the subject (SK) Unsure of the best way to deliver the subject to her disadvantaged students – '*trawling*' (Interview 3) for resources takes considerable time and energy (PED) (R)	Appreciative of all feedback and advice; Cath has had no other opportunities for mentoring and coaching (M&C) Impact of lesson observations on teaching practice highlighted; Cath believes she does less 'live teaching' whilst being observed – to avoid the '*unexpected*' (M&C) Significance of feeling safe stressed (M&C) No similar opportunities provided by school (M&C)	Cath found the collaborative planning and shared mini-teach experiences, to be the most valuable part of the retraining (LS/CO) Back in school - no opportunities for such, whatsoever; Cath feels very isolated (TA) No opportunity to observe other maths teachers believed to be a barrier to further development (TA) (BD) The network and support of the group is greatly missed; feels like she is floundering on own (TA)	Cath anxious when asked by SMT to fill the role of maths teacher (TA) (PER) SMT seem oblivious to the need for further subject/pedagogical support; Crisis of confidence leads Cath to question her 'success' as a maths teacher (SSup) (BD) (TA) Cath isolated and anxious, questions whether she should have been more proactive requesting support (TA) (BD)	The SMT and school environment appears caring and concerned with teacher well-being; there appears a disconnect that a teacher's sense of self-efficacy impacts health (PER) (SSup) With no department colleagues, Cath experiencing plummeting self-esteem (PER)	School under constant threat of closure has led to insecurities amongst staff; new merger with hospital has led to increased security but with increased demands on teachers (PER) (PRESS) A belief that there is a discord between what Ofsted wants to see and the style of teaching promoted (and embraced by Cath) on the retraining course (OFS) (PED) (PER) Budgetary pressures lead to a deficit of professional development opportunities (PD) (PRESS) (TA)

Euan	Limited teaching opportunities curbed Euan's development as a maths teacher – acknowledging it would take 5 or 6 years to accrue the same experience as a fulltime maths teacher (PED) (SK) Began to acknowledge that his preference for '*control*' of the lesson stems from limited pedagogical subject confidence(SK) (PED) Believes retraining has increased his confidence and thereby affected his style of delivery(SK) (PED) Poor choice of resources appeared to limit learning opportunities; Clerical/admin type activities employed(SK) (Ped) (R) (MT-Obs)	Embraced suggestions which could be seen being enacted and voiced during succeeding lesson observations (M&C) No similar opportunities provided by school (M&C)	Prior to course, Euan had never observed another maths lesson (LS/CO) Believed the introduction to Lesson Study (during retraining) to be extremely valuable and embraced the teaching opportunity, finding the '*non-threatening environment*' to be key (TA) (LS/CO) No opportunities for any collaborative practice back at school (LS/CO) Keen to set up sharing of resources facility (R)	Euan instructed to attend retraining course in order to '*boost*' the maths department; Frustratingly for Euan - no opportunities provided to disseminate (SSup) (PER) Lack of support affects Euan's morale (TA) (BD) Isolated and struggling to keep the ideas from course alive, Euan determined to teach for understanding (TA) (PED) (SSup) Euan knocked back when SMT unimpressed with teaching approach (SSup) (BD) Euan departs profession in 2015 (BD)	Department drive for consistent approach had led Euan to a didactic approach with '*bad habits*'; Euan keen to evolve from this position (PED) (PRA) (TA)	Euan's opinion: With school in special measures the focus on the next Ofsted inspection restricted creativity / risk taking (TA) (PED) (OFS) Euan explicit that he would not teach the '*SKE+ way*' during an Ofsted inspection; he would not take the *'risk'* (TA) (PED) (OFS)
Janet	Limited knowledge and experience leads to an unambitious and pedestrian approach to teaching; clerical and admin activities observed(SK) (PED) (MT-Obs) Comes to believe that her prior limited subject knowledge is insufficient for her ever to become a proficient maths teacher(SK) (PER) Believes mastering the subject knowledge is key before one can begin to master the teaching of the subject (SK) (PER) Realises advantages of teaching parallel groups (SK) (IMM)	Janet experienced no mentoring or coaching during her short time as a maths teacher – none was offered and none was available (M&C) Janet identifies the difficulty of being creative within a subject in which you are not an expert (M&C)	Prior to course, Janet had never observed another maths lesson (LS/CO) Believes best way to develop is to observe good maths teaching; Janet believed this was not possible as there is none at her school (TA) (BD) Non-judgemental group dynamics identified as key for the success of Lesson Study during course – not made to feel '*silly*' (TA) No collaborative planning opportunities at school (LS/CO)	Janet asked by SMT to fill maths teacher 'hole'; readily accepting challenge, Janet encouraged to attend course (SSup) (SHORT) No other support offered or suggested (SSup) In 2014, SMT redirect Janet away from teaching maths (BD)	Lack of expertise and knowledge throughout department limits Janet's opportunity to learn (PRA) Janet uninspired by departmental colleagues but nevertheless has no other carbon to copy (PER) Janet teaches to the textbook, as do others in the department (PED) (PRA) Differentiation by resources/activities encouraged within lesson (PRA) (PED)	A belief that there is a discord between what Ofsted wants to see and the style of teaching promoted on the retraining course(TA) (PED) (OFS) Imminent arrival of Ofsted absorbing all SMT attention and energy; sense of initiative overload amongst staff (PER) (OFS)

Table 6.1 Narrative Summaries

6.1 Shortage of Mathematics Teachers (SHORT)

All participants in this study reported personal experiences which reflected the general issues surrounding the shortage of suitable mathematics teachers (discussed in Chapter 2); typical participant comments are shown in Table 6.2. Indeed, the driver for all participants being retrained (bar Katy, initially) was the shortage of teachers of mathematics in their schools (*and* a lack of applicants for vacant posts). Katy's college faced an acute shortage of mathematics staff - with the need to deliver mathematics to large re-sit cohorts.

	Shortage of mathematics teachers… (SHORT)
Harvey:	• '*can't get maths teachers'* (Interview 1) • '*adverts in the TES…only 2 applicants…neither turned up for interview*' (Interview 1) • *'Yeah - well we've got another PE teacher and an ICT teacher currently on [TSST] courses…'* (Interview 3) • *It's quite scary to think that was it the work load that was being put on her [*recently deceased teacher]- *but that is because there aren't any maths teachers about and you look at the ones that are here and they are stressed, they are haggard and they are not coping not at all - but there is nothing being done about that - for their well-being.* (Interview 3) • *NS: and when you left your last school where they able to fill the vacancy there?* • *H: at Christmas - it took them a term and then it was a primary school teacher and they were going to specialise the timetable so it was key stage three - rather than key stage four. They had no applicants first time round* (Interview 3)
Darcy:	• '*we had a whole year without a [maths] teacher…that was a really hard year…complaints from parents…'* (Interview 2) • *'Well we had one applicant but we had been told we probably didn't want to interview him – unofficially!*' (Interview 3)
Bea:	• '*disappointed by the quality of* candidates' (email: 14/12/2014) • '*Five colleagues are non-specialists'* (Interview 3) • '*HOD is a primary teacher'* (Interview 3)

Anna:	• '*In fact, I was recently contacted by a school who, knowing I had retrained in maths, asked me to apply for their long-empty post as Head of Maths*' (Interview 2) • '*we had no applicants the last time* we advertised' (Interview 3) • '*We are looking for a KS3 coordinator with no luck as yet'* (Interview 3) • '*We are really struggling to recruit'* (Interview 3) • '*…you walk around the maths department and underlying - is the inexperience*… (Interview 3) • '*I was talking to a deputy head from another school in the city and I know he's got someone we were trying to recruit - so I said "how is he doing, you stole him from us" and he was like – "sorry but we were really struggling to recruit"'.* (Interview 3)
Katy:	• '*We are short of maths'* (Interview 3)
Cath:	• '*Was very comfortable teaching science and then it's suddenly I am asked to teach maths - there was no one else…'* (Interview 3)
Euan:	• '*There is still a question mark over the quality of some of the teachers'* (Interview 2).
Janet	• '*a vacancy became available for a maths teacher and, as the department was at crisis point, I was asked to fill some 'holes''* (Interview 1) • '*There's better ways of getting around the shortage of teachers…make the job more attractive for people to want to do it…I think that teaching is held in quite low regard in general…'* (Interview 1)

Table 6.2 Comments from Participants Regarding the Shortage of Mathematics Teachers

In regard to what would constitute a *suitable* candidate for a vacant post, the participants shared their views regarding 'effective' mathematics teaching, and this is considered next.

6.2 Effective Mathematics Teaching

The definition of effective mathematics teaching can vary enormously – and is discussed in detail in Chapter 2. However, there was much consensus amongst the participants concerning traits of an effective practitioner, including being able to: engage and motivate students; explain clearly; build confidence and be supportive. In fact, most participants reflected ideas and definitions (concerning effective practice) highlighted in the literature review (Chapter 2) and often discussed during the retraining. Table 6.3 highlights some of the participants' views.

	Effective mathematics teacher… (EFF)	Top 5 attributes* for effective mathematics teaching: **Prior to retraining**	Top 5 attributes* for effective mathematics teaching: **Post retraining**
Harvey	'*I think cos of the teachers I've seen … they're born rather than created because I see good teachers and when you try and replicate what they do it's incredibly difficult because what works for them doesn't necessarily work for you …* (Interview 1) '*enthusiastic… which is another reason probably more born than taught into you'* (Interview 1) '*…competent and comfortable with mathematical knowledge'* (Interview 2) '*…not to struggle with the content'* (Interview 2)	1. Explains clearly 2. Well prepared 3. Excellent subject knowledge 4. Sets challenges 5. Patient	1. Patient 2. Excellent subject knowledge 3. Explains clearly 4. Sets challenges 5. Well organised
Darcy	'*… someone who can have a laugh with children, be friendly and approachable and be organised which I think are skills that [you] are born with.'* (Interview 1) '*With that you need to have your subject knowledge…'* (Interview 1) '*…enthusiasm that desire to work with kids…'*(Interview 1) '*not - a lot of didactic teaching - and here's your exam questions - here's your textbook…*' (Interview 1) '*effective maths teacher is someone who gets the kids wanting to learn …'* (Interview 2) '*someone who is able to get the students to have enough information for where they want to go which is initially obviously that exam paper in Y11'* (Interview 2)	1. Well organised 2. Enthusiastic 3. Approachable 4. Explains clearly 5. Patient	1. Explains clearly 2. Encouraging 3. Enthusiastic 4. Patient 5. Well prepared
Bea	'*... you can make good teachers but truly outstanding teachers have something special'* (Interview 1) '*I think I will have been an effective maths teacher if my children look at a GCSE question in the middle of an A3 piece of paper and talk about how they solve it and ultimately that would be nice if they came to an answer, what would be really nice if they came to the right answer.'* (Interview 2) '*people who are engaged and interested in the subject are engaging and interesting to listen to.*	1. Enthusiastic 2. Patient 3. Explains clearly 4. High expectations 5. Encouraging	1. Excellent subject knowledge 2. Explains clearly 3. Patient 4. Well prepared 5. Enthusiastic

	Lessening (but perhaps not negating) the need for 'props" (Interview 3) *'so it's about having confidence in your subject knowledge and confidence in your relationships with the kids'* (Interview 3)		
Anna	'*someone who can engage with students'* (Interview 2) '*I think if you've got the ability to engage them and get them to even question the maths - I think that's effective.*' (Interview 2) '*really engage them with the maths, get them to problem solve, that's my effective maths teacher'* (Interview 3) *'to feel really confident with subject knowledge'* (Interview 3)	1. Well prepared 2. Encouraging 3. Explains clearly 4. Supporting 5. Enthusiastic	1. High expectations 2. Sets challenges 3. Supporting 4. Enthusiastic 5. Encouraging
Katy	'*somebody who is knowledgeable, who understands, who can facilitate - pulling together of ideas …and be able to discuss them knowledgeably'* (Interview 2) *'… you know - it doesn't have to be the answer you have got, necessarily. I think being a good maths teacher is recognising that as well, rather than discounting what doesn't fit your idea of an answer'* (Interview 2) *'… but actually you have got to have a better knowledge than the level you are teaching to be able to unpick their misconceptions… knowledge needs to be deep… it is harder to teach struggling students…'* (Interview 2) '*Having that confidence in problem solving...' (*LO6) *'I see teachers teaching students in rows with very much chalk and talk – it's not right – just telling.'* (Interview 2) *'you need to be comfortable - at ease - with all the maths - to know where to go,where to get them, how to provoke…'* (Interview 3) *'it's - and this is different in maths, than perhaps anywhere else - it is those point where children say - oh, I get it now, or I can do it now - which you don't really get in any other subject - the nature of it perhaps - it is recognising those moments perhaps where - and trying to find out what it was that you did or the class do that made the child say - I can do it now'* (Interview 3)	1. Approachable 2. Patient 3. Explains clearly 4. Well prepared 5. Excellent subject knowledge	1. Excellent subject knowledge 2. Enthusiastic 3. Explains clearly 4. Patient 5. Approachable
Cath	*'maths knowledge'* (Interview 1) '*I think an effective maths teacher is someone you can build confidence in all their learners and is someone that is making everyone feel safe…'* (Interview 2) *'…all those classic things that the learners I receive haven't had at all - feeling safe in the classroom, not having to hide their mistakes um being clueless in room, not knowing what to do, no practical activities. I am trying really hard to be that effective maths teacher'* (Interview 2)	1. Explains clearly 2. Excellent subject knowledge 3. Encouraging 4. High expectations 5. Supporting	1. Explains clearly 2. Excellent subject knowledge 3. Sets challenges 4. Encouraging 5. Supporting

	'*I put it on the wall - that list [effective maths teacher] - cos I love it and I think it's true.*' (Interview 2) *'Mistakes and errors - picked up on and used as teaching points…'* (Interview 3)		
Euan	'*Um - I think an effective maths teacher, in simple terms, is someone who can get children enthused in the subject…'* (Interview 2). *'…then yes [you] need to be able to actually deliver the content'* (Interview 2) '*to be able to teach it, not just being able to do the maths…'* (Interview 2) '*It isn't the standard [practice] - as in literally get your books out, copy what is on the board do these exercises that sort of lesson…'* (Interview 2) *'…gets them involved in the lesson…'* (Interview 2) *'chalk and talk would turn off the vast majority of students from maths if you taught that way'* (Interview 2)	1. Supporting 2. Enthusiastic 3. Patient 4. Approachable 5. High expectations	1. Enthusiastic 2. Approachable 3. Explains clearly 4. Patient 5. Encouraging
Janet	'*somebody who could make a student want to turn up to the lesson and learn and go away thinking I really enjoyed that'* (Interview 1) '*exceptional subject knowledge…'* (Personal reflections) *'an effective teacher has a more holistic view of maths'* (Personal reflections)	1. Well prepared 2. Well organised 3. Patient 4. Enthusiastic 5. Encouraging	1. Excellent subject knowledge 2. Well prepared 3. Well organised 4. Explains clearly 5. Enthusiastic

Table 6.3 Comments from Participants Relating to Effective Mathematics Teaching

* From Mathematics Attitude Questionnaire: Participants were asked to choose 5 attributes, in order of importance, which are key qualities of an effective mathematics teacher, from: *Sympathetic; Humorous; Patient; Strict; Well prepared; Explains clearly; Hard-working; Friendly; Excellent subject knowledge; Enthusiastic; Kind; High Expectations; Approachable; Encouraging; Punctual; Well organized; Respected; Sets challenges; Supporting*

From the table above (Table 6.3) it can be seen that all the participants, at various junctures, mirrored Kay's reflection that to be effective '*it is essential to know your subject well'* (Katy, Personal reflections), a point definitively made by Rowland and Ruthven (2011). The issue of subject knowledge (and lack of it) does in fact appear to be one of the most significant themes arising from this research. This theme, along with several other interconnecting themes, are each discussed in turn in the next section.

6.3 Themes Arising from the Study

The six themes are analysed below.

6.3.1 Subject Knowledge

All participants believed their subject knowledge improved as a result of retraining (see Table 6.4 below). However, concerns surrounding issues with subject knowledge remained evident for all but one of the participants (the exception, Bea, having previously been a physics teacher); comments in Table 6.5 illustrate this.

<table>
<tr><td></td><td>Responses from Subject Questionnaire for Mathematics 1:

Use 1-5 scale (below) to give an indication of your mathematical competence ON EACH of the 29 TOPICS
1. Excellent Understanding: (I am confident and proficient in all aspects of this topic)
2. Above Average: (I am reasonably confident with this topic, but with some gaps)
3. Average: (I have a reasonable understanding of the basics of this topic, but need lots of help with more challenging questions)
4. Below Average: (I can just about cope with the basics of this topic, but need a lot of help)
5. Poor Understanding: (I really do not know much about this topic at all)</td><td>Responses from Subject Questionnaire for Mathematics 2:</td></tr>
<tr><td></td><td>(i) at the start of the course</td><td>(ii) at the end:</td></tr>
<tr><td>Harvey:</td><td>73</td><td>37</td></tr>
<tr><td>Darcy:</td><td>50</td><td>43</td></tr>
<tr><td>Bea:</td><td>51</td><td>40</td></tr>
<tr><td>Anna:</td><td>87</td><td>45</td></tr>
<tr><td>Katy:</td><td>113</td><td>58</td></tr>
<tr><td>Cath:</td><td>51</td><td>39</td></tr>
<tr><td>Euan:</td><td>57</td><td>41</td></tr>
<tr><td>Janet</td><td>95</td><td>71</td></tr>
</table>

Table 6.4 Participants' Self-Reported Responses to Subject Questionnaire for Mathematics SKE+ Evaluation (see Appendix J)

A criterion for applicants for the government funded retraining SKE+ course (GOV.UK 2016b) was that they had no prior formal mathematics qualifications or training at degree level; many (perhaps the majority?) had a GCSE as their highest previous qualification. With no consensus in the research community on what, or if, mathematical qualifications are important (see 2.3.1, Rowland and Ruthven 2011, Davis and Simmt 2006), Janet suggests: '*a good mathematics A-Level is required*' to be able to teach mathematics at GCSE; failing this '*exceptional subject knowledge at GCSE'* could suffice if one was skilled enough '*in order to "look back" at these concepts';* Janet believes teachers *'learning up to A* GCSE material is not a viable option'* (Personal Reflections, September 2014). Janet's thoughts may resonate with the idea of teaching knowledge involving the explicit 'unpacking' of mathematical ideas (Ball and Bass, 2000); Janet was still focussed on *doing mathematics* for herself – with no 'unpacking' possible.

Janet is clear that her subject knowledge is insufficient, and so arrives at the realisation she would never become a proficient practitioner; she lost the confidence she could be '*good*' (Personal Reflections). As Janet clearly articulated, confidence to teach mathematics appears to be closely linked with subject knowledge: as subject knowledge increased so too did general confidence and self-efficacy. Being immersed in teaching the subject had a similar effect: as immersion increased (through involvement with the retraining course and teaching several mathematics classes) confidence increased; as it waned (as the course became more distant) confidence and self-efficacy deteriorated. The significance of subject immersion, to develop high levels of subject knowledge, is recognised by Garet *et al* (2001).

	Subject Knowledge… (SK)
Anna:	*'My worry is - can I always stretch the top ability' (Interview 2)* *'it has been nearly 10 years since I had done any maths' (Reflections on Course)* *'I need to try and stay one step ahead' (discussion following LO4)* *'I need to think what is in a GCSE question - the end point' (discussion following LO4)*
Bea:	*'that picture up there [poster showing connections between all mathematics topics] - that is my scheme of work' (Interview 3)*
Cath:	*'I want to self-check on my knowledge, my maths knowledge.' (Interview 1)*
Darcy:	*'the first course it was a bit of a must for me - moving across and my maths knowledge was very - I could do it - but I couldn't necessarily teach it.' (Interview 3)* *'because that was the point when I needed to go back to the A / A* stuff - that we had done because I haven't done that stuff myself because I only did the intermediate' (Interview 3)*
Euan:	*'not 100% sure on my terminology' (discussion following LO3)* *'Interesting, I thought I was really good at algebra...but quickly found myself with a lack of vocabulary!!! Could do the maths, but needed to ask to be able to teach it' (Interview 2).*
Harvey:	*'…and [unsure of] how topics seem to relate to each other' (Interview 1)* *'I can now see the, ah - when people finish I know what extensions because of my increased subject knowledge.' (Interview 2)* *'Subject Knowledge has gone up, confidence has gone up - so I can try things - and I am willing to let them [students] try' (discussion following LO4)* *'The bigger picture is coming…' (discussion following LO5)*
Katy:	*'Having that breadth of knowledge - not having it - it's really limiting' (Interview 2)* *'But [to be an effective teacher] - you need to be comfortable/at ease with all the maths - to know where to go/where to get them/how to provoke' (Personal Reflections)* *'One of the things we covered this session was negative numbers and I know that this is one of the concepts I really struggle with. I will have to practice using them in a variety of applications.' (Personal Reflections)* *'At some point I will return to the higher level content, but for the immediate future I need to ensure I'm secure in the knowledge I already have and start thinking of interesting and engaging ways of presenting the information.' (Personal Reflections)* *'A colleague, in an effort to reassure me, said that sometimes teaching content that you have freshly learnt helps you to explain it in a more accessible way.' (Personal Reflections)*

	'…they [students] really don't like it if I don't know whether something is right or wrong' (discussion following LO3) *'Need to learn and do maths myself' (Interview 2)* *''I feel like If I had a bit more knowledge when I started ….Too traditional perhaps. I look at a question and I try and do what it asks. I don't see other ways…/around it…Having that confidence in problem solving.' (discussion following LO6)* *'New knowledge – a great feeling, it has given me a new lease of life in my teaching' (Personal Reflections)*
Janet	*'there are others who have a much better subject knowledge that takes the knowledge completely outside my sphere.' (Personal Reflections)* *'Much of the subject knowledge … is outside of my reach and I have realized that without either a) exceptional subject knowledge at GCSE or b) some knowledge above GCSE level in order to 'look back' at these concepts, I cannot begin to comprehend them by 'learning up' to A* GCSE.' (Personal Reflections)* *'The [school] feedback was on my lack of Maths subject knowledge.' (Personal Reflections)*

Table 6.5 Comments from Participants Regarding Subject Knowledge

Significant deliberate practice and immersion in the subject domain are key in determining expertise (Berliner 2001); Berliner (2001) argues that adaptive and fluid expertise are core attributes for effective teaching, and reaching a level of automaticity relies on acquiring rich subject knowledge through such practices. Others agree (Ericsson and Pool 2016, Wiliam 2016, Stobart 2014, Covin 2009, Stigler and Hiebert 1999) – and this is discussed in more detail in Chapter 2.

Immersion and deliberate practice were limited for the retrained teachers - with only 100 hours of face-to-face sessions combined with a similar commitment to the e-learning element of the course. Comparisons can be made with typical pre-Initial Teacher Training (pre-ITT) Subject Knowledge Enhancement (SKE) courses which may provide up to 600 hours of subject immersion (for example, at Bath Spa University), this prior to PGCE training which will entail further study of mathematics. Both types of retraining courses are intended to provide non-specialists (those without a mathematics, or mathematics related, degree) sufficient training to be able to become mathematics teachers. It remains questionable whether the post-ITT retraining, experienced by my participants, provided sufficient subject immersion.

All of the participants successfully completed the e-learning on-line tests achieving merits or distinctions. These tests are deliberately engineered to be developmental – with participants encouraged to attempt each test as many times as they wished with only the highest score being relevant. It is unascertained as to how well these test results reflected secure subject knowledge; Euan summed this up, noting that with some topics '*I had forgotten a lot of it since doing the on-line tests*' (Personal Reflections, November 2014). This raises questions regarding the retention and comprehension of subject knowledge – and what can safely be assumed from the on-line test results. Nevertheless, without exception, all the participants proudly 'own' and display their 'Certificates of Mathematical Mastery'. This is exactly what Crisan and Rodd (2011) discovered (see 2.4.2): certification was seen to be very significant amongst their participants with accreditation affording teachers the potential of enhanced opportunities. Certification may also validate their sense of belonging to the community of mathematics teachers (Wenger 1998) – with participants now feeling '*qualified*' to teach mathematics (Darcy, Interview 3).

Increased confidence can be seen to have enabled all the participants to start to develop their mathematical teaching pedagogy, moving away from a predominantly '*chalk and talk*' and '*just telling'* (Euan, Interview 2) approach to a style more rooted in students developing understanding for themselves. Key to this is of course the teacher's own subject knowledge and understanding, so as this develops so too does their scope to develop understanding in their students. The TALIS Video Study (OECD 2016b) describes this progression as one of teachers moving from understanding ‘how’, to understanding ‘why’; the former focussing on methods, procedures and processes, the latter encompassing conceptual understanding and learning goals. This distinction was described by Skemp (1976) in terms of ‘instrumental’ and ‘relational’ understanding (see 2.2.2). Comments from participants, shown in Table 6.6, indicate their pedagogical perceptions and their views in regard to their developing practice and their changing attitudes. The comments illustrate a growing appreciation of the need to make connections, to be able see what is coming next (‘horizon knowledge’ (Ball *et al* 2008), see 2.2.2), to use and unpick misconceptions in their teaching and to be able to respond to students’ real-time needs (Mason and Spence, 1999, see 2.3.2). Much of this is captured in the ideas of different forms of knowledge, suggested by the ‘Knowledge Quartet’ (Turner and Rowland 2006) - discussed in Chapter 2. Having further developed their ‘foundation knowledge’, all the participants could be seen attempting to use ‘transformation knowledge’ in terms of the choice of examples and explanations offered (Turner and Rowland 2006). ‘Connection knowledge’ and ‘contingency knowledge’ (Turner and Rowland 2006) proved more difficult: having wide enough knowledge to make connections to promote conceptual understanding and being able to view students’ interjections as teaching opportunities and to use them in in real-time, proved challenging for most of the participants. Lack of this ‘web of interconnections’ (Davis and Simmt, 2006: 301) may have limited the participants’ effectiveness of teaching. Participant comments pertaining to pedagogy are shown in Table 6.6.

	Mathematical pedagogy… (PED / SK)
Anna:	*'I wanted to develop my pedagogy'* (Interview 1) *'My only experience of maths teaching was stand at the front here is a method and get going. Now when I started teaching maths last year, last September, I knew that is not how I wanted to teach - it's not how I teach Science. But I didn't know how to teach maths differently.'* (Interview 2*)* *'So I did try and teach in my science way but I didn't always feel like the students could get what I wanted them to get …I didn't have the knowledge of how to teach things.'* (Interview 2) *'…this September I feel that the kids have got more of a handle on what I want to get at - and they're exploring things, playing with things, exactly how we do it on the course, rather than me saying here's a rule and here's 10 questions'* (Interview 2) Describe the teaching of a perfect maths lesson: *'Students being engaged from the start, problem solving and unpicking the maths independently. They would be sharing ideas and discussing the methods they have used to get the answer.'* (Reflections on Course)
Bea:	*'I am way more sure that I am right and that maths should be taught holistically'* (Reflections on Course) Describe the teaching of a perfect maths lesson: *'A hard question on the board that challenges the kids to think, to make links. Students that then tackle that problem with courage and tenacity; making mistakes, pushing the boundaries, trying a method that fails and then going at it again. Very little in books except stuff that helps them revise later on.'* (Reflections on Course)
Cath:	*'Um - I think I feel I'm on a journey, a bit of a journey and actually I can see where I'm going to get, I want to be like that teacher on the video, I can see glimpses of it starting in me, in the way I plan, and idea for an activity or investigating a misconception where I would never have done that before.'* (Interview 2) *'When someone would give the wrong answer I would think – "no that's not what I'm looking for, someone give me the right answer and then we can move on" -* *but now I'm prepared to say we won't learn unless we can work out how you got that and let's talk about how you got to that answer.'* (Interview 2) *'… in terms of making it rich and pedagogy, that's where I need developing'* (Interview 3) Describe the teaching of a perfect maths lesson: *'Light bulb moments. All engaged. More confidence developed in learners. Active learning. I'm not there yet but I know what I'm aiming for.'* (Reflections on Course)
Darcy:	*'…um cos I have had to relearn everything almost and I would like to think that this helped me and my teaching because I have had to learn it.'* (Interview 2) *'All my year 11 classes are working for their resit in November so my priority is to get from D's to C's. Whilst I would love to take them out on the tennis courts and do your shaving foam with string which I know would sit in their head …in my head I'm thinking okay I've only got x many lessons before the exam … I just feel there isn't that time. And even in the KS3 lessons - you know we have the scheme of learning where you are told do you this in three weeks, do this in four weeks…'* (Interview 2) *'ultimately it's about being able to teach isn't it. You can have the greatest*

	knowledge in the world but if you can't get that knowledge across to the children then I would argue it's a bit pointless because you've got to be able to teach to them and give them the skills that they need that to then understand it.' (Interview 3) Describe the teaching of a perfect maths lesson: *'Kids coming in enthused about the lesson. Engaging in starter from the off, discussing ideas and concepts. Topic for lesson explained, kids helping one another, discussing and moving onto more challenging questions. Link to GCSE/grades. Pupils aspiring to do as well as they can.'* (Reflections on Course)
Euan:	*'With 'chalk and talk', I think certain students could still learn but I think you would turn off the vast majority of students from maths if you taught that way.'* (Interview 2) *'…there is definitely - there is less behaviour management and that sort of thing you need to employ and there is more enthusiasm with kids to learn it in general so yes it does make a difference.'* (Interview 2) *'And again with those time constraints, you know, you might fall back on the old chalk and talk sort of thing.'* (Interview 2) Describe the teaching of a perfect maths lesson: *'Fun. Practical activities, not obsessed with meeting lesson-by-lesson objectives, use of ICT, Videos, Music, etc. Go "outside" the curriculum with ideas or student wishes. Get students to lead parts of the lesson. Use real-world problems wherever possible.'* (Reflections on Course)
Harvey:	*'… as my subject knowledge has improved I feel more confident in doing different types of activities as well whereas it would have been before out of the book or off one website am happy to do a whole range of activities.'* (Interview 2) *'I understand how to do that because I know about misconceptions, knowledge that I have gained from the course'* (Interview 2) *'…making more connections - definitely of what impacts on what in the curriculum and where it goes'* (Interview 2) *My teaching style is changing from chalk and talk towards a more discovery method.'* (Reflections on Course) *'Whereas before I did not understand the level of learning … I believe I have a much stronger understanding know and push the students to aspirational targets. I still, sometimes, take the learning too far when I should stop at a logical point and reinforce what they have learnt but that is part of my own learning.'* (Reflections on Course) *'I am starting to notice the common misconceptions and can avoid them.'* (Reflections on Course) Describe the teaching of a perfect maths lesson: *'Hook of a starter, real life would be good, main body of lesson would be problem solving with a lot of guided discovery. I would then want to reinforce knowledge and set home study'* (Reflections on Course)
Katy:	*'it's about the difference between something being taught and something being learned'* (discussion following LO2) *'Got really excited the other day when a learner got something wrong - because I UNDERSTOOD WHY she was getting it wrong. I can EXPLAIN this to you'* (discussion following LO3)

	'I'm going to do it this way and expect the students to think…' (discussion following LO4) *'… but actually you have got to have a better knowledge than the level you are teaching to be able to unpick their misconceptions… knowledge needs to be deep… it is harder to teach struggling students… Need to learn and do maths myself'* (Interview 2) *'it is one thing to understand something but it is quite another to help someone else understand it - um - I don't want to be seen as a fraud, I want to be seen as a facilitator'* (Interview 2) Describe the teaching of a perfect maths lesson: *'Less emphasis on chasing students for non-attendance and sorting out admin issues and more emphasis on sharing ideas and discussing…developing understanding'* (Reflections on Course)
Janet	*'until you know your subject knowledge really well and kind of sticking to the tried and tested, speaking at the front, chalk and talk work out of the text book kind of thing which isn't the way I want to teach but it's the way at the moment I'm just building the base at the minute - it's not where I want to end up.'* (Interview 1)

Table 6.6 Comments from Participants Regarding Pedagogical Perceptions

Opportunities to use student misconceptions to promote deeper thinking and questioning were frequently missed, as too were students challenging questions or unexpected responses. Similarly, not seeing how to connect or link lessons or topics was very common. Participants also expressed concerns about not knowing how to extend or differentiate for higher attaining students – and most struggled with the level at which to pitch the mathematics, usually erring on the side of too easy. Berliner (2001: 470) refers to the 'degree of challenge' as the feature which most discriminates between expert and non-expert teacher, this being dependent on deep subject knowledge.

In scenarios where the subject knowledge was not secure, teaching and learning often appeared to be compromised. Usually this manifested itself with teachers teaching from a textbook or PowerPoint script, wholly maintaining control of the material, being unresponsive to questions and/or misconceptions posed by the students and requiring students to engage in significant clerical activities such as copying from the board. As Wragg (2012) has highlighted, teachers without expansive subject knowledge may feel the need to keep control over the lesson by imparting information and limiting student discussion. William and Bartholomew (2001) suggest that those who are least well-qualified to teach mathematics, have 'lower expectations of their students, frequently set work that was undemanding (often just copying off the chalkboard), used a narrower range of teaching approaches and hardly ever responded to students' frequent requests for more demanding work' (2001: 285). At times, most participants mirrored this type of teaching behaviour: Anna when she taught her lower attaining Year 10 groups; Darcy when she favoured teaching didactically; Euan with his behaviorally challenging Year 10 group; Harvey when he found his subject knowledge lacking with older pupils, when he struggled to identify appropriate extension work (questioning how he '*could better manage the very able pupils*' (discussion following LO1)) and when he moved to his 'new' school; Janet who knew no other way than to teach by '*chalk and talk'* (Interview 1); Katy who liked to stay in control at the front of the class, when she feared subject knowledge weaknesses being exposed.

The retraining (and associated mentoring – see 6.3.2) enabled the teachers to identify where they could begin to develop their pedagogical practice. Euan noted he needed to relinquish some control; Bea and Cath referred to the idea of doing more '*real-time'* (Bea, Interview 3) or '*live*' teaching (Cath, Interview 3); Darcy acknowledged the need to assimilate the Higher GCSE content, and improve her knowledge of terminology*;* Anna wished she could employ a more '*guided-rediscovery*' approach (Interview 2); Katy wanted to introduce more '*problem solving'* (Interview 3); Harvey was keen to teach less didactically and explore using different tasks and activities; Janet wanted to move away from '*teaching to the text'* (Interview 1).

The issue of task and resource selection was an interesting one. The participants were particularly keen to move away from the sole reliance on textbooks (a practice clearly seen in Janet's case) which as Cockcroft (1982) points out is a practice from which 'few pupils are able to learn satisfactorily' (1982: 91). (Instead concepts should be introduced by 'appropriate oral and practical work and the necessary links with what has gone before established by discussion' (Cockcroft 1982: 91)). Nevertheless, a good textbook could provide invaluable support (Cockcroft 1982), and be especially relevant for retrained teachers with limited mathematical subject knowledge. The support textbooks and other resources can provide, for teaching and learning, has been recognized by Rowland and Ruthven (2011) with gains in subject knowledge and PCK evident. Hodgen (2011) points out there is 'certainly an urgent need to examine how textbooks and other materials can best support teacher knowledge' as 'there is a great deal of evidence that materials on their own are insufficient' (2011: 38).

Harvey (in interview with Hedger 2014) commented: *'the course resources are easy to access and are of high quality'*; Darling-Hammond (2014) highlights the significance of reputable resources and the role they can play in enhancing teacher effectiveness. However, many of the participants referred to the efforts required to plan lessons and '*trawl*' (Cath: Interview 3) for useful resources, once the course was complete. For some, this time 'cost' (of planning and hunting for resources) and learning '*new ways of doing things'* (Janet, Interview

2) created significant anxiety (Cath, in particular), and for others explained the rationale for sticking solely to text book questions: '*this is how you do it, use the text book, purely because of the time constraints*' (Janet, Interview 1). The use of seemingly inadequate resources was often observed, for example during Darcy's probability lesson (LO7) when Darcy appeared not to be able to determine the difference between combinations and permutations; she did not identify the chosen internet resource as inappropriate (LO7). Similarly, Anna could not distinguish between 'expressions' and 'equations' and selected equally questionable resources from the internet (LO5); Anna's use of a series of misleading resources confused many of her students (LO6). Harvey appeared oblivious to the demands of the selected histogram resource - which left many students floundering - failing to identify that histograms with unequal class-widths pose different issues (LO2). The comment from Janet (and echoed by Euan) also typical: '*The pupils I teach work at a far lower ability so I cannot take the resources straight from the SKE+ course'* (Personal Reflections), articulating the restricted scope of many, to adapt and edit resources and activities. Hiebert and Wearne (1993) propose that 'what students learn is largely defined by the tasks they are given' (1993: 395), and Watson and Mason (2007) suggest the adaptation of tasks can be a mathematical enterprise. A 'task' may be defined as 'anything that a teacher uses to demonstrate mathematics' (Watson and Ohtani 2012: 4) and includes the use of instructional materials. Ball and Bass (2005) point out that 'how well teachers know mathematics is central to their capacity to use instructional materials wisely' (2005: 14). Whilst planning, as well as in teaching, 'teachers must show awareness of students' conceptions and misconceptions about a mathematics topic' (Petrou and Goulding 2011: 22).

Being able to distinguish mathematically rich resources from those which simply seem attractive or appealing appears to be a subject-knowledge related task which many found difficult. As a result, inadequate resources were sometimes employed. The evidence - from both literature and the data - suggests that subject knowledge can impact on task and resource selection and application.

Limited subject knowledge also appeared to be revealed in a variety of other ways. Darcy and Euan frequently referred to inadequacies of their terminology; this appearing to limit both their teaching and their students' learning. Thames (2006) agrees: 'Mathematical language has a function and logic' and teachers need to 'speak and write mathematics correctly' to promote mathematical sense making (2006: 11). Anxiety was often referred to, in terms of being nervous or fearful of getting things wrong in front of students. Katy described her apprehensions as experiencing '*white noise'* whilst trying to *'perform'* in front of students (Interview 2). The most likely cause of the many anxieties experienced by the participants was a lack of automaticity with the subject. Automaticity frees up the brain but is more than being just about efficiency (Bereiter and Scardemalia 1993). Automaticity allows cognitive resources to be 'reinvested in other and higher-level cognitive activity' (Berliner 2001: 474). In other words, if a teacher does not need to worry about the actual mathematics, they can focus on the reactions of the students, monitoring and responding to student engagement, motivation, progress and needs: misconceptions and questions can be handled with ease. Fenstermacher and Richardson (2000) describe this teaching as 'learner-sensitive' (2000: 15). Cath and Bea made references to adaptive '*live*' and '*real-time*' teaching which resonates with the ideas of this learner-sensitive pedagogy. For automaticity to develop, substantial deliberate practice and immersion with the subject - and within the teaching of the subject - are required for the rapid accumulation of subject and pedagogical content knowledge (PCK) (Ball and Bass 2000, Ericsson and Pool 2016, Wiliam 2016, Stobart 2014, Covin 2009, Stigler and Hiebert 1999).

Some of the participants were immediately immersed in teaching mathematics, while for others this was not so. In general, the experiences of the participants suggest the more mathematics teaching they undertake, the better their progress; in particular, having the opportunity to teach parallel groups in the same school year (allowing for instant adjustment, polishing and refinement of the subject content – to the benefit of students in the second group). Berliner (2001) highlights a similar finding, with student teachers preferring to 'teach the same thing twice' giving them an opportunity to improve and 'polish' their practice (2001: 474).

Anna: *'I think if I were more immersed in the Maths and was able to reflect on my practise more regularly then it would have helped but I was teaching two classes, different year groups and different specifications. If I had two classes in the same year group and was able to reflect, instantly, on the lessons and resources and adapt and re try them with the next class this would have improved my confidence massively.'* (email 2/9/2016)

Jacob and Rockoff (2011) also discovered that teachers who have the opportunity to repeat-teach similar lessons over and over again show the greatest improvements, and that teachers developed more quickly when they could focus on a narrow domain.

Immersion in teaching mathematics does suggest opportunity for substantial subject knowledge growth (Ball and Bass 2000, Berliner 2001, Jacob and Rockoff 2011). There does however seem to be one caveat: for teachers with the least subject knowledge and the least confidence, teaching full time mathematics may be too stressful for the teacher and too '*damaging*' for the students (Bea: Interview 4). Katy believed she would have been '*overwhelmed'* if she had more than one mathematics group at the outset, believing she simply did not have enough subject knowledge to plan for, and engage with, more than one group (Interview 3); similarly so, for Janet. Both Anna and Euan initially noted they were appreciative to have only one mathematics group on which to focus, but later believed being immersed in teaching mathematics would have been a far more productive experience otherwise as Euan articulated, it would take 5 or 6 years to accrue the same experience as a fulltime mathematics teacher would accumulate in a single year. Anna did express her concern that the increased demands of being immersed in teaching mathematics would result in a deterioration of her lesson plans; support and additional time for planning could provide a solution. Bea was a strong advocate for immersion, believing you learn best by teaching it. She did however temper this stance with her concerns for students; if a teacher is '*not very good at it'* a lot of students could be badly affected (Interview 3).

Janet and Katy started the retraining with the least subject knowledge; both felt they would have been undone by teaching too much too soon. The others believed they benefited, or would have done so, by being immersed in teaching the new subject. Perhaps then there is the idea of a subject knowledge threshold – a minimal level needing to have been met – before a teacher could 'graduate' to immersion, Katy doing exactly this, immersing herself in teaching mathematics in her *second* year post-retraining.

From the ‘six components of great teaching’ (Table 2.8) identified by Coe et al (2014), ‘Pedagogical Content Knowledge’ and ‘Quality of Instruction’ were seen to exercise the greatest impact on student outcomes. All participants reported the retraining provided opportunities to develop their subject knowledge and their mathematical pedagogy. Orchestrated activities were designed to support the quality of instruction, with opportunities to: observe others teach; plan together; present; team-teach; share resources; give and gain support by way of an informal network; access and debate current research. Teaching by ‘problem solving’ was seen to be new to many, as too was recognising the significance of connecting mathematics to real-life contexts and the linking of topics together. All the participants professed to be motivated and enthused to further develop their practice once the course had concluded. Reflecting whether there was any conflict between the pedagogical style promoted on the retraining and the pedagogical practice ‘expected’ in their school was commented upon by all on the ‘Reflections on Course’ feedback. These responses are discussed in section 6.3.5.

Several suggested that the retraining could accelerate their development as practitioners by highlighting typical teaching problems and potential pitfalls. Effectively managing common student misconceptions was believed to be one such example, this being something Janet recognised could ordinarily take years of practice. Katy described a key ‘*strength*’ of the retraining as one of being able to move away from a ‘*just telling*’ approach towards a more engaging, interactive modus operandi (Interview 3). Cath describes being released from having to ‘*tick off a list of objectives’* (Interview 3) and being enabled to move towards more meaningful mathematical experiences. Coe *et al*

(2014) agree with all that the participants have identified, pointing out that the most effective teachers have deep knowledge of the subjects they teach, are wise to the worth of students' struggles and can recognize and unravel students' common misconceptions. Identifying students' 'common misconceptions and act to ensure they are corrected' is a grade descriptor used to describe the quality of teaching and learning as outstanding (GOV.UK 2018b: 53); the JMC (2017) suggest 'Recognizing and working with errors and common misconceptions' is a key feature of effective mathematics teaching.

Without exception all the participants appeared to embrace the ethos of teaching for understanding and to promote deep thinking – the retraining providing the catalyst to provoke their interest. Some teachers were able to enact this style more successfully than others. All agreed secure subject knowledge to be essential for this approach but for some this was a tricky obstacle and for Janet, an insurmountable barrier. Providing sustained subject support after the completion of a retraining programme seems an essential step. Watterson from the National College of Teaching and Leadership (NCTL) seems to agree: '*we certainly don't think that the subject knowledge journey should end when TSST training is complete and we are keen to promote a range of professional learning opportunities*' (conversation with Watterson 2016). Without such continued subject support, further teacher development could be curbed.

Other catalysts and barriers, promoting and limiting professional development, are discussed within the following themes.

6.3.2 Mentoring and Coaching

Drawing on all the literature outlined in Chapter 2 (2.3.3), mentoring and coaching were delivered in a style very similar to that summarised by the 'six principles' presented by Coe *et al* (2014: 5). These are illustrated in Table 6.7. (The sixth principle was obviously beyond my control, but is discussed in section 6.3.4)

1	the focus is kept clearly on improving student outcomes
2	feedback is related to clear, specific and challenging goals for the recipient
3	attention is on the learning rather than on the person or to comparisons with others
4	teachers are encouraged to be continual independent learners
5	feedback is mediated by a mentor in an environment of trust and support
6	an environment of professional learning and support is promoted by the school's leadership

Table 6.7 Six Principles for Mentoring and Coaching (Coe *et al* 2014)

All the participants reported a strong positive response to the mentoring and coaching experience and all considered it to be very helpful for the development of their practice, as highlighted by comments shown in Table 6.8.

	Response to Mentoring and Coaching… (M&C)
Anna:	. *…really appreciated the visits and feedback* (following LO4) . *It is nice to have the time to set aside to be so reflective and Naomi is impartial to the school so there is no pressure.* (Feedback-on-feedback2) .
Bea:	. *Thank you for being my inspiration* (email 22/1/2015) . *I think the confidence I have gained as a consequence of going and having those conversations with you, the department wouldn't be as it is*

	(Interview 3)
Cath:	. *I am very keen for any [ongoing] advice, help, support, input* (post LO1) . *even though observations do you heighten your anxiety - ok less so because I know who you are and I feel really comfortable with you - I think it is still really important to get the feedback and to evaluate and reflect* (Interview 3) . *I am not getting the mentoring I need - no I don't get anything* (Interview 3)
Darcy:	. *It does make you think - actually you know maybe I shouldn't do that and you know - you can only ever learn from coaching and feedback* (Interview 3)
Euan:	. *It is a two-way conversation* (Feedback-onfeedback1)
Harvey:	. *This has been so beneficial it's unreal. Just having the conversations with someone who is non-judgmental, not in the department, with a wealth of experience, just come in and say what about this, what about that…* (Interview 3) . *it's been so nice for someone external coming in and seeing it, I mean you are the only one really that's seen me over the four years* (Interview 3) . *'the coaching role is fantastic, it is very supportive - and it does push you'* (Interview 3) . *There was precise instructions on how to improve and I could use this effectively* (Feedback-onfeedback1)
Janet:	. *An extremely good use of my time* (following LO1)
Katy:	. *It's about finding out what we can do in our day to day teaching that can really make a difference, rather than simply being judged. It's how all observations should be.* (Feedback-onfeedback1) . *…determined to change after the excellent feedback… I have been encouraged* (Feedback-onfeedback3 (from LO5)) . *You know it's stuff like that that is so valuable for me - the subject knowledge, the maths knowledge. And also different ways of approaching teaching it because - it is almost like there is a community and you are the facilitator to that by sharing what other people have done as well. It's just really, really valuable* (Interview 3) . *I need to feel secure when comments are given. That isn't to say no negative comments can be given, it just means that the comments are non-judgmental and fair.* (Interview 3) . *I do think that our rapport helps as I don't feel as vulnerable with you because you have seen 'my journey' (for want of a better phrase).* (Interview 3) . *when you first came in it was like - wow this is great because I can say whatever I like - it's a two-way discussion - and you are supporting me, it's not like you are criticising, you are not there to criticise, you are there to support and that is exactly what I got from it.* (Interview 3)

Table 6.8 Comments from Participants Regarding Mentoring and Coaching

Most teachers attempted to enact most of the ideas elicited from the sessions. Only Darcy, although keen to engage with observations and discussions, appeared unable or unwilling to truly embed suggestions into practice, doing so on one occasion only to 'please' me (Lesson Observation 7). Harvey was the only participant who had previously received any other mentoring or coaching related to teaching mathematics; none of the teachers received any support (other than from me) *during* or *post* the retraining programme.

The teachers received, from me, both written and verbal feedback. I set out to determine which format was more preferable but discovered only that both versions were valued; participants' comments (recorded on the Feedback-on-feedback forms) relating to this are listed in Table 6.9. Engaging in a verbal discussion immediately after the lesson enabled a two-way, inclusive, reflective process; the detailed written feedback, received a few days later, was valued for its longevity and as a point of reference. Both formats fulfilled Wragg's (2012) directive that if lessons are '*worth observing*' then they are also worthy of proper critique and feedback (2012: 2).

M&C:	Verbal feedback…	Written feedback…
Anna:	*It allowed me time to reflect on my lesson and the discussion was along the 'coaching' type and therefore I was able to notice areas to improve myself with her guidance.* Feedback-on-feedback1(from LO5) *It enabled me to see areas for improvement as Naomi spoke through the lesson with me, I could pinpoint areas where I could have allowed learning to progress at a higher rate.* Feedback-on-feedback1 (from LO5) *I was able to discuss my thoughts and Naomi was able to coach me through the lesson and I reflected on how to make it better.* Feedback-on-feedback1 (from LO5) *To be able to discuss ideas straight after the lesson and actually have a conversation about it, allows me to think through the lesson and together we are able to think of ways forward. I feel part of the process and not judged, where as if I were to receive the information in a written form and only in this form I may feel slightly anxious to read it back.* Feedback-on-feedback2(from LO6)	*It was spot on but I preferred discussing the lesson as I may not have reflected as well without it.* Feedback-on-feedback1(from LO5) *It allowed me to replay the lesson again in my head and it also spotted areas that I wouldn't have necessarily noticed myself.* Feedback-on-feedback1(from LO5) *I think if I were to just receive the written feedback I may not have thought about linking the lesson to other aspects of maths.* Feedback-on-feedback2(from LO6) *It is a permanent log, blow by blow, what happened in the lesson.* Feedback-on-feedback2(from LO6) *I wouldn't want to just get the written feedback* Feedback-on-feedback2(from LO6)
Bea:	*….it's a two way thing* Feedback-on-feedback1(from LO5)	*I can refer back to it!* Feedback-on-feedback1(from LO5)
Cath:		
Darcy:	*It is good to know straight after the lesson, but also have the written to refer back to.* Feedback-on-feedback1(from LO2)	*It's more detailed and I can read it and re-read it. I don't always remember the verbal!* Feedback-on-feedback1(from LO2)
Euan:	*It is a two-way conversation and can go beyond confines of a pre-determined list of topics/ points. Clarification could be sought on points made.* Feedback-on-feedback1(from LO3)	*It was forward thinking and constructive whilst also being an honest appraisal of the teaching seen.* Feedback-on-feedback1(from LO3)
Harvey:	*Immediate when all the "feelings" of the class were still fresh in my mind.* Feedback-on-feedback1(from LO3) *The verbal feedback seemed less formal so I was slightly more at ease with this and it did not in any way seem like a judgement on the observed lesson.* Feedback-on-feedback2(from LO4) *the verbal feedback allowed me to think deeper about the tasks and the possible issues relating to the tasks than I had previously done.* Feedback-on-feedback3(from LO5)	*….it gave me time to reflect upon the lesson and because it was written I can refer back to it over time to make sure that I improve* Feedback-on-feedback1(from LO3) *I felt that the written feedback added on to the verbal feedback issued directly after the lesson and combined allowed me to "polish" the lesson ready for use next time.* Feedback-on-feedback2(from LO4) *because it was written I had a chance to read the feedback several times and to really get to grips with what was being written. There was precise instructions on how to*

		improve and I could use this effectively. Feedback-on-feedback2(from LO4) *The written feedback was instructive and allowed me to develop my pedagogy.* Feedback-on-feedback3(from LO5)
Katy:	*…. It was immediate. It confirmed a lot of what I was thinking and left me with a clear goal as to how to improve any similar lessons. The atmosphere was relaxed and I felt comfortable asking questions and hearing the feedback despite it not being a good lesson* Feedback-on-feedback1(from LO3) *It was interactive and therefore an opportunity to share my thoughts and to gain specific knowledge on how to improve.* Feedback-on-feedback1(from LO3) *the verbal feedback was so good and helpful that it made me determined to develop my practice.* Feedback-on-feedback2(from LO3) *I preferred the verbal feedback as there was an immediate response to the points put across. We were able to develop ideas which gives me the impetus to develop my practice and try to think of different approaches that will benefit the learners.* Feedback-on-feedback4(from LO3) *I was embarrassed by my last lesson – so I was reluctant to reflect on it in any detail. I didn't want to go over what I knew was a poor lesson again (after the last lesson not being great either). I had wanted to show you that I was developing in my practice but actually I didn't prove that at all…So I couldn't engage with the process of reflecting as well as I would have liked. However, having said all that, the feedback was still non-judgmental and developmental and although I felt despondent because of my poor teaching, there was nothing in the feedback discussion that compounded that.* (Interview 3)	*The written feedback was really useful though.* Feedback-on-feedback1(from LO3) *Reading what was actually said I was shocked at how vague my instructions were and that helped me to see the lesson from the student's perspective.* Feedback-on-feedback1(from LO3) *…having had time to digest the feedback (which is constructive and helpful) in written form, I am able to consider the changes I want to make to the lessons.* Feedback-on-feedback3(from LO3)

Table 6.9 Comments from Participants Regarding the Value of Feedback

Previous experience of lesson observations and feedback - for all the participants - had tended to be related to Ofsted-style judgments and performance management related issues, usually following on from a 'show' lesson. The ensuing feedback was seen to be of little relevance or value for day-to-day type lessons. The mentoring and coaching these teachers experienced following on from the retraining course was seen to be altogether different, with teachers comfortable to be observed teaching '*normal*' lessons. Katy's honest narrative describes it as being refreshing to reveal and then discuss what she actually does – without pretence – and with the goal to improve her regular practice. The value of developmental lesson observations, as opposed to those for performance management or Ofsted, is highlighted by Coe *et al* (2014), Hobson *et al* (2015) and Wragg (2012) (see Chapter 2); the 'performance management' aspect of observations should be avoided (Hobson *et al* 2015). Bea's senior teachers were observed attempting to combine the roles of assessor and mentor; this is something Renshaw (2009) suggests should never be done, in spite of potential pressures on time and the temptation to do otherwise (Lord *et al* 2008). Instead observations should provide the scope for support which encourages risk taking, embraces learning from mistakes and enables honest discussions in a safe, non-judgmental environment (Robins 2006).

A safe and non-judgmental approach to the mentoring was something all the participants referred to regularly and considered to be the key to its success, believing as Harvey that there '*are not many opportunities to get feedback that is non-judgmental - this is an opportunity to get [that] feedback*' (discussion following Lesson Observation 6). The teachers actively wanted to engage with the process, and willingly relinquished significant periods of their free time to do so; this indicative of the high regard in which it was held. Renshaw (2009) identifies enhanced interpersonal skills to be significant for an effective mentor, and relationships between mentor and mentee should be approached with sensitivity and understanding. The extended face-to-face sessions, over the year-long course, enabled scope for the relationships between myself and the participants to develop deeply, establishing mutual respect and trust (see Table 4.7). Building on this rapport and creating inclusive and safe environments (as promoted by Anthony and Walshaw 2009) encouraged 'openness, honesty, informality and risk-taking' (Renshaw 2009: 39, Robbins 2006). Katy summed up the participants' experience of mentoring and coaching saying she '*LOVED it and didn't want it to end'* (Feedback following LO6); she wondered how other retrained teachers were coping without such sustained support.

Bea and Anna, both strong advocates for sustained mentoring and coaching, shared the concern of who '*in-house*' could fulfill the role, believing there was no one skilled enough and qualified enough to do it (Anna: Interview 3). For this role, Anna suggested the need for experience and subject specialist knowledge.

Anna: *'we have got so much inexperience I don't know who could drive it forward - because I know that is a big job in itself … our head of department hasn't got - she wouldn't feel comfortable with the subject knowledge - the one who has got very good subject knowledge is on SLT [and is unqualified inexperienced teacher] so he has got other responsibilities that couldn't then allow him to be regularly doing that - everyone else is new, so* – [laughter]' (Interview 3)

Katy, Cath, Janet and Euan all expressed a similar concern believing a mentor should be an expert practitioner. The Carter (2015) review (see Chapter 2) also recommended that mentors should be excellent teachers who could demonstrate outstanding practice as well as disseminate valuable ideas and concepts; Wragg et al (2002) and Evans et al (2014) concluded likewise.

Considering the financial implications, Bea believes mentoring may be an expensive option especially if, as she believes, the benefits only impact one teacher.

An unexpected side effect of the mentoring and coaching sessions was the profound influence on Harvey. Having experienced the positive power of insightful feedback, Harvey has now reconsidered the way in which he conducts observations of others, believing '*mentoring and coaching*' to be far more effective than '*telling and judging' (*Lesson Observation 4) (M&C). Handling lesson observations skillfully is something Wragg (2012) refers to when he points out that, when done well, lesson observations can '*benefit both the observer and the person observed*' and '*inform and enhance the professional skill of both people*' (2012: 2).

Seeing suggestions being enacted and verbalised by the teachers, post mentoring and coaching, was commonplace and admittedly rewarding. Sometimes teachers even appeared to incorporate and absorb ideas unwittingly – suggesting them as anew the next time we met. Sometimes too many reflections, for a teacher to process and affect, may have been considered in one session. Mentoring and coaching could be seen to have the most immediate and direct impact when a teacher had two parallel (or similar) teaching groups, the mentoring session directly influencing an improved experience for the students in the 'second' group. This was most clearly articulated by Katy but also commented upon by Bea, Anna, Cath and Janet, resonating with the idea that: reaching an understanding of subject matter for teaching in a way that makes the subject 'comprehensible to others' (Shulman

1986: 9) takes time as teachers reiterate the teaching of topics to different groups (Ball and Bass 2000).

Mentoring and coaching is not without risk and some teachers identified the disappointment they felt when an observed lesson had not gone to plan or when they felt they were not developing quickly enough as proficient practitioners. Although several teachers (Katy, Anna, Darcy, Euan, Janet, Cath) articulated this disappointment, they were all, without exception, keen to continue. The sense of not being judged was absolutely critical: to feel '*safe*' to dissect the disappointing lessons honestly and to receive valuable feedback. These experiences were often directly contrasted with the stressful experience of a performance management or Ofsted-style observation – with no, or of limited value, feedback. It was a common sentiment that the mentoring and coaching approach is '*how all observations should be'* (Kate, Interview 3).

Another danger of lesson observations is the detrimental impact observing can have on lesson delivery. For example, a teacher may plough on regardless through a lesson plan, determined to showcase their effort and resources. Cath describes this as typical, suggesting she is likely to engage with more '*live teaching*' (and go off plan) when not being observed, but is not '*brave*' enough to do so otherwise (Interview 3). She fears her subject knowledge may not be strong enough to avoid potential '*curve-balls*' from students – so likes to retain tight control whilst being observed (Interview 3).

Both Cath and Bea referred to 'live' or 'real-time' teaching and the benefits of doing so, this linking to the idea of contingency knowledge (Turner and Rowland

2006, see 2.3.2). This capacity to be flexible, opportunistic and in a position to respond to the situation in which they find themselves has also been identified by Berliner (2001) as one feature to discern expertise. To do otherwise, rigidly sticking to a pre-prepared script, risks missing valuable 'teachable moments', ignoring pertinent interjections from students (Berliner 2001: 475). Cath aspires to engage in more '*live teaching*', but does not yet have the confidence to do this whilst being observed. Anna did not ever have the confidence to go off plan; neither did Katy or Janet. Bea, on the other hand, promoted live teaching as a matter of course. Expert teachers can engage in the impromptu thinking required for real-time or live teaching, whereas as described so succinctly by Katy with her description of it being like '*white noise*', novices do not have the cognitive resources to process and then adapt during a lesson (Berliner 2001:475). 'Fear and inadequate cognitive resources prevent novices from thinking in this more expert-like way.' (Berliner 2001:476). This fear of losing control (Wragg 2012) was identified and addressed in many a mentoring session.

A powerful influence for change (Boyle *et al* 2005), mentoring and coaching have enabled the teachers to realise for themselves what could be improved and enhanced (Hafford-Letchfield *et al* 2007). This self-determination to change is critical (Mason 2002). The impact of this tailored input for each teacher may now be being seen in the classroom. The most recent lesson observations highlighted more teaching demanding deeper thinking from learners. To maintain this momentum - and to avoid stagnation or a backward slide – continued and sustained support appears necessary. A real problem arises if there appears to be no one '*in house*' who could adequately fulfil this role, this being the scenario described by several participants. Lesson Study could provide a viable alternative and is discussed as part of the ‘collaborative practice’ theme, discussed next.

6.3.3 Collaborative Practice

Just as feeling ‘*part of the process and not judged’ (*Anna: Feedback-on-feedback1) was central to the reported success of mentoring and coaching, so too for collaborative practice. The introduction to Lesson Study - encountered on the course - was appreciated by all and for some was the most valuable component of the retraining programme. Being able to practice in a ‘*safe*’ and ‘*supportive*’ environment (Cath, Interview 2) with ‘*well-structured’* (Janet, Personal Reflections), ‘*constructive*’ (Euan, Feedback-on-feedback1) and ‘*useful*’ (Harvey, Interview 2) feedback was considered invaluable. The independent evaluator, Hedger, was present during one such Lesson Study session and wrote in his report: ‘*An excellent session that will doubtless lead to improvements in the practice of course members and a deeper understanding of higher level topics.’* (Hedger 2014). As the participants grew in confidence with these mini-Lesson Study sessions, the value of their feedback contributions to colleagues grew in breadth and depth; Hedger: ‘*there were many supportive and creative suggestions from the group about how to improve aspects of each presentation’ (2014).*

For those teachers (at Venue 2) who also had the opportunity to observe - and in some cases, partake in - demonstration lessons (initially by NS and then by other participants), this too was seen to be ‘*one of the most useful parts of the day’* (Cath: Interview 2). Again participants stressed the significance of the ‘*non-*

threatening environment' and of a *'very supportive'* group (Kate, Interview 2). The general belief - and expressed powerfully by both Cath and Janet - was that a good way to develop and improve as a practitioner is to observe expert teachers; the course at Venue 2 providing exactly this opportunity. Cath continued to say that teachers not only need this opportunity to observe, but that they '*deserve*' it (Interview 3) (TA). Cockcroft (1982) agrees there is a need, and that those who teach mathematics should 'be given opportunity to observe and work with each other and to share teaching materials and other resources' (1982: 219). Coe *et al* (2014) also believe peer classroom observation to be effective for professional development but suggest the need for challenge in the process, possibly by way of involving external experts. This links with the ideas of Lesson Study (discussed in 2.3.3), originating from Japan, where these external experts are often referred to as 'knowledgeable others'.

The question of entitlement and who is responsible for enabling such developmental opportunities, is explored further in 6.3.4.

A potential pitfall of Lesson Study was highlighted when Katy attended an alternative venue and was required to collaborate with teachers she did not know; this, coupled with her sense of there being a lack of expertise within her group, brought into sharp focus the significance of group dynamics and the necessity for expert input. None of the teachers experienced Lesson Study in their schools. Harvey felt he and his colleagues were engaging with something similar, but in practice were focussed solely on resource provision. Anna believed she had introduced collaborative practice amongst her mathematics team – but again the focus was related to administrative tasks; Bea went as far to say that this venture '*failed*' (Interview 4) due to lack of expert input.

Another real danger of collaborative practice without any expert input, is the potential for perpetuating poor practice (Burghes and Robinson 2010). Darcy is now a mentor to, and being observed by, a new aspiring teacher of mathematics - a PE teacher currently on one of my TSST retraining courses.

Appreciating what Lesson Study actually is and defining it in culturally relevant terms is not easy; much may have been lost in translation (Wiliam 2016). Fernandez et al (2003) argue 'substantial challenges…must be overcome to make this practice purposeful and powerful' in a western context (2009;181); simply explaining to teachers the research nature of the process does not necessarily equip teachers to conduct and sustain such a practice (Fernandez et al 2003). Teachers must 'learn how to generate powerful questions about their practice, skilfully design lessons that can answer the questions, and look for concrete evidence in a lesson to shed light on their questions' (Fernandez et al 2003: 182). Initiating and sustaining such a process takes time, often a scarce resource (Bowland 2014a, Wiliam 2016). Bea's comments, suggesting Lesson Study could take an inordinate amount of time for a very small reward ('*an enormous fuss for a drop in the ocean'* (Interview 4)*)* may be typical of the British mindset. And Wiliam (2016) concurs, concluding the costs may outweigh the benefits. Katy and her department *were* in the enviable position of *having* significant synchronous planning time and yet this was never used for anything other than organising administrative activities. Katy's lack of opportunity to collaborate with colleagues for teaching and learning purposes, was typical for the participants. Katy experienced a very '*closed door'* approach and lamented the lack of opportunity to observe others (Interview 3).

Having no opportunity to observe other mathematics teachers was a recurring reproach (and common practice – see 2.3.3); typical participant comments are shown in Table 6.10.

LS/CO:	Opportunities to observe mathematics lessons… (LS/CO; PRA; BD; PD; SSup; TA)
Anna:	. *'…not in maths'* (Interview 1)
Bea:	. *'We never get the chance to [observe] ...'* (Interview 1)
Cath:	. *'We never, ever get the opportunity to observe'* (Interview 1)
Darcy:	. *'I haven't had the opportunity [to observe lessons]'* (Interview 1)
Euan:	. *'None [lesson observations] in maths'* (Interview 1)
Janet:	. *'… certainly no [lesson observations] with maths'* (Interview 1)
Katy:	. *'I don't think I've ever observed a maths lesson'* (Interview 1)

Table 6.10 Comments from Participants Regarding Opportunities to Observe Mathematics Lessons

Only Harvey had *ever* done so, and this prior to the course commencing. This is quite an astonishing reveal: teachers (who often had been *directed* to teach mathematics) were never expected, encouraged or directed to observe a mathematics lesson prior to teaching mathematics themselves. Cath summed this up when she contrasted the opportunities for the inexperienced practitioner to observe lessons ('*none*') with those for an '*expert*' observer ('*loads'*) (Interview 3). And this is precisely reflected in the literature where it is established novice teachers in England rarely have the opportunity to observe; expert teachers, on the other hand, have plentiful opportunities (Gore 2013, Wragg 2012). Ironically the UK government has identified that the most successful education systems in the world are 'characterized by high levels of lesson observation' (GOV.UK 2011b).

Observing demonstration lessons (by me) did create some concerns for a few. Janet in particular, although impressed by the actual lessons, wondered how they would be viewed back at her own school and through an Ofsted lens. Thinking about what actually constitutes '*progress*' for students (Janet, Personal Reflections), became a valuable discussion point for all.

For Cath, the lack of opportunity to observe others teach may have been exacerbated by being a lone mathematics teacher with no departmental colleagues; she finds this to be a very isolating role. Feeling isolated, was something others also experienced, in particular Katy, Janet and Euan. Just as mentoring and coaching have been identified as means to address professional isolation (Lord *et al* 2008) (as well as means to provide professional development), collaborative practice and Lesson Study could provide a similar support system.

The informal peer support network of the retraining group also helped to alleviate isolation. Harvey (at Venue 1) and Euan at (Venue 2) attempted to maintain and manage these organic networks once the course was complete and this collaborative support survived online and virtually for a while, but faded over time. All were disappointed by this loss of connectivity; Anna, Katy and Cath particularly missed the support and wished, as Euan had also suggested, that the group could meet again. Without sustained support, Cath summed up the sense from many: '*I am back floundering on my own really*'. This is a reasonable regret; Cockcroft (1982) identified follow-up sessions 'to be essential' without which, 'long term effectiveness would be greatly diminished' (Cockcroft 1982: 226). Further comments, relating to opportunities for collaborative practice, are illustrated in Table 6.11

	Collaborative Practice… (LS/CO)
Anna:	*'…from [retraining] together - we've [Bea] got that time for each other it is open door policy. She* [Bea] *came in the other day and it was all going wrong I was just like let's think about this …I would not think she is now going to judge me. Taking risks, Make it better…'* (Interview 2) *'…the collaborative planning [from course] I would love for us to do like that at school.'* (Interview 2) *'in the future would be fantastic to do - sitting down planning some lessons, observing each other and like having the confidence to have your door open when you teach the subject that you've not taught before'* (Interview 2) *'…but time constraints have not allowed this to happen.'* (Interview 2) *'What's tricky we are so inexperienced – I think the collaboration would be hard because I think at the moment - we have got so much inexperience I don't know who could drive it forward'* (Interview 3) *'our head of department hasn't got - she wouldn't feel comfortable with the subject knowledge*' (Interview 3)
Bea:	*'we never get the chance to* [work together]' (Interview 1) *'Actually it would be good for - something that we have planned together, somebody's taught, we've all watched, we've all observed* - [but] *yeah we are not great are we at putting massive long term investment in, it's all about the next set of GCSEs results, it's all about the next government, it's all about - possibly because education is so political.'* (Interview 3)
Cath:	*'What we are also trying to do with CPD is to share good practice across the subjects and observe each other but that's a real challenge as not all the teachers want to do that. A real challenge.'* (Interview 1) *'the opportunity to share good practice would help improve teachers' practice' (Interview 1)* *'the [on course] collaboration I found it difficult because I am much slower at coming up with ideas than some of the others…'* (Interview 2) *'I think I would gain so much from that – [peer observation]'* (Interview 3) *'more often than not you are being observed by someone who has not taught before, and you start to get a bit cynical about it - all you know is they have never taught maths…'* (Interview 3) *'…where's my opportunity to observe so that I can - [an observer is] learning loads watching me, good and bad…but I want that for me - for my maths teaching - as I'm the one that should be learning …'* (Interview 3) *'I was learning the most from where you know when we would all sit and watch*

	each other [on course] and you would say why did you do it, and did you think about that, and… definitely useful.' (Interview 3) *'what I think anyone deserves is the best professional development you could ever get is opportunity in your timetable to share good practice and observe other teachers …and none of that opportunity is there.'* (Interview 3) *'I would far rather do that than a day with the buffet of sandwiches, in-service day learning something else, on Blooms taxonomy or whatever - I'd rather be watching other maths teachers'* (Interview 3)
Darcy:	*'I go to my head of department - and he laughs at me - then he helps me - in a nice way… But really it is just who I find first - I am not ashamed of it…'* (Interview 3)
Euan:	*'we don't as teachers have any of the time to do this sharing'* (Interview 2)
Harvey:	*'I always think about the thing you said about 'polishing the stone'; this sticks in my mind. Not that "this is wrong; that is wrong" but about "how can we make it better"'* (feedback following LO4) *'what we are aiming to do is have a set of resources that we all teach from, that's a collaborative learning from the resource point of view'* (Interview 3) *'…collaborative learning – it was much better run at the last school.*' (Interview 3)
Katy:	*'I am all on own, very isolated. Opportunities for collaborative work really minimal'* (Personal Reflections) *'… we don't share practice.*' (Discussion following LO6*)* *'as an idea for us to learn from others and our own mistakes it [Lesson Study on course] was really useful'* (Personal Reflections) *'but here at the moment with lack of staff and lack of time we just don't have enough people to give that kind of support.'* (Interview 3) *'the only thing that we have done collaboratively is pull this together [scheme of work] which is a list of the whole content of the GCSE - with places to tick to show if students understand it, diagnostic ticks,…'* (Interview 3) *'We have a whole morning - and it's all admin staff – we have three hours a week'* (Interview 3) *'We just get on with our own planning or marking - but what a wasted opportunity where we are all available'* (Interview 3) *'there is no collaborative* practice' (Interview 3)
Janet	*'in our department we all tend to be teaching at the same time, so our 'frees' are all at the same time so it doesn't work'* (Interview 1)

Table 6.11 Comments from Participants Regarding Collaborative Practice

The advantages of two (or more) participants from the same school being simultaneously retrained were captured by the comments from Bea and Anna. Shared experiences helped them to work more collaboratively and to promote this approach with colleagues, and to more easily embed ideas from the retraining into everyday practice. (Probably also assisted by Bea's senior position within the school and department at that time.) Bruce and Flynn (2013) report that the impact of professional development is 'magnified when teachers participate with colleagues from the same school' (2013: 693). Colleagues collaborating in such a way is documented to be of benefit (Cockcroft 1982), and is common practice in countries such as Japan and Finland (see Chapter 2). Bea and Anna could be seen to be engaging in 'co-mentoring', a term used by Renshaw (2009) to describe the collaborative learning process involving an 'equal exchange of knowledge, skills and experience' (2009: 3).

Apparent – from all the participants' stories – was the need for sustained support once the retraining course was complete This was coupled with an apparent lack of know-how, in terms of requesting this next-steps support. One idea suggested by Bea and seized upon by others, was for course providers to supply a post-retraining script, addressed to senior leaders, outlining the types of sustained support required. This to avoid teachers feeling they were '*floundering*', to limit the sense of '*isolation*' (Cath, Interview 3), and to promote their progression as proficient teachers of mathematics. Buying into this vision - for sustained support - is something Bea was sure should be built '*into the contract for schools'* from the start (Interview 4). As Berliner (2001) points out, 'Development of expertise is not linear' (2001: 463), and the cyclical process of development must be embraced, to prevent teachers getting stuck at the novice level of mathematics teaching.

The role senior management teams can play, and the influence they can exert in terms of professional development, are discussed next.

6.3.4 Senior Management Influence

Harvey, Anna, Bea, Cath, Euan and Janet were all '*roped in'* to teach mathematics by their senior managements, some more willingly than others. For all teachers - other than Harvey - the sanctioning of their attendance on the retraining course appears to be the extent of the support offered by their senior management teams. No other support during or post the course has been evident, this summed up by Katy: '*there is nothing, no support, nothing …there has to be more support after the course*' (Interview 3).

The general consensus (Harvey aside) was that the teachers were being granted a favour to attend, and on occasions had to '*plead*' (Katy, Interview 2) to be exempted from other duties so as not to miss a session, the face-to-face sessions not being seen as a priority. There appeared little awareness that participants were investing a great deal of their personal time into the retraining experience, for completing the 100 hours of online e-learning and assessment. For some travel expenses were not even met. And this is exactly what Cockcroft discovered (1982): 'It is clear … that a great deal of in-service work is undertaken by mathematics teachers outside school hours and sometimes at their own expense.' (1982: 229). Comments surrounding support from the schools are listed in Table 6.12.

	Support from School … (SSup)
Anna:	'*Both me and C were allowed to go out …So very supportive of the school for that - you know there were no problems at all for that - that was absolutely fine.'* (Interview 3) *'Same during - you know we were able to come out and we didn't miss any of the sessions apart from when we had OFSTED and had to leave halfway through.'* (Interview 3) *'Um and – post course - how we been supported post course – um - wouldn't necessarily say support in terms of time – um - I think because I just carried on - just with my normal timetable and things like that…'* (Interview 3) *'it would be really great if when you get back to your school there could be some time for some joint planning'* (Interview 3)
Bea:	*'I have had the time without any quibble, I haven't had travel expenses paid but I have had my parking paid. Nobody has enquired about my progress. It was very easy to be released for the sessions.'* (Interview 3) *'No one has enquired how I got on or asked how it was or how much hard work.'* (Interview 3) *'No one said you know all that work you're doing at the weekend, those hundreds of hours sat frustratingly inputting into those stupid tests - you know could we give you half a day off or anything like that.'* (Interview 3) *'Post course support - I guess it's a tricky thing - picking up the subject knowledge enhancement stuff, aspects of that…'* (Interview 3) *'Every school I have worked in has somebody responsible for CPD, so maybe it is just a little tweak - if you have been on this course headteacher - let the person in charge of CPD know because then the focus for CPD for the next year needs to be - we can do these things but you can set things up in a house like peer planning, set up observations, a list of things, suggestions to make as part of - your person has been on this course, we strongly recommend that there is some follow-up and the focus of…' (*Interview 3)
Cath:	'*because we never get the chance to escape from our classrooms ...*' (Interview 1) *'In terms of supporting subject development, maths teaching …essentially impossible financially...'* (Interview 3) *'So they are really supportive as looking after me [pastorally] but in terms of maths development perhaps not really, not even having that awareness that it is needed actually, there is no awareness that it would be helpful or - then that is my fault - I need to tell them that I needed it maybe or, I don't know'* (Interview 3) *'…it is the beginning of the journey. It is the lack of awareness'* (Interview 3) *'what I would really love, what would really help anyone's maths teaching - it would be to have half a day a week in another school observing - but how would that be – that would be…impossible… but that would be really lovely.'* (Interview 3) *'I think I would gain so much from that – [peer observation]'* (Interview 3) *'Just want some time to plan, just sometime, I need time that's what I need. I need time to plan and think and reflect - there is never any time. You never get time to reflect.'* (Interview 2) *'I need the support'* (Interview 3)

Darcy:	*'…more professional development would be nice but I don't know even where to go to look into that, I've got no idea.'* (Interview 3) *'SLT probably didn't even know I was out to be honest…No they have never once asked me - can you show me what you have done…I wonder whether that is because they are trusting though or whether they don't care'* (Interview 3) *'…whether it was because they deem at me to be a good member of staff and they feel they don't need to check up on me or whether it is the fact that they just don't care - I'm not sure'* (Interview 3)
Euan:	'*…it's interesting that their views on this style of teaching are still so backward.'* (Interview 2) *'Policies are too restrictive and all teaches are required to teach in the same way.'* (Reflections on Course) '*I have sent some emails and volunteered to use remitted time to share ideas in the summer term, but not taken up. Kind of disappointed*.' (Reflections on Course) *'Hopefully if we get out in special measures in the next month, then I think she will listen to that and she will be prepared to change things but she is under so much pressure that she won't.'* (Interview 2) *'no one has come to see me, no one has checked my marking yet, no one has observed me, no nothing yet'* (Interview 2)
Harvey:	*'the Head said to me whatever support you need we will provide'* (Interview 1) *'…there has been so much support for me - it has been amazing*.*'* (Interview 2) *'yeah so it's fell away- but rightly so I think. I don't think I need that level of support'* (Interview 3)
Katy:	'*It is a little isolating here'* (discussion following LO6) *'… we don't share practice'* (discussion following LO6) *'but here at the moment with lack of staff and lack of time we just don't have enough people to give that kind of support.'* (Interview 3) *'So they are doing learning walks but you get no feedback from that and that's not from a maths specialist either so even if I did get feedback - probably on only how it went generally, there will be no specific feedback like that* [points to our notes].*'* (Interview 3) *'our maths manager - manages a huge area - really over real diverse range of subjects and apart from investing money - in textbooks – there is nothing, no support nothing'* (Interview 3)
Janet	*'…very keen for me to come on this, very keen for me to do any kind of CPD but as I say it is difficult within my own school because as much as people are offering me stuff I don't think I'm seeing what I need to be seeing'* (Interview 1)

Table 6.12 Comments from Participants Regarding Senior Management Support

A teacher's sense of well-being, involving their professional self-esteem and self-efficacy, is intertwined with their confidence in the job they are doing (Hobbs 2015). Senior managements may need to accept responsibility for this and safe-guard their teachers. This is especially true when teachers have been directed, by their senior managements, to step outside their comfort zones to teach mathematics. Euan, Janet and Anna have already resigned from teaching mathematics. Cath and Katy regularly spoke about feelings of isolation, and Cath broke down discussing these issues during the final interview. These issues are not insignificant.

Cath, who was directed by her senior leader to teach mathematics to an increasingly diverse group of students, epitomizes the growing demands on teachers (Schleicher 2012). The changing landscape of teaching has been identified by OECD (2012) where it is recognized that teachers need to respond to increasing diversity amongst learners. OECD has suggested that teaching needs to become more inclusive, and teachers need to be more effective and more creative to accommodate diverse needs (OECD 2012 and OECD 2017)). The idea of inclusivity was picked up by Euan when he described more didactic styles of teaching being for the '*few*', and not for the '*many*' (Interview 2). Shifting to a more inclusive approach to teaching, suggests placing more emphasis on students' understanding, and teachers learning 'more about the subjects they teach, and how students learn these subjects', that is, the mathematical pedagogy (Shulman and Sparks 1992: 916). This in turn impacts on the support and professional development provided to teachers, and the need to recognize 'deepening of knowledge and skills is an integral part' (Shulman and Sparks 1992: 916).

Euan's experience perhaps highlights the lack of 'joined up thinking' from some senior management teams. He was sent on the course because the senior management recognised inadequacies within the mathematics department (and because Ofsted was '*looming*'), but was given no opportunity to disseminate nor to continue his own development. There was no shared vision for the development of the school's mathematics provision, clearly revealed by a damning in-house observation from the leadership. Although determined to do so ('*It will last - definitely'*, Interview 2*)*, Euan struggled to '*persevere*' teaching in the '*new*' interactive and engaging style. Shortly after his in-house observation, Euan left the profession. Euan had not felt supported by his senior teachers and had not been encouraged to share his experiences with colleagues back at base. He felt that the retraining had not been embedded in a wider school vision; his experience suggesting that the leadership team was not demonstrating the principles advocated by the DfE, outlined in Table 2.21 (GOV.UK 2016e).

Cockcroft (1982) cites lack of interest and lack of support, following professional development, as reasons for 'training courses to result in no long-term improvement' (Cockcroft 1982: 226).

An example of the lack of awareness by a head teacher (and perhaps by Anna herself) of the intent, impact and cost of the retraining could be seen when it was decided to switch Anna from teaching mathematics back into science, and replace her with another non-specialist with absolutely no retraining. This absence of awareness of the magnitude of the task, for non-specialists to teach mathematics, is illustrated by the same head teacher who believes that teachers '*should be able to teach any subject*' (2014). But as Berliner has shown, teachers 'ordinarily seem not to be "general" experts with unlimited capacity to transfer knowledge from one situation to another.' (2001: 472). Teachers' expertise and knowledge tend, in fact, to be 'limited to a particular domain' (Berliner 2001: 472). The headteacher's clear lack of regard to this may explain his ambivalent approach and apparent lack of interest toward the retraining.

The tone for teachers is, unsurprisingly, set by headteachers. And for most schools, GCSE results dominated the agenda. Ofsted primarily make judgements on data, namely exam results, and of these the pressure on GCSE results appears to be highest. A triple high stakes performance measure – for students, the school and the system – GCSE exams create pressure which, for some settings, was a major determinant in decision making. This was most evident at Darcy's school. A 'fire-fighting focus' (with breakfast, lunch and after school revision sessions), to drive Year 11's through their GCSEs, appeared the norm; teachers were simultaneously directed to relegate Key Stage 3 duties with reduced marking and planning for these younger students. Darcy's perception is clear – this is what is demanded by senior management; engaging in richer and '*frivolous*' experiences for students is not. Students are also encouraged to continually focus on their GCSE potential – and are reminded daily of the '*significance*' of these examination results. Darcy's experience may have been the most extreme, but the pressure for GCSE exam success and the effects of this on teaching, were evident everywhere.

Darcy's senior management team was also happy to encourage (and exploit?) her natural competitiveness. Competing with her colleagues to achieve the best exam results, Darcy worked incredibly hard. A superficial approach to teaching (and teaching-to-the-test) has, in Darcy's view, paid dividends in terms of her 2017 GCSE results. This could be described, by Fenstermacher and Richardson (2000), as 'successful' teaching as opposed to 'good' teaching (2000: 6) - and there is much discussion of this in Chapter 2. Whether the huge investments of her time (in terms of revision and exam preparation sessions) is sustainable remains to be seen. Interestingly, the Progress 8 report for this school (for 2016-2017) shows a 'below average' score for the school (of -0.48) with the 'grade 5 or above in English and maths' measure well below the county (and country) average. It appears teaching-to-the-test might not be producing the best results. The Chief Inspector of Ofsted, Spielman (2017), believes it unlikely school leaders would have deliberately prioritized testing and exam performance above a quality curriculum, but does recognize some schools may feel a tension between good examination results and a good curriculum (GOV.UK 2017). Under enormous pressure to 'succeed' teaching-to-the-test became a temptation for many schools encountered during this study – even though there is no evidence for its worth for most main-stream students (Skemp 1976, Swan 2005, Cockcroft 1982, Smith 2004, Smith 2017b, Tall 2013, Van de Walle *et al* 2013, Askew *et al* 1997, Porkess *et al* 2011, Anthony and Walshaw 2009, Boaler 2009, Ellenberg 2015, Coe *et al* 2014, Ball and Bass 2000, Polya 1945).

With schools and senior managements focussed on the short term goals of annual exam results, it may not be surprising that some have been criticised by the participants for '*lack of vison'* (Katy, Interview 3). And that this lack of vision manifests itself by way of lack of support: lack of support for offering, promoting, encouraging or expecting professional development. Katy summed this up: '*there is nothing, no support, nothing' (*Interview 3). Without the will to make the necessary financial provision, the Cockcroft (1982) report concluded there would be insufficient 'opportunity to influence and improve the quality of mathematics teaching' (1982: 229).

Opportunities for ongoing professional development are a significant factor in determining the ethos, conditions and climate of an institution, which in turn can 'powerfully affect' teachers' perceptions and practices (Berliner 2001: 466). And Darling-Hammond (2014) has highlighted (see 2.2.1) that less effective teachers can be boosted by professional support. The opportunity for professional development also plays a significant role in retention (Smithers and Robinson 2013); as of 2018 only half of my participants are still teaching any mathematics.

Recognizing the limitations of their pedagogical subject knowledge, all of the participants (with the exception of Cath – who worked with extremely diverse groups of students with mixed age and prior attainment) were initially directed to teach younger students or lower attaining mathematics groups - a decision endorsed, or even encouraged, by senior leadership. Ní Ríordáin and Hannigan (2011) found this to be the norm for out-of-field non-specialist teachers of mathematics in Ireland. This reflects the findings of Ofsted (2012), with 'Less experienced, temporary and non-specialist teachers … more likely to teach lower sets or younger pupils' (2012: 9). And yet we now know that the younger and/or lower-attaining students, who require the most help, stand to lose significantly more (than their older or higher-attaining counterparts) if placed with less experienced or less effective teachers (Wiliam 2016, Marshall 2013, Ofsted 2012, Cockcroft 1982). The loss these students can experience is often irreversible (Marshall 2013). Cath, battling against these constraints (and the 'loss' previously experienced by many of her students), experiences great anxiety about not being able to compensate for this deficit. Cath was concerned her efforts – modelling activities and ethos from the course - were not translating into 'success' for her students. Watson and Mason (2007) suggest factors which influence the effectiveness of a mathematics task include: 'ethos and atmosphere; established practices and ways of working; students' expectations of themselves and of each other as influenced by the system and their pasts; and learners' sense of self-confidence, agency (mathematically and socially) and identity.' (2007: 206). Cath worked hard to create a conducive ethos and atmosphere and persevered in offering an alternative to established practices, but had little influence over the other factors listed above.

In future, with the implications of Progress 8, senior leaders may reconsider the deployment of their weaker or least experienced teachers – especially as we now know effective practitioners have a disproportionately positive impact, in terms of attainment gains, for lower attaining students (Wiliam 2016, Marshall 2013). Senior leaders may see it strategically sensible to deploy their strongest practitioners with their weakest students. Alternatively, the Progress 8 accountability system may provide the driver for senior teachers to ensure that all their mathematics teachers are properly equipped to teach effectively; and to invest in sustained professional development. This may be encouraged by Ofsted's directive for schools to evaluate and tackle any inconsistencies in the quality of mathematics teaching within schools (GOV.UK 2018b).

The Sutton Trust (2015) suggests that professional development should be a priority for all teachers, and a responsibility schools should not evade. Wiliam (2016) believes most teachers could be as good as the very best practitioners – with the application of hard work and proper support – providing the route to reducing the detrimental in-school-variation, identified by the National College (2011), and raising achievement for all.

Senior management teams must decide how best to provide post retraining support, be it by way of mentoring and coaching, or by collaborative practice such as Lesson Study, or by other means. The provision of such sustained support should be non-negotiable. The TAM training model provides one example of a funding model with sustained support. As Cockcroft (1982) recommended, teachers should 'receive all possible support to enable them to improve the effectiveness of their teaching' because any improvement in mathematics provision in schools will be largely dependent on the current workforce (1982: 217). The McKinsey report (2007) reiterates this and highlights the significance of an environment that sustains support. Guskey (2005) points out that it is this level of senior management support, or lack of, that determines the success, or otherwise, of a professional development initiative. I think this a particularly pertinent point for the retraining concept. Teachers complete a retraining course, often at personal expense, enthused and inspired to employ an interactive and engaging teaching style, ready to promote deep thinking for students – only to potentially find it more challenging than they anticipated and that the necessary support to sustain this approach is missing. Many factors for the successful implementation of such an approach are clearly at play and some of these have already been discussed: the pressures on school for immediate results; the lack of time for planning and reflecting in what is essentially a new subject; access to peer developmental lesson observations; and support from senior management to provide and fund further training opportunities. The department or school 'mould' within which the teacher must fit, is another influencing factor and this theme is discussed below.

6.3.5 The School/Department Effect

The powerful influence of *socialisation* (see 2.3.5) – the idea that teachers in the same school or department will adopt similar practices despite differing beliefs or views towards teaching – is well documented (Ernest 1989). Considering potential conflict, between pedagogy promoted during the retraining and typical departmental practice, I posed the following question to provoke reflection:

'*Is there a tension between the way things are done on the course and the way your school expects things to be done?*'

The participant answers (captured on the 'Reflection-on-Course' questionnaire) are documented in Table 6.13.

	Is there a tension between the way things are done on the course and the way your school expects things to be done? (PRA; PER)
Anna:	*There was to start with as me being a non-maths specialist it was a bit 'what do you know' but this year has seen a new ethos being adopted and people are far more up for trying new ideas and exploring the understanding rather than lots of '10 ticks!'*
Bea	*Yes. And it's reinforced in every text book I have ever seen. Maths is not used in isolated skills. We should teach the kids by putting them in real life situations where maths is used to solve real problems and then teach them the discrete skills etc. if they don't have them as we go along. I think of it like a treasure chest of mathematical skills that the children should acquire really quickly and then use to solve real problems*
Cath:	*Yes – in terms of tension between what course advocates and what Ofsted may expect*
Darcy:	*Pressure in school for progress and attainment. Time always seem short and I would love to have time for 'hands on' activities (as experienced on course). Don't feel have time in school for this.*
Euan:	*Yes. Forced to fold pages in books for all students - Aarrgghh. College being in special measures means SLT are nervous about "risky/out of the box" lessons. Policies are too restrictive and all teaches are required to teach in the same way.*
Harvey:	*No, the department [in 'original' school] are willing for me to try anything that I have learnt as they trust me.*
Janet:	*I think it's difficult to depart from the department norm until you know your subject knowledge really well and so I am kind of sticking to the tried and tested, speaking at the front, chalk and talk work out of the text book kind of thing which isn't the way I want to teach but it's the way at the moment I'm just building the base at the minute - it's not where I want to end up.*
Katy:	*The rest of the department teach by telling – but I think this is a better way - the more active methods.*

Table 6.13 Comments from Participants Regarding Possible Socialisation Effects

Department 'norms' did, in fact, appear to exert huge influence on all the participants. Darcy understood the exam driven nature of her environment; Katy was frustrated by the passivity of her department and the expectation emanating from her colleagues to '*just tell them'* (Interview 2); Janet believed there to be no one of any calibre to learn from in her department and as '*everyone teaches to the text*' (Interview 1), she felt she had no other option; Euan tried to teach differently – but was given no opportunities to influence others in the department – and was knocked back by senior management; Anna desperately wanted to follow Bea's lead (but was unsure of what she was doing); Harvey's practice appeared to take a backward step when he moved to a less supportive environment; Cath was crying out to do things differently, and have a handle on what could be considered '*good practice*' (Interview 2), in her unusual and challenging circumstances.

The ethical question of whether participants should indeed be encouraged to teach differently from their departmental colleagues is an interesting one, although one that is perhaps beyond the scope of this study. Using the working definition of effective teaching - as one that promotes active participation and deep thinking and understanding amongst learners (see 3.2) - this ethos was inevitably reflected and promoted during the retraining.

Participants' comments, relating to typical department practice, are shown in Table 6.14.

	Department Practice… (PRA)
Anna:	*‘Because my HOD* [Bea] *was also on the course, the usefulness of much of its content was discussed regularly at department meetings...’* (Personal Reflections) *‘I think they* [the rest of the department] *could see the benefit of it* [Bea’s ideas] *- but they were like we have been doing this for years and we are not going to change completely how we teach*.’ (Interview 2) *‘I think it's nice to be able to bounce ideas [with Bea] - you know when you're in your classroom and you've got six lesson days … ‘cos you can get so bogged down…’* (Interview 3) *‘The worksheets came from various sources, often the TES. All teachers source their own.’* (discussion following LO4)
Bea:	‘*They* [the department] *don't particularly want to teach like this...’* (Reflections on Course) *‘In some senses we do try and support each other - there is so much stuff.’* (Interview 3) *‘you know the heads of department in this school are pressured to do nothing but concentrate on outcomes’* (Interview 2)
Cath:	*‘I am working completely in isolation here’* (Interview 3)
Darcy:	‘*cos ultimately your head and your HOD telling you - you must get grade C’s you must get grade B’s you must get grade A’s….and more often than not the way you’re going them is exam papers you know doing a lot of didactic teaching and here’s your exam questions...here’s your textbook’* (Interview 2) *‘if I look at some of the other maths teachers in my department, the head of department - we teach quite similar’* (Interview 2) ‘[use] *things like Maths-is-Fun.’* (Interview 3) *‘I quite often wonder through my head of department’s room because the printer is in there and I’ll often look at what he is doing. I couldn’t tell you what anyone else in my department is teaching really - which is a shame’* (Interview 3) *‘if an SLT came in and saw that* [a lesson such as the demonstration one] *I don't know what outcome they would say to me about the lesson because there is no proof of the progress - yes they* [students] *have all said things in the lesson - I don't know what they would say to that and I would feel a bit scared in case turn around and say that’s not …’* (Interview 3)
Euan:	*‘the standard - as in literally get your books out, copy what is on the board do these exercises that sort of lesson’* (Interview 2) *‘I think* [there are] *lots of different styles of teaching... So yes lots of different styles* – [but] *none in maths* [department]’ (Interview 2) *‘… part of the reason of coming on the course - to try and get some new ideas for the department’* (Interview 1) *‘I would like to say yes* [to having any influence on department practice] *but practically at the moment it hasn’t. Not the time to do it’* (Interview 2)

	'the pages of my books are perfectly folded in half, with kids writing in columns I have written in red pen week and they respond in green pen every week and with a blue stamp on it - I have to do those things' (Interview 2) *'Within the maths department because I am not a head of department, I am a teacher within there, I have to follow the policy'* (Interview 2)
Harvey:	**Original School:** *'The department have been so supportive and my transformation from PE teacher to Maths teacher would not have been possible without that support.'* (Reflections on Course) *'The department have said that they would rather have a stronger teacher that they can support with subject knowledge than a teacher with stronger subject knowledge but weak class management skills.'* (Reflections on Course) **Current School:** *'The main difference is the emphasis on the amount of marking and the testing here… And like the book marking…'* (Interview 3) *'…so I am working my socks off at school to make sure when I go home it is my home time otherwise I am working until nine or 10 o'clock every night - it is unsustainable'* (Interview 3) *'…because they* [students] *don't like making mistakes in their books, they hate it'* (Interview 3) *''cos at the minute we teach stuff in year seven, then [the same] again in year eight, and then again in year nine'* (Interview 3) *'and so for consistency to make sure we are all teaching the same way and the same methods…to make sure we all teaching the same - that's the plan anyway'* (Interview 3)
Katy:	*'I am going to say - can we do some* [shared planning] *…but I am quite new to the team so I don't want to say can we do this, can we do that that - and them going bloody hell who does she think she is…'* (Interview 3) *'the norm - being didactic and just getting them to do it'* (Interview 2) '*department colleague advised me – "oh tell them to just accept - that's the way it is*"' (Feedback following LO6) '*they [students] may just accept it, I don't know'* (Interview 2) *'The further away from the SKE course I become, the harder it is to continue to use the more active methods.'* (Feedback-on Feedback (following LO5))
Janet:	'*our department just teaches to the text book and it is just so dull and boring so I'm, not experiencing what I think is outstanding teaching to be able to observe it in my own school. So I'm keen to pick up other people's ideas.'* (Interview 1) *'I work through every holiday, I work in the evenings, I work at weekend, I have no life'* (Interview 1)

Table 6.14 Comments from Participants Regarding Department Practice

A spiral style of delivery through concepts in the mathematics curriculum was observed in most settings and directly endorsed by Darcy, believing it necessary to reteach students again and again, as '*they can't retain stuff from one day to the next*' *(discussion following* Lesson Observation 7). The idea of a spiral, or a linear, progression seems 'entirely inadequate' to Davis and Simmt (2006: 308) and they offer, instead, the process of 'recursive elaboration' as a more useful way to describe the manner in which mathematical concepts can be developed: 'A recursive elaboration is a sort of repetition that not only adds to, but that fundamentally transforms the original form'; the idea to 'promote integrated mathematical understandings' and the web of connections (2006: 308). The development of teachers' own 'connection knowledge' (Turner and Rowland 2006) could be simultaneously strengthened.

Without fail, each participant - whilst at school themselves - had experienced a linear and didactic approach to mathematics but all were of the view that things should be '*better*' now (Euan, Interview 2). I was curious to discover why they believed things could be '*better*' – especially as all had been relatively successful at school. Euan encapsulated why, explaining: we now need to move towards a more inclusive approach and towards a teaching style which works well for the '*many*' and not just for the '*few*'. However, learning to teach differently is not easy. Harvey makes the significant point that it was the retraining course that opened his eyes to explore different ways of teaching mathematics; he felt none of his colleagues were doing so, so without such external input: '*how could I?'* (Interview 3).

Harvey's experience chimes with others' observations and from the literature; Watson and Barton (Watson and Barton 2011) point out that 'too often, the modes of enquiry used in planning and teaching are drawn from a set limited both by teachers' own mathematical experiences and by the ways they were taught' (Watson and Barton 2011: 80).

Each of the participants made some in-roads into trying to do things differently. But the pressure to conform to department norms was huge. Harvey attempted to transform his practice in his original school but with the influence of the course fading, and no further developmental support from his 'new' school, Harvey could soon be seen slotting into departmental 'norms' and slipping into delivering didactically. Teaching procedurally for, and to, the regular school tests - the socialisation effect was clear to see. Harvey's trajectory appears to exemplify the findings of the Sutton Trust (2015), which found that for teachers to continue to develop beyond their first few years of teaching, they need to be well supported at all stages of their careers.

Stigler and Hiebert (1999) describe teachers following 'scripts' and that their effectiveness as teachers will depend on the 'script' they are using. During the period of retraining, the teachers embraced, and were given opportunities to enact, a different 'script'. Without doubt, when the course influences and support are withdrawn, the school itself appears to exert the stronger force in determining teaching 'scripts'. This has directly led to comments such as Anna's: '*it was harder to teach maths the further away from the course we got'* (Lesson Observation 6).

Given that - as a rule - the participants had no opportunities to observe other mathematics teachers, it is not surprising that they often reverted to teaching mathematics in the only way they had ever experienced, in the way that they themselves were taught. This is indeed very common practice (Burghes and Robinson 2010, Stigler and Hiebert 1999, Wiliam 2016).

Several participants suggested non-specialist teachers may be of benefit to a mathematics department: they may influence and impact upon the department 'norms' by incorporating different personalities and perspectives - bringing different ways of working with them from their original subjects. Anna and Katy both referred to the idea of non-specialists tending to be more '*normal*', and that retraining had the potential to introduce '*more rounded'* mathematics teachers into the system, by drawing from a diverse group of teachers (Interview 3's) (BRING). This, both Anna and Katy believed, could add to, rather than detract from, the effectiveness in teaching mathematics. Research from Smithers and Robinson (2013) and Porkess *et al* (2011) seems to suggest Anna and Katy may have a point: personality-types most attracted to studying subjects such as mathematics at university may be less likely to be interested in connecting with people, yet the significance of human connections in regard to mathematics teaching have been established and may matter more than for any other subject (Cockcroft 1982). Anthony and Walshaw (2009) describe effective teachers to be those that really care about the engagement of their students, and create inclusive and safe environments; the subject of mathematics engenders such feelings of fear in so many (Smith 2017b), fostering an inclusive culture, which ensures all learners feel safe, may be more significant in mathematics than in any other field. Bea’s students clearly referenced this sense of ‘safety’ as significant for learning.

Teaching depends on the dynamics in the classroom; separating the ‘teaching’ from the ‘teacher’ is virtually impossible (Coe *et al* 2014, Schleicher 2012, Wiliam 2016, Darling-Hammond 2014). Euan’s experience of being observed by senior management was extraordinary. His observer asserted the lesson was only graded ‘*good*’ because it *was* Euan delivering it, and that it would have been graded *‘requires improvement’* if anyone else had tried to teach it - thereby asserting the *teacher* and the *teaching* to be separable. The style and approach were clearly unfamiliar to the observer, the observer seemingly unaware that quality is less about the shape or style of teaching and more about ‘the quality of thought and effort that can occur within these structures’ (Good and Biddle 1988: 116).

The default mode for Euan’s department was to teach didactically, and interestingly even though he said he did not want to teach this way – he would do so if time was ‘*tight*’ or if an ‘*Ofsted* inspection was looming’. The department norm was ultimately the most dominating influence.

The next section considers the impact of Ofsted and other external factors.

6.3.6 External Pressures

Ofsted inspections featured in the narratives of all the participants; typical sentiments are reflected in Table 6.15.

	External pressures … (OFS / PRESS)
Anna:	'*I was starting my first year of teaching maths and we had just received an Ofsted report saying our teaching needs to be more conceptual.*' (Reflections on Course) '*It terrifies me.*' (Interview 1) *'was nearly sick when Ofsted came*' (feedback following LO2)
Bea:	'*In terms of showing progress in books - is going to be an issue 'cos a lot of what we do is on whiteboards'* (Interview 2) '*So although there's not much in there… I've marked them to within an inch of their lives.'* (Interview 2) *'So yes I am anxious I think it very much depends on the inspector we get.'* (Interview 2) '*Ofsted certainly was all about a few years ago - reducing the school variation everyone has to be doing the same thing…So they may say: How come your HOM is teaching like this… and yet the rest of the department are being allowed to teach in a traditional way'* (Interview 2) *'I think a lot of people under perform when they are Ofsteded. I think the stress ... Some regularly outstanding teachers only get a good when ofsteded.'* (Interview 3) *'I think Ofsted inspectors are not skilled enough to observe. They don't know how to do it or what they're looking for. Doing lesson observations is a real skill'* (Interview 3)
Cath:	'*we've had an Ofsted at…and I was really nervous for that because I was teaching maths and I'd only just started'* (Interview 1) *'noticed they* [students] *are slightly more engaged so I was really disappointed when we didn't get many C's thinking that would translate to C's … hoping that it might - um huge of pressure to produce that - not by the school - but by the world outside that looks in on us. I wish that could go away, that pressure'* (Interview 2) '*Ofsted - in relation to this style we are promoting - they don't really go together do they - in synergy or whatever'* (Interview 2) *'In terms of supporting subject development, maths teaching …essentially impossible financially...'* (Interview 3) '[crying] *I'm sorry… we are under such pressure - these girls have immense problems and issues…the girls at … are all self-harmers… so I suppose what happens is that you take a lot of that [stress] on…*' (Interview 3)

Darcy:	'*so they're always going to underachieve and I think that part of the problem for whatever reason the assessment* [benchmark testing] *when they're younger doesn't work and then you're fighting a battle from then on'* (Interview 1) *'I think the pressure comes that actually by the time they leave school they have to get the grades that someone has told you they have to get'* (Interview 1) '*I think there's too much pressure on the staff and on pupils to achieve the grades that are potentially made up by people who have got no idea of what's actually going on in the real world'* (Interview 1) '*OFSTED is due this year - so … there are just so many new initiatives - they get brought in what seems like every term - that you know you just feel you get to grips with something and then you've got another thing that you got, and something else has - so all those things [related to collaborative planning] that would be nice to do just don't think they happen.'* (Interview 1) '*it was horrible; I was the first person she saw on the first day of the inspection so I felt massive pressure...'* (Interview 1) '*In our school somebody got a 4 and it was like who was that and that's horrible - and in fact it was because he tried something and it didn't work…it's the rumour mill isn't it that goes around the school'* (Interview 2) *'I just really enjoy teaching maths, I like the challenge. Don't enjoy the pressure so much and trying to get the grades.*' (Interview 2) *'you could have an OFSTED inspector coming in and they could look at your style of teaching and the progress of the kids or what they perceived to be the progress of the kids - but they might not have a clue about whether what you have taught is right or wrong. The example of my friend who taught longitude and latitude the wrong way round but got an outstanding lesson - because the person wasn't a geography specialist'* (Interview 3) *'as a core PE teacher you are not valued amongst SLT particularly, because you do not contribute to the results whereas a maths teacher - is totally different - you know there is huge pressure but I love that'* (Interview 3)
Euan:	*'…when inspectors come they are looking for certain things. You do that lesson which is maybe not the standard teacher lesson and something goes wrong or maybe they don't show progress in 15 minutes whilst the inspector is in the room, is still that concern that you will be judged'* (Interview 2) '*Will it impact the college coming out all special measures, will it impact the maths department - so you have that fear of letting colleagues down'* (Interview 2) *'… the next inspection is the key one, the one that we have to do what they expect to see'* (Interview 2) '*I do honestly believe OFSTED is constraining good teaching because people don't want to take risks.'* (Interview 2) '*You talk to any teacher - at our school, certainly - and they will have that lesson up their sleeve which they will want to deliver when OFSTED come in and you hear them delivering stuff out of sequence because they know OFSTED is coming in*' (Interview 2) '*Now if OFSTED came in - the fear is there's looks like no teaching going on, no learning – see, you have to, I would never take the kids outside during an OFSTED lesson, I would never spend 10 minutes making paper hats to get to the point where they are learning something from that just because if something goes wrong either behaviourally or with an activity that takes longer - they come in they walk out - so you tend to do shorter activities and tend to fall back on - here's a concept,*

	right everyone understand that, here's an exercise, we'll check that, right let's move on. They see the kids learning something in 10 minutes, wow, tick - as opposed to a longer thing which they would learn more' (Interview 2)
Harvey:	*'Everyone is literally worried about OFSTED and making sure that when they come they look through books there's marking, there is regular marking showing progress, showing everything else'* (Interview 3) *'If you look around you in this department, people are breaking'* (Interview 3) *'I think this one has a better reputation than the other one and therefore I feel that's what they've got to keep up with'* (Interview 3) *'I think it is because I have been observed so many times by so many different people that I welcome it now, I don't mind it at all - in fact if OFSTED come in and don't see me I will be upset - having put all that effort in'* (Interview 3) *'don't get me wrong I still love the maths I would never go back to PE, I love the maths, I love the teaching, and if it was just the kids and the classroom it would be happy days… It's everything else that goes on in between, the assessment policies, the marking policies, … OFSTED, the extra stuff* (Interview 3)
Katy:	*'Ofsted was here in February - I wasn't observed - but I did feel anxious'* (discussion following LO6) '*Ofsted gave the College a 4 in February 2016.'* (Personal Reflections) *'For OFSTED I would probably put a little bit more effort in - no offence – you know it's got to be bells and whistles and everything hasn't it'* (Interview 3) *'I don't think it's* [professional development] *even on the agenda - they are so strapped for cash at the moment'* (Interview 3)
Janet	'*I mean we are teachers who work in institutions where we are inspected and observed and we are expected to produce neat exercise books where handwriting is nice and everything is underlined neatly and it is all beautifully done. OFSTED inspectors look at it and that is how we will be judged - um - that is really hard because if a child and you know - the classic year 9 top sets scruffy boy who has got it all there but absolutely does not see the point in writing down any working or doing anything if you have asked them to do - they understand it exactly, they probably understand it more than the nice, neat girl who is highlighting everything in pretty colours - but - still we have to live in the world where that is our evidence'* (Interview 1) *'We are in initiative over load. I think that is a big impact - Ofsted, staff well-being has gone out the window and we are expected to pick up this, this, and this initiative in an effort to be outstanding and it's not necessarily where we can see the benefit for the children.*' (Interview 1) *'I think there's initiative overload anyway…They don't let it get embedded first so…' (*Interview 1)

Table 6.15 Comments from Participants Regarding Ofsted and Other External Pressures

Bea and Anna missed part of the final face-to-face session for the inspection – during which their school moved from 'requires improvement' to 'good'; the decision for them being on the course in part to achieve this very outcome. Anna had felt '*terrified*' (Interview 1) at the prospect of letting anyone down and was desperate not to be observed: this stress is not uncommon (Iris Connect 2014). Harvey believed a significant difference between his 'original' school and his 'new' was the Ofsted status, his new school being determined to hang on to 'outstanding' and therefore less willing to take any risks and so stick to a more traditional test and label system into which he felt he needed to fit. (Interestingly the two schools' have very similar Progress 8 measures for 2016-2017, of around 0.2 (Average).) Darcy believed Ofsted drove the school's agenda, and therefore the teaching style, for achieving GCSE results. Euan's school was desperate to move out of '*special measures*' (Interview 1) and the school believed consistency of practice (including such detail as folding pages of exercise books the same way) would be the route to success; teaching differently, experimenting and taking any sort of risks were clearly not encouraged. Janet's school was heavily focussed on an upcoming Ofsted visit and she felt the school to be in '*initiative overload*' without any concern for '*staff well-being*' and with doubtful '*benefit for the children*' (Interview 1). Katy's college was assigned a grade 4 ('*inadequate*') by Ofsted which had the immediate impact of her being drafted in to teach more mathematics – the college in a fortunate position that Katy had previously organised retraining for herself. Cath's institution had been under the threat of closure for years – and Ofsted's '*decision*' always loomed large. Cath invariably worried if what she was doing was '*good enough*' (Interview 2), believing she needed to meet three separate ideals – what she '*should*' do to '*satisfy*' Ofsted, what she '*wanted*' to do to enrich the learning for her students and what she '*must*' do to '*get the girls a C grade*' (discussion following LO2). This distinction of needs, identified by Cath, is identified in the literature (Gunter 2007, Forrester 2005) and shows 'doing the best for the inspection regime' ultimately commands a higher status than 'doing your very best for the children' (Forrester 2005: 274).

It was common for the participants to say they would teach differently for an Ofsted lesson. Euan expressed the opinion that he believed Ofsted was still looking for certain things, all of which had to be demonstrated within the short segment of time an inspector remained in the classroom. He would not, therefore, spend time setting the scene or risk an activity which could potentially go wrong, if he was likely to be observed. Katy pointed out she would not teach a '*normal*' lesson if she were being formally observed – but instead a '*show*' lesson which would have taken hours of preparation, and created much stress (Interview 2). Janet, Cath, Bea, Anna wholeheartedly agreed with this sentiment. The idea that teachers teach differently for Ofsted inspections was suggested first by Euan but repeated by others: this suggests Ofsted inspections may actually diminish and constrain good teaching, as teachers are unwilling to take risks.

The focus and energy directed to forthcoming Ofsted inspections was also notable. The usual rationale for why initiatives or ideas were not being explored was '*because of Ofsted*' (Anna, Interview 2). Like Anna, most of the participants would very much have liked their schools to have been more engaged with *'collaborative planning' (*Interview 2*),* but acknowledged the schools' focus to be elsewhere, with Ofsted on the horizon.

At various times, Anna, Bea, Katy, Cath, Janet and Euan expressed their discomfort surrounding the practice of 'learning walks' – where a senior teacher, or teachers, briefly enter the room, at any stage of the lesson, observe a short segment of the lesson, talk to a few students about their learning, and then subsequently make judgments. Katy highlighted the anxiety she experienced at being judged (and graded), as too did Cath and Janet. Janet was wedded to the mythical idea of an approved Ofsted model lesson, this restraining her from moving away from a textbook heavy lesson and experimenting with other forms of delivery – nervous of getting it '*wrong*' (Personal Reflections). Cath too, was concerned that she might not be delivering what '*Ofsted wants*' if she moved away from ticking *'off a list of objectives'* (Interview 2) – and the pressure to keep the school open by pleasing Ofsted was immense. Being graded by senior teachers is still common practice, although it is no longer a component of an Ofsted inspection (GOV.UK 2018b). Anna, as a newly appointed senior teacher, actually became involved in conducting these performance management inspections. This was fascinating to observe. Previously Anna had regularly referred to feeling '*terrified*' at the prospect of formal observations; now she appeared to slip seamlessly into the role of passing easy judgments on others' teaching. The value of these type of observations was often questionable: Katy considered the observations – often conducted by non-specialist teachers - to lack '*quality or purpose'*, and the feedback to be '*poor*' (discussion following LO6); Harvey also referred to the lack of quality of feedback from non-specialist senior teachers; this concern was echoed by Janet, Euan and Bea.

The pressures of potential Ofsted inspections and the related practice observations, along with the tensions surrounding GCSE exam results was noted by all. Euan summed this up with: '*we just literally do not have time to breathe*' (Interview 2). Commonplace amongst the participants' schools was the practice of multiple extra revision sessions for Year 11 students – with varying pressures on the teachers to staff these sessions. Bea, now feeling her position to be vulnerable, felt she had no option other than to squeeze in the extra sessions, leading to her regularly teaching seven lessons a day. Darcy, keen to keep the competitive edge for her own groups' exam results was happy to deliver these extra sessions. Resisting 'the urge to squeeze every last hour of teaching' from teachers is advice given by the Sutton Trust Report (2015: 9); a practice which could be counter-productive if teachers are not provided the time and energy and to 'work on their practice' (2015: 9).

Pressure on school budgets was also identified as a constraint. Trying to balance reducing budgets is a real and significant concern for schools and colleges (Ofsted 2017). Professional development may now simply not be a priority – with many schools and colleges in precarious financial situation. Katy: '*professional development is just not a priority; I don't think it's even on the agenda… they [the college] are so strapped for cash'* (Interview 3).

6.4 Summary of the Successes and Limitations of Retraining

Fenstermacher and Richardson (2000) have distinguished qualities which illustrate the difference between 'good' and 'successful' teaching (2000: 6). In England, 'successful' teaching may be associated with a 'teaching-to-the-test' approach, whilst 'good' teaching can be seen to enrich the learning experience for students with the aim being for students to achieve deeper levels of understanding (see Chapter 2 for more detail). Several comments from all of the participants suggest that they now (at least at times) attempt to enact this mode of ‘good’ teaching – seeing it as a more effective practice. Not all manged to successfully do this, and most have struggled to sustain this practice over time - especially as the retraining became more distant.

Ofsted’s chief inspector, Spielman, has recently acknowledged that we have given ‘a great deal of our collective time to exam grades and progress measures’ and that good GCSE results don’t necessarily equate with a good education (GOV.UK 2017: 1). In the worst case scenarios, teaching to the test, rather than teaching the full curriculum, ‘leaves a pupil with a hollowed out and flimsy understanding’ (GOV.UK 2017: 2). In other words, ‘successful’ teaching may not always be indicative of ‘good’ teaching. Spielman also goes as far as to say school leaders are mistaking ‘badges and stickers’ for ‘learning and substance’ and gives a strong indication that Ofsted has a role to play in reversing this mindset to ensure learning takes ‘precedence over performance tables’ (GOV.UK 2017: 6).

This may be particularly pertinent for the participants. The gains from the retraining programme have been seen to be many, and for the teacher include: motivation; inspiration; new ways of seeing mathematics; enhanced personal skill levels; and awareness of quality resources. Similarly, for the students, deeper learning opportunities have been observed along with more motivation and resilience. However, a common concern amongst the participants has been whether there is impact on pupil exam performance. For some (most notably Darcy) and in some scenarios (most notably when under Ofsted-related stress) the pressure to be seen achieving 'results' has been the driver in determining teaching styles, often to the apparent detriment of teaching and learning. This may be where it is particularly important to invoke the ideas expressed by Fenstermacher and Richardson (2000), with the differentiation between 'good' and 'successful' teachers. Darcy, who very much teaches to the test, could be considered a 'successful' teacher but probably less so a 'good' teacher; her exam results are good but the confidence of her students and their levels of retention are low. Cath, on the other hand, could be considered a 'good' teacher - in terms of inspiring and motivating her students and giving them deeper learning opportunities (within the context of their lives) - and yet her students often fail to achieve the GCSE 'success' they crave.

The successes of the retraining process are highlighted with Harvey inspired to '*move into teaching mathematics full-time*' (Interview 2), believing he '*would never go back to PE*' (Interview 3), and Katy so inspired and reinvigorated, she decided against '*leaving*' the profession (Interview 2). Bea used the retraining as affirmation of her intentions to '*transform*' (Interview 2) the mathematics department and Anna, in her new role in management, appreciated how '*beneficial'* retraining could be (Interview 3). For Cath, the retraining seemed like a life-line – keeping her afloat in challenging circumstances. Euan and Janet were equally inspired – until they realised they would no longer be teaching mathematics. Being inspired led all to reflect upon and question their practice (Hafford-Letchfield *et al* 2007) – and in many cases, this led to richer and deeper learning opportunities for students.

Lesson Study, introduced during the retaining sessions, was highly regarded, with all claiming to have learnt '*loads*' (Cath, Interview 2) and all wishing to emulate something similar in their own schools. Cath's comment sums up the consensus view: '*the best professional development you could ever get - and that all teachers deserve*' (Interview 3). Mentoring and coaching were considered invaluable, with the detailed guidance providing the catalyst for many to take on the responsibility to effect change. With increased teacher confidence, came increased self-efficacy.

The limitations were also clear to see, the lack of prior subject knowledge, and the associated pedagogy, being the biggest obstacles for most. Some believed they had simply '*not done enough mathematics*' (Katy, Interview 1) to teach effectively; '*I could do it – but I couldn't necessarily teach it*' (Darcy, Interview 3). Darcy's point reflected Shulman's (1986) findings: Being able to do it for yourself does not equate to being able to teach it to others. This was demonstrated clearly by both Euan and Cath who, with strong mathematical prior attainment, worked hard to improve their pedagogical position, often reverting to '*teaching by telling*' if '*time was tight'* or if feeling '*under pressure*' (Euan, Interview 2). Anna, equipped with an A level grade C, '*struggled to remember'* the content (from 10 years previously) (Interview 1). Darcy also has an A level qualification, but '*only did the Intermediate'* at GCSE and needed to work hard at learning '*up to*' the GCSE grade A and A* material (Interview 3). Harvey, recognising his limited mathematical qualifications, embraced all professional development his 'original' school wisely placed his way. Katy and Janet openly acknowledged their lack of subject knowledge was a serious hindrance to teaching.

Retraining, as Watterson (2016) from the NCTL points out, can only be seen as starting place – sustained support and development are essential. Although enamoured by Lesson Study, all saw barriers to it being introduced in their schools, these often related to perceived Ofsted pressures; likewise, for mentoring and coaching. According to Berliner (2001) 'Desire, practice and coaching' are the essential ingredients to the development of expertise (2001: 466). Although teachers may be 'loaded with desire, [they] have few opportunities to practice or be coached' (Berliner 2001: 466). The coaching (and mentoring) stemming from this research project, was universally recognised by the participants to be of critical significance. Katy could not imagine how other participants of such a course were coping without it.

Without dedicated support, and without a recognition that retraining takes time, teachers may settle for getting stuck in the rut of being a basic level practitioner ('Level 1', as described by the Japanese model, see 2.2.3), possibly reverting to how they themselves were taught. Alternatively, they may cease teaching mathematics. Evidence of this was highlighted by Harvey reverting to a didactic approach at his 'new' school, and by Euan when under pressure. Katy, amongst others, cited that without any sustained support, it to be more difficult to teach mathematics as the retraining experience receded into the distance. Janet, Anna and Euan now no longer teach any mathematics.

External influences, including pressures from GCSE exams and the possibility of Ofsted inspections, may have also impacted on the teachers' scope to experiment and to develop. Most have felt constrained, at least at times, by their (or by their senior leaders') perceived ideas regarding what Ofsted wants. Department 'norms' may have detracted from progress – especially for Darcy working within the confines of an 'exam factory' ideal.

Another limiting factor, in terms of the teachers' development, *may* have been the style of the course delivery itself. Using principles of constructive alignment, the aim has been to model expert (Level 3) practice. Subsequent lesson observations of participants, conducted by myself and triangulated by my supervisor, suggest that an ineffective attempt of Level 3 style teaching *may* be less effective than simply Level 1 'teaching by telling'. Anna demonstrated this dichotomy – being eager for her students to engage with more creative, innovative and challenging teaching scenarios, but without a confident grasp on where to steer the learning. Harvey too, struggled to identify when his students were making limited progress. With Level 1 teaching, it can be argued that a student is receiving information; it is being transmitted to them. With an unperfected Level 3 approach, there is the possibility students make little or no progress. This is of course the long standing argument against the guided rediscovery approach to teaching mathematics (Ellenberg, 2014); teaching effectively this way is a highly skilled activity. As Skemp (1976) identifies in his debate concerning 'instrumental understanding' versus 'relational understanding', this approach can only be effective if learning behaviours and dispositions allow it. This is something both Katy and Cath regularly encountered with their students (and Euan with his lower attaining Year 10's): the students were resistant to being taught in any way that challenged them, they simply wanted more of what they had previously experienced to date, and to be told what to do (even though this approach had previously 'failed' them).

Murphy (2015) disclosed similar experiences: Teachers on the TAM (Teach A Level Mathematics) programme have proclaimed they wish to teach like Murphy (precisely the sentiment Janet addressed to me) – yet fail to do so. The fact that experts, in any field, can make their trade look deceptively easy does not necessarily help the novice master their craft. The participants may have benefited from more reflection, in regard to what newly retrained teachers could realistically achieve. Recognising the need for an extended period of retraining, Darcy and Harvey both used the TSST Core Maths programme in 2014-2015 (GOV.UK 2018a) as an additional year of study; and Katy repeated the GCSE year in 2017-2018 under the TSST umbrella (GOV.UK 2016b).

The 100 hours of face-to-face tuition appears to have been insufficient to master a Level 2 (or Level 3) approach to teaching. More time for teacher collaboration and professional development - which slow down and examine the modelling process, so by making the expert's knowledge visible and open and understood (Hiebert *et al* 2002) - was suggested by all. Time to develop expertise is certainly a significant factor, with Turner (1995) suggesting it takes 4 to 5 years to simply learn the trade, and this not even to be exemplary.

Murphy (2015) finds it is not unusual for teachers at the start a TAM course to express the opinion that they are a good teacher because they are *not good* at maths and so can empathize with students, but that this sentiment shifts; by the end of the course they believe they are a good teacher because they *are good* at maths. Something similar was the case with Katy. Katy wrapped her limitations of lack of expertise with the cloak of empathy - believing she could help her students more *because* she could appreciate their struggles. Wenger (1998) describes this as teachers needing to accommodate their contribution in order to legitimize their participation within a community. Crisan and Rodd (2011) encountered this exact scenario amongst their case study teachers (as described in 2.4.2). Katy's students surprised her when they revealed that they valued expertise above empathy. Katy, now keen to enhance her expertise, has enrolled for a further year of retraining to become a '*better teacher'* (Interview 3).

Plymouth University - as is common for many providers of teacher retraining - provides certification on completion of a course. Certification, so valued by all, could actually create issues. Certification implies qualification but what are these teachers qualified in – or for? We could be creating an even bigger problem, with some certified semi-skilled mathematics teachers filling the void of teacher vacancies but not filling the gap in expertise. We might collectively convince ourselves we have solved the shortage of mathematics teachers - when all we have done is satisfied a head count; 'it remains true that the lack of good qualifications must seriously limit the efficiency of teaching' (Howson 2002: 81).

The final chapter - which draws on all the analysis to address the research questions and to suggest further propositions for future retraining programmes - follows next.

Chapter 7: Conclusions

7.0 Review

Back in 1982, Cockcroft identified the inadequate supply of competent mathematics teachers. Acknowledging the limitations of graduate recruitment, Cockcroft concluded: ‘any improvement in the standards of mathematics in schools must come largely as a result of the efforts of those teachers who are already in post’ (1982: 217). The recommendation for these teachers to ‘receive all possible support’ (Cockcroft 1982: 217) to improve the effectiveness of their teaching, can be seen to be the catalyst for government retraining initiatives such as the MDPT, the SKE+ and latterly TSST; each version of which has progressively become more contracted in scope, time and budget.

The question of whether a non-specialist teacher can become a specialist teacher is a difficult one to address, as the definitions of each are often nebulous. Nevertheless, some of the participants did offer various perspectives: Darcy believed she would feel more like a ‘*proper maths teacher*’ (Interview 2) when all the students who had known her as a PE teacher had left the school; Harvey felt moving schools helped him to identity more readily as a mathematics teacher; whereas others (Anna, Janet and Katy), concerned with issues of inadequate subject knowledge, were unsure if they would ever feel ‘*fully-fledged’* (Anna, Interview 3).

From this study, a particular finding is that the participants, all of whom are experienced and in some instances senior teachers, appeared to exhibit some very similar patterns of behaviours as to student and novice teachers, described by Berliner (2001), so supporting Ingersoll's (2002) proposition: Highly qualified teachers, may actually become highly unqualified if they are assigned to teach subjects for which they have few qualifications or training. Common behaviours observed, and which reflect Berliner's (2001) findings, include: the participants being 'inflexible', and sometimes ignoring or restricting interesting points made by students, 'letting teachable moments go' (2001: 475); 'Fear and inadequate cognitive resources' (2001: 476) preventing the teachers from doing otherwise. The participants were often incapable of 'in flight' decisions' (Berliner 2001: 475), and usually 'stayed close to lesson plans' (2001: 475), static teaching, rather than dynamic, being the norm; many described not being able to 'understand all that was happening in a classroom while it was happening' and felt 'cognitively overloaded' (2001: 475). And it was common for the participants to struggle to 'accommodate a range of learner skills and abilities' (Berliner 2001: 474). All, at times (bar Bea), referred to simply not knowing 'enough of the topic to discuss it freely' (Berliner 2001: 475). Only Bea regularly demonstrated the flexibility to regularly '*live teach*' (Bea, Interview 3), a kind of 'plan independence' demonstrated by experts when teaching in areas of their pedagogical strength (Berliner 2001: 475, Schempp *et al* 1998).

The participants exhibited typical behaviours to those of novices, yet were expected to perform at a commitment level commensurate with their years of teaching experience. This then may explain why the participants believed they faced an additional work-load burden, compared with their contemporaries working within their specialisms; Cath: '*sometimes the only way when you feel bad is to try harder or try and do something differently so yeah - more hours of planning… hours, honestly*' (interview 3). The time for preparing mathematics lessons and searching for appropriate resources appears to be comparable to that for novice teachers.

Professional development programmes, to retrain teachers, *may* help mitigate some of the issues faced by teachers teaching-out-of-field (TOOF). The research question, and the associated subset of questions, were designed to explore these issues and probe the impact of retraining:

Does retraining teachers (in the way described (see Chapter 3)), provide a means to help meet the demand for competent teachers of mathematics?

- *Can the part-time retraining course, delivered as described, affect change in teachers' subject knowledge and mathematical pedagogy?*
- *If so, what are the successes of this retraining and what are the limitations?*
- *What factors affect whether any changes are sustainable, and so become embedded in long-term practice?*

The themes analysed in the previous chapter provide detailed evidence to address these questions. The answers are, of course, complex and variable. Retraining teachers can clearly be seen to affect teachers' practices – but the extent and longevity of these developments depend on a multitude of factors, many beyond the control of an individual teacher.

All participants could be seen to develop subject knowledge, evident from the online assessments and from participant comments. The reach and depth of this new knowledge appeared to be dependent on the participant's starting point. All participants described a developmental process in terms of pedagogical practice (see 6.3.1) with teaching practices demanding deeper thinking and understanding from students. Other successes of retraining may have been many, including: motivating, inspiring and retaining teachers within the profession and the impact on student experience. Harvey, Darcy, Bea and Katy would now favour teaching mathematics, as they feel they are now making more of a difference to young lives, with *'much more impact, much more impact'* (Darcy, Interview 2); this lending weight to the argument that 'mathematics matters most' (see 2.1.3). But there have been barriers and limitations too, and the development of teachers' practices has been stymied by short-comings in in-depth subject knowledge and a complete absence of ongoing support. The factors affecting whether any changes are sustainable in terms of the embedding of practice, reflect these limitations. The suggestion from Katy that: '*it was harder to teach maths the further away from the course we got*' (discussion following LO6), may imply her environment was limiting her ability to sustain any changes in practice previously developed (McKinsey 2007). Bea also believes the course would have more sustainable impact if professional support continued in subsequent years. The solution suggested by both Katy and Bea - and endorsed by others - is for professional support to be maintained post retraining, to provide opportunities to continue to develop as a teacher of mathematics. It appears more time, space and opportunities for further professional development may be needed for changes in practice to be sustained (Boyle et al 2005) and so embedded in everyday practice. Continuous professional development models could include mentoring and coaching, and collaborative practice such as Lesson Study (Boyle et al 2005, Doig and Groves 2011). Mentoring and coaching were considered hugely valuable by all the participants, but there was consensus of opinion in terms of questioning where this expertise could come from - given the shortage of specialist mathematics teachers. Collaborative practice, along the lines of

Lesson Study, was equally valued by all but with very limited opportunities to emulate back in schools. Without on-going support, progress for teachers may be impeded – or indeed reversed. Cath experienced this eventuality, in terms of feeling like she was once again struggling on her own. Follow-up sessions might quite simply be essential for development to be sustained in the long term (Cockcroft 1982). Watterson (NCTL) appeared to reflect this sentiment when she acknowledged a range of professional learning opportunities should be promoted post retraining (conversation with Watterson 2016).

Post the professional development programme, the retrained participants identified issues surrounding: subject knowledge and a lack of confidence with delivery; inadequate opportunities to observe other mathematics teachers; a sense of isolation; limited collaboration; anxiety and stress linked to external influences; minimal ongoing support from senior management. The question could be posed which of these issues present as essential 'needs' for a retrained teacher, and which as 'wants'; detailed consideration of which could require further study. From the data and the literature reviewed (see Chapter 2) there is evidence to suggest that subject knowledge and sustained professional support are essential 'needs'.

Some senior leaders (with most significant impact on Anna, Cath, Euan, Janet and Katy) appeared to underestimate, or simply not acknowledge, the magnitude of teaching out of field. The tailored mentoring and coaching, experienced by *only* the participants (as a result of this study), appeared to alleviate, in part, some of these issues. Enhancing the retraining provision for all teachers and tackling what comes next – after the completion of such a programme – may be key in determining the long term success of such initiatives.

The overarching question considers whether retraining, can be a long-term solution to the government's ongoing crisis surrounding the shortage of effective mathematics teachers; the evidence I have suggests this *could* provide part of the solution *if* a series of enhancements are embraced – these detailed in 7.1 below.

7.1 Propositions

In the light of the findings from this longitudinal research study, outlined in the previous chapter, a series of propositions (as typical from a grounded theory approach) are presented. These are connected within themes and *may* prove to be valuable for future retraining programmes.

7.1.1 Subject Knowledge

Pinpointing a pertinent issue, Janet realised the need to have mastered the subject content for herself before she could master how to teach it; it is this mastery of the subject which is so pivotal (Shulman 1986). Without having previously mastered the subject, and in some cases with very limited prior subject knowledge, participants managed as best they could. Janet referred to the idea of doing '*pre-learning'* (Personal Reflections) prior to a session, along the lines suggested by Bloom (1984), and Katy attempted to immerse herself in the subject.

A need for participants to be immersed in doing mathematics, so subject knowledge could be assimilated rapidly, quickly became apparent. For students to achieve the high standards currently being demanded of them, teachers need to be expert enough to support them (Garet *et al* 2001). For this, teachers should have high levels of subject knowledge and ‘must be immersed in the subjects they teach’ (Garet *et al* 2001: 916, Boyle *et al* 2005). The current online tests alone may be insufficient to assure these high levels of subject knowledge are secure and embedded. Euan, having achieved 100% on all online tests, referred to his knowledge gaps: ‘*I had forgotten a lot of it since doing the on-line tests*’.

To procure enhanced subject knowledge, teachers should also be immersed in *teaching* mathematics (Ball and Bass 2000, Berliner 2001, Jacob and Rockoff 2011, Garet *et al* 2001). This immersion can mean more rapid accumulation of the all-important pedagogical content knowledge (Ball and Bass 2000). Jacob and Rockoff (2011) discovered that, as expected, teachers improved in their first few years of teaching, but that there were greater improvements for those teachers who repeatedly taught the same year group, year after year. In other words, teachers developed more quickly when they could focus on a narrow target audience, and so have the opportunity to repeat-teach similar lessons over and over again (Berliner 2001).

Being immersed in teaching mathematics also appears to be an indicator of success in terms of retention; the teachers who were least immersed and taught the fewest mathematics classes (Euan, Anna, and Janet) no longer teach mathematics.

It does appear that a certain threshold of knowledge and experience needs to be reached before complete immersion can be invoked; and for a teacher to feel that they can cope with the new demands (Berliner 2001). This was particularly the case for Janet and Katy.

Berliner (2001) found that novice teachers preferred to repeat-teach the same lesson, giving an opportunity to 'iron out snags' and 'polish' the original and so be better prepared for next encounter (2001: 474). The participants echoed this sentiment, pointing out that teaching parallel groups (or similar) is ideal. Knowledge, which is usually built up over time, as teachers reiterate the teaching of topics to different groups (Ball and Bass, 2000), can be assimilated more quickly with immediate repeat-teaching opportunities. Repeat-teaching can also help reduce the demands on time for planning lessons 'out-of-field' – and so reduce stress and anxiety.

Proposition 1:	Participants should aim to become immersed in teaching mathematics and teach mathematics full time where possible; the exception being when participants have yet to achieve a threshold of subject knowledge alluded to above. Teachers to teach parallel (or similar) mathematics groups where feasible, enabling immediate development and reflection on teaching.

Many studies of mathematics teacher practice have promoted the idea of teachers doing mathematics themselves as key for professional growth and development (Miyaawa and Winslow, 2017). There was general consensus among participants that they just needed to do more maths; this being key to their developing ‘Foundation Knowledge’ and ‘Transformation knowledge’ (Turner and Rowland 2006).

Whilst acknowledging that immersion, and immersion into teaching the subject, are significant – there seems little doubt that continuing deliberate practice is essential. That is, deliberate practice along the lines outlined in 2.2.1, with well-defined goals, strategies, direct instruction and reflection (Ericsson and Pool 2016, Stobart 2014). Simply doing more mathematics - or teaching more mathematics - in isolation, is insufficient to continue sustained improvement and for developing the ‘connection knowledge’ and ‘contingency knowledge’ discussed in 2.2.1 and 6.3.1 (Turner and Rowland 2006). For this, ongoing professional development is required. Reducing the teaching commitment for newly retrained teachers, to accommodate the demands of further professional development *and* for planning and designing mathematics lessons ‘out-of-field’, could (as is commonplace for novice teachers) be provided for newly retrained teachers. According to one head teacher, this would be ‘*pragmatic in an ideal world*’ but unlikely in the ‘*real word’* (Headteacher interview, Venue 2, September 2015). Instead, he suggested there should be a commitment to ongoing mentoring and support for these newly ‘*up-skilled*’ teachers.

7.1.2 Mentoring and Coaching

The success of the mentoring and coaching for the participants has been well captured; numerous forms of positive feedback have been collated. All found the process developmentally helpful; none wanted it to end.

Mentoring and coaching can help expose a teacher's level of awareness about their own practice of teaching mathematics, and to reflect upon, and explore, their own beliefs (Ernest 1989, Hafford-Letchfield *et al* 2007). Without exception, during their own school days all the participants were taught in a didactic fashion; all expressed a desire not to teach solely in this manner. Cath described the fear she felt whilst in mathematics lessons at school and hopes for the polar opposite for her students. Mentoring and coaching can help guide teachers to enact a ‘script’ for their students, different from the one with which they are most familiar (Stigler and Hiebert 1999). During this study, mentoring and coaching were also used to highlight and address the successes and limitations of each lesson – following developmental observations (Boyle *et al* 2005). Turner and Rowland (2011) also found considerable evidence that participants’ content knowledge for teaching developed through ‘focused reflections on their mathematics teaching’ (2011: 209), supported by a ‘knowledgeable other’ (2011: 211).

The value of developmental lesson observations, as opposed to those for performance management or Ofsted, was highlighted by Katy, and echoes Coe *et al* (2014), Hobson *et al* (2015) and Wragg (2012). From 2017 onwards, participants engaged with the Plymouth University model, have been offered a developmental lesson observation as part of their retraining. This is an optional additional feature. Evidence that teachers would embrace this opportunity came from Freeman (2016), working with Cambridge TSST participants. Freeman (2016) offers confidential and developmental observations, and the participants report the experience to be '*non-judgmental', 'valuable'* and *'powerful*'. The non-judgmental approach chimes with the ethos promoted by Bowland (2014a, 2014b), to observe others in a 'spirit of mutual development and professional learning - it is not a tool for teacher evaluation' (2014a: 2).

Establishing a '*safe*', supportive environment was key for the success of the mentoring and coaching (Robbins 2006). Participants valued the sense of *'not being judged*' and of the positive relationships we forged; the teachers felt they could honestly express themselves. Renshaw (2009), Anthony and Walshaw (2009), (Renshaw 2008) and Wragg (2012) articulate the significance of building rapport to encourage this open and honest dialogue, and for the need for: 'trust, respect, approachability, empathy' (Renshaw 2008: 39).

Proposition 2:	Robust, non-judgmental developmental lesson observations should be used to identify areas of subject weakness; the subsequent mentoring and coaching sessions should be used to extend and develop teachers' subject knowledge and pedagogical skills (Boyle *et al* 2005).

Embracing Wragg's advice, that if lessons are 'worth observing then they are also worth analysing properly' (2012: 2), all observed lessons in this study received proper critique and feedback – both verbal and written; both formats were highly valued by all.

Proposition 3:	Both verbal and written feedback should be provided. The teacher should always be invited to reflect first, in an open two-way discussion; the teacher should be given the right-to-reply for any written feedback.

The requirement for a school-based mentor would emulate the criteria for the MDPT - which *required* a school-based mentor (Crisan and Rodd 2011). However, several participants expressed the concern that there would be no one '*in-house*' who could fulfill the role of mentor; no one who was skilled and qualified to do it – with both sufficient subject knowledge *and* teaching expertise, and also with appropriate and rigorous mentor training (Carter 2015). Another limitation posed by a mentoring and coaching model, could be the danger of developing a dependency culture – with a recently retrained teacher dependent on the mentor's expertise; something which could not be sustainable over time. However, it is suggested that new teachers 'can best be *retained* by offering long term support for professional development' (Hammond 2002: 147) and this could equally well apply to newly *retrained* teachers. Collaborative practice, along the lines of Lesson Study, may offer a more sustainable model of professional development, with teachers 'actively in charge of their ongoing learning process' (Fernandez et al, 2003: 182).

7.1.3 Collaborative Practice

Lesson Study could suggest a sustainable solution for providing subject knowledge and pedagogical development (Williams 2008; Fernandez et al 2003, Perry and Lewis 2009). The essential ingredients for the long term success of a retraining programme may be seen to be reflected in the likely benefits of Lesson Study:

. opportunities to work alongside specialist colleagues;

. subject knowledge enhancement;

. improved quality of lesson plans and the sharing of rich resources;

. increased opportunities to observe colleagues;

. introduction of professional networks;

. opportunities for issues of confidence, motivation and sense of efficacy to be addressed

(Boyle *et al* 2005).

Hodgen (2011: 39) does however question the value of Lesson Study in western contexts and instead suggests more general collaborative practice, for example collectively: 'constructing pedagogic strategies, examples, tasks, etc. that enables students to do and learn mathematics' (2011: 39).

Lack of opportunities for participants to observe mathematics lessons was a recurring theme throughout this research project, and one which is commonly reported (Wragg 2012, Gore 2013). Collaborative practice with the integral element of lesson observations *and* the involvement of a 'knowledgeable other' to mitigate any less than best practice shared could benefit many. It has also been suggested non-specialist teachers should observe mathematics lessons to be able to absorb the culture of a mathematics classroom as out-of-field teachers typically do not understand ‘the culture of the learners’ (du Plessis 2017: xiv).

Proposition 4:	Applicants for a retraining programme should be provided opportunities to observe mathematics lessons prior to commencement of the course and throughout the duration of the programme. Lesson Study could provide the vehicle for this.

As Stigler and Hiebert (1999) point out, teachers will come and go; teaching styles and standards persist. These standards therefore need to be perfected. Mckinsey (2007) encapsulates this by comparing an outstanding American teacher with an outstanding Japanese teacher: when the American retires, ‘almost all of the lesson plans and practices that she has developed also retire’; when the Japanese teacher retires, ‘she leaves a legacy’ (2007: 31). Lesson Study could provide a model to perpetuate these legacies. For this, a supportive stance from senior management appears essential.

7.1.4 Senior Management Influence

Mathematics is not an easy subject to teach; it follows that non-specialist teachers ‘can be especially in need of support, particularly in schools in which the standard of mathematics teaching is not high’ (Cockcroft 1982: 215). Without such support, these teachers are ‘liable to find themselves falling back on a narrow style of teaching’ rather than working in the ways which ‘have been advocated during their training' (Cockcroft 1982: 215). And yet, teachers often struggle to attain release time for training, and therefore struggle to be properly supported:

> 'Losing class time with high stakes exam classes is not permitted and funding is not available to support attendance to training events. We have experience of even free high quality training events being cancelled due to lack of delegates, not because the teachers did not want to attend but because they were not allowed to by their schools.'
>
> (Parliament. House of Commons Education Committee 2017: 20)

It may be shocking that so few advancements appear to have been made since Cockcroft's 1982 report. In fact, The Sutton Trust (2015) suggest: 'it should shock us all that many of today's teachers do not benefit from the professional learning they need and deserve' (2015: 2). Schools *with* effective support programmes are apparently the 'exceptions not the rule', and too often the learning of our children is entrusted to teachers who 'do not themselves have high quality learning opportunities' (Sutton Trust 2015: 2).

As to why senior teachers are sometimes unwilling to properly embrace and support professional development, Darling-Hammond (2006) explains:

> 'Much of what teachers need to know to be successful is invisible to lay observers, leading to the view that teaching requires little formal study and to frequent disdain for teacher education programs. The weakness of traditional program models that are collections of largely unrelated courses reinforce this low regard.' (2006: 1)

This is not to suggest senior leaders are lay-people, but rather they may be oblivious to the intricacies, and nuances, of teaching mathematics as a non-specialist teacher. Here, there is also a reference to short and disjointed training courses which may have minimal impact, a point Wiliam (2016) addresses, acknowledging these traditional overtures to training may 'have been relatively unsuccessful' (2016: 35).

Professional development is seen to be most successful when embedded in a wider culture of enrichment, encouraged by effective leadership (GOV.UK 2016e). If retaining teachers is a part of this vision, then sustained support must also be embedded within this picture; extensive and long term deliberate practice is needed in order to achieve expertise (Stobart 2014).

Proposition 5:	Sustained professional support should be coupled to any retraining programme; without such, the long term effectiveness of professional development will be 'greatly diminished' (Cockcroft 1982: 226).

Berliner (2001) highlights 'the power of context' and that teachers will perform differently depending on the 'organization of a school and its climate'; the 'working conditions of teachers exert a powerful influence on the development of expertise' (2001: 466). Given the right support 'most people currently teaching could be as good as the very best teachers if they work at it' (Wiliam 2016: 6).

With no globally agreed definition of what constitutes being the 'very best' (or being an expert), defining what is 'effective' teaching continues to be an ongoing challenge. The TALIS Video Study 2018 (OECD 2016b) is attempting to reveal what effective mathematics teaching may look like on an international stage and is attempting to understand which aspects of teaching relate to student learning and behaviours. Motivation, attitudes, engagement, context and human relationships are all to be considered. Teaching is undoubtedly an 'extremely complicated interaction of many human characteristics' and attributes (Berliner 2001: 465) and is clearly culturally and contextually dependent. Context has been proven to be a significant factor when considering expertise, and one often overlooked (Berliner 2001). The ethos, conditions and climate of an institution can ‘powerfully affect teachers’ attitudes, beliefs and enthusiasm, sense of efficacy, conception of their responsibilities, and teaching practices’ (Berliner 2001: 466). Traditionally much has been invested in the idea of expertise residing in singular persons, and being of something we can observe and emulate. Harvey identified the limitations of this: ‘*I see good teachers and when you try and replicate what they do it’s incredibly difficult because what works for them doesn’t necessarily work for you’* (Interview 1). Expertise may then be a combination of ‘the person and the environment’ (Berliner 2001: 466). It is true people may be selective and choose their environments carefully, aligning self with systems, but this is not always so; teachers being directed by their senior leaders to teach a new subject could exemplify how one occupies a potentially unexpected environment. The idea that expertise can be enhanced - or indeed diminished - by the environment is a powerful one, and one which has been clearly highlighted by Darling-Hammond (2014) and others (Campbell *et al* 2004, Wragg 2012, Kyriakides *et al* 2013, Wiliam 2016); when greater recognition is given to this idea, some senior management teams *may* choose to reflect on their current support systems.

Barmby (2006) highlights the negative impact of work-load on recruitment and retention rates of teachers in shortage subjects, such as mathematics. Teaching outside an area of specialism creates *additional* work-load and teachers, in this scenario, are more likely to leave (Staufenberg 2017). Effective professional support systems, which can empower teachers to ‘feel that their workload is more manageable' (Parliament. House of Commons Education Committee 2017: 18), may therefore be most critical for non-specialist teachers.

Ofsted (GOV.UK 2018b) has directed schools to identify and tackle any inconsistencies in the quality of mathematics teaching (see page 17). Senior leaders may need to address this concern, in relation to their retrained teachers, and find ways to support and further develop these teachers. Expert practitioners can enhance future outcomes for their students and this links to my personal experience, shared in Chapter 1. The reverse is also true: Without properly trained and supported teachers, there is a risk to social mobility (GOV.UK 2017, Marshall 2013, Smith 2017b, Cockcroft 1982).

7.1.5 The School/Department Effect

Expert practitioners have a good deal of independence of others; their experience and expertise give them autonomy in terms of their choice of style, content and pedagogy (Ernest 1989, Schempp *et al* 1998, and Henry 1995). Novice teachers, on the other hand, have no such autonomy, often dependent on their environment – their team and colleagues (Ernest 1989, Schempp *et al* 1998, and Henry 1995). Newly-trained teachers are often receptive to the mode of practice (the department 'style') in which they are immersed, and can become moulded, or cloned, in this style (Ernest 1989, Burghes and Robinson 2010). This was also the case, to a greater or lesser extent, for all the retrained participants.

Strategies for overriding the department socialisation effect is particularly critical when there is a lack of expertise within the department and 'in schools in which the standard of mathematics teaching is not high' (Cockcroft 1982: 215). Janet was sure her department fell into this category, as too were Euan and Katy. Cath had no department to speak of and Darcy was directly influenced by the exam culture of her school. Expert influence is essential: Higher levels of reflection and evaluation, facilitated by professional support systems, may lead to a teacher's teaching practice being more closely aligned to their beliefs (Ernest 1989) and to the practices promoted 'during their training' (Cockcroft 1982: 215). This may then lead retrained teachers towards the 'autonomy' of expert practitioners (Ernest 1989: 6).

Maintaining the support network established during the retraining, with opportunities to review new resources and research, was requested by all the participants. Euan made a clear case for refresher, or '*top-up'* training. Darcy and Harvey used the Core Maths TSST for this purpose, and Katy has enrolled again on a GCSE retraining programme (GOV.UK 2018a).

7.1.6 External Pressures

It was typical for the participant teachers to be graded, following lesson observations by senior leaders. It is perhaps not surprising then that few participants were aware of the new Ofsted inspection criteria: 'Inspectors do not grade individual lessons' (GOV.UK 2018b). The unnecessary in-house grading of lessons can place additional stress on teachers teaching outside their areas of specialism; as too can performance management (Hobbs 2015).

Several participants frequently referred to this stress. The Parliamentary report on ‘Recruitment and Retention of Teachers’ (Parliament. House of Commons Education Committee 2017) has recently requested Ofsted to ‘do more to dispel any misunderstandings of its requirements and promote good practice by monitoring workload in its school inspections’ (2017: 19).

Several participants were concerned that the demonstration lessons they observed (of me, during the retraining) did not conform to a particular style or format approved by Ofsted; many were of the impression Ofsted require a certain style – and would adjust their teaching accordingly during inspections. Ofsted inspections may therefore be seen to distort teaching approaches. There is no doubt the educational cuts, with schools facing 8% reduction in real terms by 2019-2020 (National Audit Office (NAO) 2016) have placed additional pressure on school budgets. Katy empathised with her college’s predicament. Nevertheless, without sustained support of retrained teachers, the initial expenditure may well be compromised at best, wasted at worst. In terms of who would pay for this support, Bea was sure it should be built ‘*into the contract for schools’;* Schools should be told ‘*we are giving you this for free but you need to pay so much for the next two years for training’* (Interview 4). The warning from Cockcroft was clear: Without the will to make the necessary financial provision, insufficient ‘opportunity to influence and improve the quality of mathematics teaching’ would result (1982: 229).

With ‘academisation’ has come the autonomy for schools to direct their teachers to work additional hours. Bea and Darcy were both engaged in teaching extra sessions – breakfast, lunch and after school. A shortage of mathematics teachers seemingly placing additional pressures on those in post. The negative impact of such practice on younger pupils was reported by participants.

7.1.7 Summary of Findings

The research has closely followed eight teachers over several years, capturing numerous 'stories' and exploring various rich lines of inquiry. In summary, these are the essential findings:

- The participants exhibited very similar teaching behaviours as to novice teachers. This appears to be neither anticipated nor accommodated for, by school leadership teams.
- All participants were expected to teach at a commitment level commensurate with their general years of teaching experience; no allowances were made for the need to master a new domain.
- Subject knowledge weaknesses remain widely reported by participants.
- Many participants developed a greater understanding and appreciation of mathematical pedagogy during retraining – becoming aware of the differences between *doing* maths and *teaching* maths.
- All participants attempted to emulate the pedagogical practices promoted during retraining – designed to elicit deep thinking and develop deep understanding amongst students.
- Most participants described a growing appreciation of the benefit of using misconceptions for teaching and learning, and the importance of making and revealing connections within mathematics.
- Participants believed they were more confident teaching mathematics as a result of retraining - stemming from pedagogical subject knowledge growth.

- All the participants viewed mentoring and coaching as a powerful influence for professional change in terms of them realising for themselves what could be improved and enhanced. There was also wide recognition that there were limited resources to replicate this form of support in schools.
- All participants embraced the idea of professional development by way of Lesson Study; none was seen in any of the participants' schools.
- Senior leaders generally appeared indifferent or uninterested in the retraining process and outcomes. No further developmental opportunities were offered.
- Many participants found the pedagogical practices promoted during retraining did not match the everyday practices of their department; many commented on it becoming more difficult to teach mathematics as the influence of the course receded in time and memory.
- All participants believed outside pressures, most notably Ofsted, negatively impacted on their pedagogical practice.
- As of 2018, four of the 8 participants no longer teach any mathematics. Euan has resigned from the profession; Janet recognised she did not have sufficient levels of subject knowledge and was reassigned to Business Studies; Anna and Bea have both been redeployed back to Science (and other non-specialist teachers without any retraining have taken their places in the mathematics department).
- Of those who remain teaching mathematics, none wished to return to teaching their original subjects, expressing the belief that teaching mathematics has the most impact on students.

- All four of the remaining practising teachers have self-sought and embraced additional professional development opportunities during twilight and/or holidays: Katy repeated the training under the TSST umbrella; Darcy and Harvey completed the TSST Core Maths; and Cath joined a Plymouth University initiative to observe maths lessons in Finland.

So can *'retraining teachers (in the way I have described and delivered), provide a means to help meet the demand for competent teachers of mathematics'?* There is evidence to suggest it may in part; it could provide the *start* to equipping some teachers with skills and knowledge to become teachers of mathematics but further support appears necessary to support and retain the newly retrained teachers.

7.2 The Impact of the Research to Date

Working as a course tutor for the Plymouth retraining models during the lifespan of the research project, I have been in a position to disseminate the emerging themes at many project meetings. Feeding into the Plymouth model: the significance of pedagogy (and the modelling of demonstration lessons); the need for foundation subject knowledge for some participants (and the introduction of Strand 0); the demand for a second year of retraining (for which the Core Maths TSST has been used); the advantages of mentoring and coaching (and the optional offer to provide this service); the need for course providers to adhere to specifications and to commit to being independently evaluated. The latter have contributed to the decision by the NCTL (at the DfE) to introduce the minimum specifications for TSST (see Appendix O) and to evaluate all retraining courses. The minimum specifications may appear a little too *minimum*, but previously providers have been able to offer *no* face-to-face instruction. The Plymouth University model has been recognised by the NCTL as an exemplar model and one of the more rigorous models available, with Burghes (2015) frequently invited to contribute at NCTL TSST meetings.

In short, the Plymouth model, supported by the evidence from this research, has had an influence at national level and has informed NCTL policy decisions. The NCTL has also expressed an interest to have access to the final findings of this study. Educational research is frequently criticised for having no impact on educational policy; there is some hope that the recommendations listed here, will at least be examined.

7.3 Limitations of this Research

Evidence for this research is drawn from participants who were keen and reflective volunteers, committed to the retraining programme. Their principle reason for agreeing to take part often mirroring that found by Davis and Simmt (2006): 'to be more effective mathematics teachers' (2006: 299). Comments from participants reflect this sentiment:

Cath*: 'for my own personal development really, because I think … that will help me um… I think, you know, it can only be a good thing…in your probing questions - I learn from…I have been really happy to take part, it hasn't felt uncomfortable, it's kept me thinking about that time I had on the course and how valuable it was, that you know it is ongoing'*
(Interview 3)

Harvey: 'I thought it would be what it is - you coming to see me and then giving me help, I was very much at point where I wanted all the help I could get –um- I loved the whole day [retraining] sessions… and then doing the study has just given me an insight into me as well and how I teach…'

(Interview 3)

It is feasible these participants are atypical of many retrained teachers, as several have A level mathematics, three have been able to take advantage of a second year of retraining and all have experienced three years of mentoring. All, also, invested emotionally in the process, with the mentoring and coaching enabling and strengthening the human connections; connections which can enhance and promote effective teaching and learning (Cockcroft 1982, Anthony and Washaw 2009, Porkess *et al* 2011, Coe *et al* 2014).

It is possible that the study itself provoked participants to greater depths of reflective practice; as alluded to in 4.5.2 (Interviews), many participants appeared to subsequently become engaged in their own lines of enquiry. This introspection may have led to a greater awareness, and desire, for perceived needs, a desire which otherwise (and for other participants in other circumstances) may have remained dormant.

The design of the retraining programme was also impacted in a way which may otherwise not have been possible without a concurrent research study. Open and regular dialogue from, and between, participants facilitated fine tuning and adaptations to the programme (see 4.5.2).

With allegiance to the programme, and to the tutor, participants *may* have inflated the impact factors (Browne 2006). Of the 150 or so other teachers I have retrained, few have A level mathematics and none have received tailored mentoring and coaching. The research participants could therefore be considered more likely to make a successful transition to mathematics teaching than most; other cohorts of retrained teachers may face increased issues.

It could be argued that teachers being retrained are likely to have been assigned to teach mathematics anyway – with or without the retraining. In that regard and in that context, any retraining could be considered a success, and any limitations of little (or less) relevance.

The findings may not be relevant for the new government funded retraining courses. The new TSST courses are significantly less well funded, resulting in a dramatic reduction in face-to-face tuition – for subject knowledge and for pedagogy. Now mostly delivered in twilight hours, with no funding for day-release cover, the disincentives to attend retraining are significant – childcare logistics and expense, proving particularly problematic.

The participants were reflective and self-motivated practitioners, determined to develop. Without such intrinsic motivation, the findings from this research – the successes and the limitations – may have been quite different.

7.4 Suggestions for Further Research

In 2004 the Smith inquiry found it very frustrating not to be able to paint a clear picture of the current and future needs for mathematics teachers in schools and colleges, due to the poor quality of data available. With retrained teachers populating mathematics departments, this may become an even more difficult but significant task: to research the current and future needs for retrained teachers. Linking with this could be a consideration regarding retention of newly retrained teachers.

As has been previously established, little is known from existing research about what effective teachers actually do to ‘generate greater gains in student learning’ (Coe *et al* 2014: 12). Further research within this arena will help inform future teacher training and retraining programmes. Cath’s clear frustration that despite her best efforts and hard work (and her attempts to employ all the techniques from the retraining) her students still struggled, highlighted the question of whether enhanced teacher performance impacts on student performance. Cath’s situation may not be typical but the question remains an interesting one.

Research (Ball et al. 2008; Shulman 1987) has indicated that teachers of mathematics need a particular type of mathematics knowledge. Analogous to this is a consideration of the knowledge required for Mathematics Teacher Educators (MTEs); knowledge about teaching mathematics which may be ‘held’ in a quite a different way to the way that teachers know and manage it (Beswick and Goos 2018: 417). Linking research on MTE knowledge with retraining programmes would be expedient.

A key issue emanating from the Smith (2017b) report was one of regional variation: students perform differently in different regions of the country. This raises the questions of opportunity. Which regions experience the shortage of specialist teachers most keenly? Where are the retraining opportunities geographically located? Which schools do, and which schools don’t take advantage of the government funded retraining opportunities? And which regions struggle to access retraining – and do these link to the government's 'opportunity areas'?

7.5 Alternative Solutions to Solving the Shortage of Mathematics Teachers

Another angle to explore is to question whether we do in fact need greater numbers of mathematics teachers. A different solution and one also worthy of future research could be the clever use of technology. Smith (2017a) encouraged this consideration, suggesting we need to be more imaginative in understanding how technology could be employed, citing social media as one example. Smith (2017a): 'the whole world is unimaginative to the use of technology; this needs to change; we need to think more creatively; teachers teaching is a tiny bit of it.' Smith (2017a) also suggested: 'If there is a star lecturer - video it and share.' The popularity of YouTube videos amongst teenagers is undeniable and they are generally easily accessible on their phones or tablets. Popular science YouTube videos are already grabbing teenagers' attention. If the power of this dissemination could be harnessed for mathematics, we could experience a sea-change in the styles of teaching and learning we wish to promote. Advanced technology already exists and according to Promethean, technology for Hologram teachers has already been developed. Curtis (2017), the European head of Promethean, suggests technology could provide 'remote teaching' where there is a shortage of specialist teachers, but that technology is a tool to support teaching rather than a replacement for teachers. For a generation who anticipate terraforming Mars in their lifetimes, hologram teachers do not seem extraordinary. Whilst we await the transition from creative hologram prototypes to practicing workforce additions, Smith's (2017a) suggestion of creating quality engaging videos may seem a sensible - if not obvious - choice.

Online teaching and learning opportunities do of course already exist, with more now becoming synchronous, such as the Further Mathematics Support Programme (FMSP) Live Online Tuition (2016). HowCloud and FutureLearns also offer online learning platforms, the popularity of which are clearly growing. With a shortage of specialist teachers, free online resources, such as the Wolfram Math World (2018), *may* provide more effective direction than inadequately trained non-specialist teachers.

Even without a shortage of mathematics teachers, Finland's new curriculum is embracing technology. This may well be a good indicator for the direction of travel for education.

7.6 Final Word

In essence, schools 'have not changed that much since Roman times, because at heart it is the personal contact that really matters' (Smithers and Robinson 2013: iii). So it seems whatever 'the technological advances, there will still be a substantial requirement' for effective mathematics teachers (Smithers and Robinson 2013: iii). Teachers, like my own Mr. Stacey, still matter most.

As is clear from the data in two recent reports (NFER 2018; Parliament. House of Commons Library 2018) the situation surrounding the shortage of skilled teachers of mathematics appears to be deteriorating. The quest to enhance the successes and limit the barriers for retraining non-specialist teachers to become mathematics teachers, remains a valuable one.

Appendices

Appendix A

ETHICS PROTOCOL FOR: QUESTIONNAIRE; INTERVIEWS; LESSON OBSERVATIONS

Who I am
My name is Naomi Sani. I am a MPhil/PhD student at Plymouth University

What this research is about
I am investigating the impact of a one-year part time government funded course on the effectiveness of mathematics teaching. The research will compare two different modes of course delivery (Venue 1 will observe demonstration style teaching; The Venue 2 will not.)

Data collection
- At the beginning of the course I would like to conduct a questionnaire to ascertain your attitudes to mathematics and your perceived skill levels.
- Participants are selected by way of two transparent criteria: Criterion 1 - you will already teach at least one mathematics class; Criterion 2 - you will represent a cross section of initial subject specialisms. There will be a total of 6 participants from the SKE+ Maths course.
- The questionnaires will be conducted at the SKE+ Maths course venue.
- The survey responses will be confidential and none of the information will be used in any way for teacher assessment or performance management.
- I would like to follow on from the initial attitudes questionnaire by conducting interviews. These will explore your teaching experiences and insights, in more depth. I will take notes of our conversation and I may also wish to audio-record the interviews - with your permission.
- The interviews will take approximately 30 minutes.
- The interviews will be held at the SKE+ Maths course venue.
- The interviews and recordings will be confidential and none of the information will be used in any way for teacher assessment or performance management.
- I would like to observe some mathematics teaching at the start of the course, immediately after the course has finished and after a period of time has elapsed (up to two years after the end of the course). These observations will be at a time and place to suit you.
- I may also wish to take notes of pupil dialogue within a lesson. No names will be recorded.
- I may wish to photograph snap shots of whiteboards and examples of work; no teachers or pupils will be photographed.
- The notes from lesson observations will be confidential and none of the information will be used in any way for teacher assessment or performance management.

Right to withdraw
Participation in this project is completely voluntary and you can opt to withdraw at any time, up to the end of data collection, without penalty. You can choose to answer some, all or none of the questions.

Confidentiality

Information and data collected will be confidential. None of the participants will be identified or identifiable. The university's research ethics policy states that data should be securely held for a minimum of ten years after the completion of the research project. Electronic data will be stored on password protected computers or laptops and individual files and/or discs must be encrypted. Hard copies of data must be stored in locked filing cabinets and disposed of securely when no longer required.
The questionnaires will be destroyed on completion of the project. Copies of notes and recordings from your interview will be available to you on request. Anything you do not wish to be included - from these notes/recordings - will be removed. The notes and recordings will be destroyed on completion of the project. The lesson observation notes will be destroyed on completion of the project.

Feedback
A summary of findings will be provided to you on request.

For any further information please contact me by email:
naomi.sani@plymouth.ac.uk

If you do agree to take part - many thanks!

Appendix B

ETHICS PROTOCOL FOR: INTERVIEWS OF SENIOR STAFF

- **Who I am**

My name is Naomi Sani. I am a MPhil/PhD student at Plymouth University

- **What this research is about**

I am investigating the impact of a one-year part time government funded professional development course (Post ITT Skills and Knowledge Enhancement (SKE)) on the effectiveness of mathematics teaching. The research will compare two different modes of course delivery (One group will observe demonstration style teaching; The other group will not.)

- **Data collection**
  - In addition to the data collected from my case study participants (in line with my initial Ethics Protocol) I would like to collect data from head teachers and senior management staff.
  - These senior staff will be those linked with my case study participants and responsible for recruitment of mathematics teachers within their schools/colleges.
  - I would like to conduct interviews to explore the following: Issues around staffing (for mathematics posts); What benefit, if any, the post ITT SKE course has had for the school/college; Whether the course was 'value for time', considering the inevitable disruption caused by staff absence.
  - I will take notes of our conversation and I may also wish to audio-record the interviews - with your permission.
  - The interviews will take approximately 30 minutes.
  1. The interviews will be held at your school/college.
  - The interviews and recordings will be confidential and none of the information will be used in any way for teacher assessment or performance management.

- **Right to withdraw**

Participation in this project is completely voluntary and you can opt to withdraw at any time, up to the end of data collection, without penalty. You can choose to answer some, all or none of the questions.

- **Confidentiality**

Information and data collected will be confidential. None of the participants will be identified or identifiable. The university's research ethics policy states that data should be securely held for a minimum of ten years after the completion of the research project. Electronic data will be stored on password protected computers or laptops and individual files and/or discs must be encrypted. Hard copies of data must be stored in locked filing cabinets and disposed of securely when no longer required.

Copies of notes and recordings from your interview will be available to you on request. Anything you do not wish to be included - from these notes/recordings - will be removed. The notes and recordings will be destroyed on completion of the project. The lesson observation notes will be destroyed on completion of the project.

- **Feedback**

A summary of findings will be provided to you on request.

Appendix C

Interview 1 Semi-Structured Questions/Prompts:

Bit of background:
Thank you for doing this...
How long have you been teaching?
So what subjects have you taught?
How many schools and what different type of schools have you taught in?
And what's your highest maths qualifications to date?

Follow on from attitudes questionnaire:
Is there anything you wish to add or expand on from the attitude questionnaire?

Motivation for embarking on this course:
That leads into your motivation for embarking on this course?
Is there anything else you want to add at this point or...

Styles of teaching (with opinions/comments):
So if we now think back to when you were a pupil. Can you think what maths lessons were like for you; what kind of styles of teaching did you experience? And moving from there to where you are now as teachers what teaching styles do you employ as a teacher?
What other methods or styles of teaching have you - over the years - observed as a teacher?

Professional experience (with opinions/comments) of:
Again this overlaps with the last question but - your CPD to date - other than observations have you been on a training course, for maths:

Ofsted experiences:

Have you been Ofsteded? How did it feel?

Any stories to tell?

Do you think Ofsted helps or hinders?

Are you aware of any international studies and comparisons? (PISA?)

Have you been on any international observational visits?

Miscellaneous:

Are you aware of the science of brain with regard to learning?

Are great teachers born or made? Opinion? Comments.

Can teachers become better teachers? If so what are the catalysts/barriers? What are your thoughts?

There is much talk of the 'tail' of underachievement in UK schools. Does it exist? if so can anything be done?

Could super-sized classes help alleviate the teacher shortage problem?

Have you any thoughts on teaching terms and conditions - Pay/pension/training/qualifications/status/class sizes/ other...?

Appendix D

Exemplar Interview 2:

Interview 2: Darcy

NS: I want to discuss a few things that were on the questionnaire and from the first interview - put a bit more flesh on the bones. Is that ok?

NS: In the first interview you said: "*but I was concerned that perhaps my mathematical knowledge and my terminology wouldn't be as good a somebody who had done their qualification I was confident in me as teacher but not necessarily being the best maths teacher I could be um so ways of breaking down and resources that you can use and different ways of explaining things for all ability*"

Do you feel any differently now?

D: I think just with teaching in general that obviously improving all the time. This year I got top set year 10 so I am teaching the higher tier - although I did do a little bit of a higher in my first year it was set three so they were targeting C/B's off higher I didn't do any of the top end stuff so there's stuff this year that I am teaching for the first time ever I have come across stuff we've done on the course so I'm not seeing it for the first time, I've seen it with you in our work so it's nice to actually be familiar - so I'd say no I still feel there is stuff that I don't know anything about and my terminology isn't there but I feel much confident with the delivery

NS: say your terminology isn't there…

D: I don't know I say things and I'm just not sure whether I said it correctly and I'll often, when was first appointed as a maths teacher one of my targets was to ensure I was using the correct terminology, I would have observations where they would come in and focus on what I was saying was I using the right terminology with the kids um so say I'd that was still something that

That is something I would like to do is go and have a look at all subjects not just

NS: Can you give me an example

D: umm… probably not

NS: Something you said in your first interview is you would like to observe more maths lessons. Have you?

D: No. No I haven't had time. No time.

NS: Your best type of lesson: …This sounds engaging and motivating for pupils….do you think they are more engaged?

D: Umm… would like to think so. I'd say I'm trying I'm definitely trying more more practical, more physical hands on stuff. You know even if it is as they come through the door having a little task at the table rather than on the board because I think it is important they in go oh this is going to be good from the beginning rather they come in and go arghh there is an addition some on the board - boring! Like them to come in and think from the off it is something different - um - I definitely say I am trying to make it more engaging and getting them more involved for more of the lesson

NS: you sent anything coming back from the kids, Any comments?

D: No, I haven't. No

NS: No? Ok

NS: am just thinking about the pedagogy of teaching maths. I know you are a PE teacher. Is there anything you bring from PE into teaching maths?

D: Mmm…little things, like volume. Even things like the social side of PE. I am a real believer in if you can get on with the kids on a more social level stand a much better chance of getting them on board in their educational… as well, that mutual respect. Umm with that - with PE you have a totally different relationship with the kids at the school I'm at at the minute a lot of those kids I did teach PE to … have that PE teacher bit within me - that does speak to the kids a bit differently than classroom teachers do perhaps that's just me as a person. Lots of things can bring across for me it if you see a kid in their PE kit after school - in club, would think nothing of saying the next day 'oh did you enjoy netball practice last night?' which I don't think a lot of other people would do

NS: I think this is a really an interesting vain to dig a bit deeper into. I guess what I'm at is what can other specialists bring into teaching maths - what advantages. You have already said about the volume of the voice and rapport

D: yeah yeah I suppose. Very important I think

NS: And do you see yourself as a PE teacher, and PE teaches, as having more rapport than more stereotypical maths teachers?

D: that is interesting because I wouldn't call myself a PE teacher any more

NS: Ahh

D: I would've said that probably by Christmas of my first year of teaching maths that I was a maths teacher…Now at start of my 3rd year

D: funny because I really enjoyed my years as a PE teacher but I would never go back

NS: Oh why?

D: Um, I don't know - I just really enjoy teaching maths, I like the challenge.

Don't enjoy the pressure so much and trying to get the grades. Knowing I'm giving the students the tools to get them into jobs and college - don't get me wrong you still do in PE, Life skills in PE in terms of health and exercise. I like the fact that giving the students more life skills

NS: do you think you are having more impact on them?

D: much more impact, much more impact. I'm more valued. I'm more valued than I ever was as a PE teacher

NS: Interesting… so just to recap summarise: you feel you are bringing bits of your PE self like volume, rapport…

D: if I look at some of the other maths teachers in my department, the head of department you have met, we teach quite similar are both relatively laid back but still have high expectations whereas if I look some of the other people in my department and they are very straight down the line and they do get on with lots of kids but there's those trickier children who a lot of the time they struggle with because they are not prepared to back down a little bit whereas I think I will partly for the easy life but partly because I think it's going to be a compromise - if I know they're coming into the room I can detect if they are in a bad mood. There is some staff who would just jump on that make it worse whereas I would like to think the majority of the time I try and take that into consideration I think a lot of that comes from maybe the PE background

NS: where you are managing all sorts of different people in different environments?

D: Yeh and maybe, you know PE has such a massive space to work in I don't know if that makes a difference as well - you know you got to be able to monitor different groups of children in such a big space and I have never had an issue with that in the classroom maintaining what's going on there so

NS: would you say you have got more periphery vision?

D: I don't know I've got rubbish eyesight

NS: That sort of sense…

D: Yeh - I would like to think so

NS: do you think, and this might tie with it, the pedagogy teaching style very different for maths and PE?

D: Yes - I think mmm ummm - I don't know, What a good question - in a standard lesson - I guess in any lesson you show them examples of how to do it and then they would go often do it and then make it more challenging.

In any lesson isn't it so you are teaching someone how to take a penalty or if you are teaching them how to solve an equation - it is exactly the same principle isn't it - you show them how to do it, you check they can do it and then you set them off.

NS: Mm ok thank you

NS: okay so this is a big question - there isn't a definitive answer, no one has come up with one: What is an 'effective maths teacher'? And how do we know?

D: Ahh…ok -so for me - are effective maths teacher is someone who gets the kids wanting to learn how something works and hopefully getting that enjoyment of it working um and then someone who is able to get the students to have enough information for where they want to go which is initially obviously that exam paper in Y11 but more importantly do they have the skills they need to go into the profession they want to - so …

NS: Hold that thought and then lead it to - We probably all have an idea of some attributes of a good teacher: good class room management; happy to be working with children; a sense of purpose about them; a level of performativity perhaps, to engage and motivate pupils;….Now - is it better to have a 'good' teacher with poorer maths skills or a 'good' mathematician with poorer teaching skills? If you were a parent which would you choose for your child?

D: for me as is apparent I would rather have a good teacher - with less good maths - I think so - if you can't get those kids on board by engaging them initially - it's a battle. Whereas with some people and their knowledge is amazing and then you ask them why and they say I don't know it just is. For a child that doesn't help. Me and my knowledge I sometimes find it difficult when a child says to me but why and I'm okay I'll try and find out and tell you and there's still things that come up… you've got two different types of child haven't you - the child who is just going to do what he's told but child who is a bit more inquisitive and is going to need somebody to explain it to them and need somebody a little bit more sympathetic perhaps somebody that didn't have the knowledge and have had to learn it themselves um cos I have had to relearn everything almost and I would like to think that this is helped me and my teaching because I have had to learn it

NS: We were talking earlier about styles of teaching and you said you were very similar to your head of department. Do you think you have modelled yourself on him?

D: Gosh, no. No I don't think so. I've modelled me on me. Never tried to be anything but me. But personality and our relationship we with our children I think is very similar in that sense. But no I think try and take my old PE job and put it into the classroom

NS: and talking about your, because you clearly enjoy maths and yet the way you were taught, I think, was mostly chalk and talk. Could there be value in this approach. Is this just a fashion to think about Problem Solving and understanding?

Could the satisfaction of simply getting things right - a lot of repetitive things perhaps - be underestimated? Where did your enjoyment of maths come from?

D: Think for a lot of the students I teach they're understanding is helped by them helping others. Often say to my students okay we're going to mark what a review on the table be the leader read out your answers if you've all got the same make the assumption you've got it correct, if you've got different answers you need to decide why and I have heard some great discussion the kids when they go no this is the answer, no this is the answer and when they get their heads together and when they show their workings it's that Eureka moment - and I think that for so many students having that time to discuss answers and prove each other wrong or right is invaluable and I didn't ever get that opportunity when I was at school - it was a matter of here's how you do it here's some questions and now let's mark

NS: And yet you came away enjoying maths, as did I, so…

D: but then what do OFSTED inspectors want to see, they don't want to see that do they, they don't want to see students sat down copying out of books

NS: So is it - a - fashion

D: possibly, yeh

NS: If OFSTED wanted to see each chalk and talk, is that what we would be doing?

D: Mmm, I don't know, gosh - I mean don't get me wrong I have lessons where I do that because I think some some subjects, some topics, are easier to do you know more hands on, more practical activities there are some things where I think it is the case of here's an example, try some mmm but I don't know why, yeh- maybe it is a case of let's try this for a few years then go back to something else - to keep teachers on their toes [laughter]

NS: mmm

D: So I don't know why

NS: talking about what we just touched on their and pressure, time pressure um I think when you described your best lesson you said 'the pressure for progress and shortage of time' what happens then is that what you're saying - when you go to chalk and talk?

D: I think yeh, cos I think there is for example all my year 11 classes are working for their resit in November so my priority is to get from D's to C's whilst I would love to take them out on the tennis courts and do you shaving foam with string which I know would sit in their head that's the one lesson with the second lesson being how to do it. In my head I'm thinking okay I've only got x many lessons before the exam I afford two lessons on one topic I just feel there isn't that time and even in the key stage three lesson know we have the scheme of learning where you are told do you this in three weeks, do this in four weeks. It's not bad as some of the others got but per lesson you sometimes feel that the time pressures are so tight you haven't Time to do that investigation work which I think the kids would really benefit from but again is SLT walk into the room and ask what are the kids learning and well they are doing an investigation I think a lot of them would-be ooo not sure…

NS: We are kind of saying two things really: SLT wants to see that immediate progress -

D: Yeh, they do

NS: - but we're also saying OFSTED don't want to see just chalk and talk so it's not stacking up is it I'm not sure who wants to see what, I don't…

D: if I had a lesson, like your factors lesson, where are they didn't write anything in their books - if an SLT came in and saw that I don't know what outcome they would say to me about the lesson because there is no proof of the progress -

yes they have all said things in the lesson - I don't know what they would say to that and I would feel a bit scared in case turn around and say that’s..

NS: right - and that's important to you

D: no - because, no - it's not important to me - it's the rumour mill isn't it that goes around the school

NS: Ok

D: in our school somebody got a four and it was like who was that and that's horrible - and in fact it was a deputy head because he try something and it didn't work. The school is about who got that and he got that and I don't really like it. Whereas I know, I'm confident, that I can do a 2 lesson - with any observation if I do what I know is the way I would teach without that kind of stuff we have done here - I would just be a bit worried

NS: more risk-taking?

D: yeah. But then sometimes you get praised for taking risks because it shows that you want to do new things for the kids

NS: so you would rather play a bit safer and make sure you get -

D: yeah I think so. Also win that I know the kids are they make progress. The majority by the end of the lesson going to understand what we have done and I sometimes almost I sometimes get you excited doing what I find really fun and I almost forget to bring it back to what we're trying to do. The cheerios I tried and the mistake of using tiny Cheerios - don't ever use them, there really sticky [laughter] - the kids were so excited, as was I, about doing something that I hink actually if I asked them what the lesson was about I think a lot would struggle to to say it was about volume it was just so exciting and also I forgot to say ‘remember this is what we are doing’…

NS: somehow said to me when they have started out teaching maths that they are ‘staggered by how little pupils could do and how little it bothered them.’ Is this your experience and ….Your thoughts on how have we got to this situation - for many, many pupils in the UK?

D: yeah- kids don't seem to be concerned that they can't do their multiplication tables… yeh - kids in Year 9 seem to be concerned that they still can't do what I would call some of the basic skills - because I think they always think I'll learn it next year and I don't think that they appreciate with the next year if they haven't got the basics then they can't then build on it for the other stuff. I do think there are some students who think it's just going to happen by miracle

NS: that’s interesting when you say they think they might learn it next year it ties in with the comment you said before about pressure and moving on, it's almost like you’ve got a spiral curriculum going on by the sounds of it, and you mentioned time constraints- actually have quite a lot of time with our students - we have five years- do you think put our own time constraints on it. If we looked at it as five years -

D: yeah I suppose - if you put it like that, yr. but I think, yeh

NS: is it artificial time constraints, that's what I am trying to say. It artificial us saying you've got three weeks on that, two weeks on that we so want to do this spiral curriculum. Is there another way of looking at it and thinking - we've got five years!

D: I don't know because kids, a lot of them, haven't got the retention. Mean one way you could look at it I suppose if you do one topic per half term. At algebra for example you could go all the way from the basics x +7 equals 12 all the way out to simultaneous equations you've got almost the whole spread and do you do it in like a 12 week block… but I'm thinking have they got the retention to remember what they did yesterday let alone a year ago, so I don't know…

NS: So mixing in with all that about how little they know and time constraints, what do you think about setting?

D: Um - it makes lessons easier

NS: to teach?

D: Yeh and to plan we had a guy who came into school and said that setting had no place in schools and it doesn't work the top end and it only works I can't remember what he said but it only works one small section. We have a weird setting structure at key stage four - split them into a J group and a K group - the J group has 150 students, the K group has 50 students. The J is mainly A* - C and the K is a few of those A* - C, but not that many of them, so is already that culture, this is our third year of doing it, working down the school - so our year eights already know that if you go into the K half…

NS: why have they set this up then?

D: I don't know - it was one of our deputy head ideas, and for whatever reason it has just stuck

NS: it sounds like the K half have some A* in there as well

D: no sorry not in the K half - just C's, some B's maybe. The other half most of the students would be expected to get C and above in five subjects or more

NS: It seems an incredibly…

NS: This chap that came in - he has obviously left an impression, people must have thought…

D: yeh - the immediate response was from one of the heads of year well why on earth have we got the J and K groups

NS: instantly telling them from year eight or below that is is there a go in there they are basically written off

D: pretty much. You see this year I have J1 and K1 - those kids in K already know, am in the K half I'm not supposed to, I'm not going to do so well. For whatever reason it's there and we have two work with it

NS: so this chap who came in and talked about setting - did he leave an impression on lots of members of staff?

D: I think it stuck out especially when this lady shouted out why have we got J and K -

NS: I can't believe other people haven’t stood up and said well why we got J and K

D: This is the third year and I don't know what impact it has had on results. Only J and K for maths English and science oh yeah and PE - only the core subjects. For Y10 and Y11

NS: so they would have had two or three sets of results - that's got to be worth looking at, ok fascinating… okay in general then, putting the J and K thing to one side for now, having heard him talk what do you think about setting

D: I think for the lower end it would be good to have, if you are in the lower you are surrounded by his other lower people - you have got no one to rise to, I think. If I think about netball, I play netball, and if we play rubbish teams we drop to their standard and if we play against higher teams we write to their standard and it surely there has got to be a link between that and the classroom. If you are surrounded by other kids that can't do it - and I think kids have this culture of ‘I don't want to be the best’ and interestingly at parents evening the other day our mother said her son thinks there is a culture of failure at our school. I don't think personally this is true. If you did have a mixed ability group and there were some kids who just didn't get it can direct them to a number of kids in the room who could help. If you've got just kids who don't know how to do it you haven't got that extra support. Because you don't have two differentiate so heavily

NS: Last question - although it comes in 2 parts: What would you say are the most significant ways - if any - the SKE maths course affected what you do, what you think, what you believe, what is important …. about maths teaching? What if anything has changed for you, your pupils, your colleagues, your school? Will they stay, take root…?

D: I have definitely tried to look at different ways students would answer a question. I do remember that when we have done things I was very guilty of well this is how I would do it… have tried to do examples on the board and either shown different ways or if a child is struggling with a method I have shown - say well actually try this instead… and also making things, can I teach it in a different way, rather than this is how you do it…field, jumping around class. It's definitely made me more aware of why some things work. It's definitely developed my knowledge

NS: so the biggest impact would be on knowledge and different ways?

D: yeah and also my confidence has grown. We've done stuff here I'm guilty I've got so many notes in my book and I haven't looked at that many if I'm honest the practical things we've done I remembered and I have done them I am reading through and thinking gosh why haven't I done this. Because we have talked about so many different ways of

NS: any of that stuff that you have just talked about taking root, Will any of that stuff stay with you

D: yeah I think so because as a Department try to look at new things and we are quite good at sharing. We'll get together and look at things and as a department we are good at sharing things

NS: Will that help things going then? Because you did say here you have a very supportive department

D: Yeh I think so

NS: because if you talk about it it's more likely to

D: when I first started every Monday lunch time we met as a department - who is doing what, any good ideas, practice - um that has kind of stopped due to time constraints… you always going to need training because there will always be a kid for who you will have to find another way to get them to do it so it's not it - always need more

NS: what do you feel more fully fledged?

D: [nodding]

NS: Thank you, thank you, thank you

D: Tests. We were going to talk about tests. I have really enjoyed them. Founded frustrating I can input them. For me just being able to reassure myself I can do something, I really enjoyed them.

NS: and how much time they take roughly

D: oh gosh, quite a long time - I did them all at the beginning, pretty much. Don't know how long they have taken me, they vary. Some of them I was pretty confident on, I don't know. Not as long as I was expecting.

NS: thank you very much

Appendix E

Exemplar Interview 3

Interview 3: Cath

Following on and flowing from Lesson Observation feedback…

C: …I was going to do angles around a point and see which ones tessellated and which ones didn't - why don't they tessellate – and starting to add different shapes so that was part of it – um - I had pictures of polygons in real life, there is actually loads of stuff I didn't show - to be honest I probably planned a bit too much for the lesson

NS: I was going to say - there was a lot in there

C: a massive amount

NS: what do you think…

C: I, yeh, what do I think - I think, probably, is I have been on my own I would have done a better job

NS: yeah - let's explore that, that's a really interesting point – what would you have done differently –'cos that's really interesting to know isn't it?

C: I think I was so busy trying to get through things I wanted to do - and I put too much in that I probably - I wasn't responding to them and also I'm more frustrated than I can tell you - we have got so many new referrals coming in in the middle of the school year with multiple problems - serious multiple problems - I just interviewed girl just now and she stormed off - and um and it's all very well but there's only so many vulnerable people we can take and that's why we have got small classes but yesterday two new girls started that I hardly know and what has deeply saddened me is at couple of girls who are not attending - one of them has just had a baby so that is why - but they were brilliant, had been there since the first term - so that constant change can be a bit putey offey - so when I had two new girls today in my head it was a bit frustrating really – because I would have dealt with it differently but it was an observation lesson I wanted to carry on with what I had planned and so I didn't respond and so G was doing her nails - I think she's following some of it but you know I probably would have done something different about that - I would have given H, I would have responded to H - but I was thinking - no, you are going to do this folding exercise [laugh], I want you to I want to see these things but it was a little bit disjointed to be honest, which I don't feel usually - but I did today, which is a shame because I did, I had some good stuff but

NS: yeah, you did, you did…

C: But..

NS: so if we were to unpack it a little bit, because there was a lot of good stuff there, a lot of good stuff. If a little bit - there was a lot of content - it wasn't going to fit. So what would you dump and what would you keep? Or don't you know yet?

C: I don't know what I would've dumped and kept but - with what I would have kept, what I wanted to do it's probably do a little bit more with that. So I wanted, didn't want to look at angles in isolation, I wanted to look at polygons - you know that the classic lesson where you're measuring an angle between two lines, I didn't want to do that - so I want to look, bring in polygons, I wanted to bring in algebra - we have just finished sequences and I wanted to - so I could have just started looking interior angles of polygons - but based upon the diagnosis I had got the day before - I know H with saying she didn't want to do it, it was too easy- but actually - it's superficial her knowledge

[discussion surrounding H's frustration surrounding 'doing activities' and her desire to just 'get on' with the maths. H has spent many years in maths class rooms doing activities….]

C: the thing is I wouldn't have a lesson like that regularly. I would do an introduction to a topic and I do, I have to do lots of practising questions as well, so I will - it's just the introduction of a topic – to be fair that there is an activity, but I wouldn't usually be doing as much of that in the lesson but…

NS: but the two girls at the end were really engaged, it was really working for them

C: but I think - I have built up a trust with them and I have had them since the beginning of term last term, when these two girls I met just yesterday and H, H has just started, she is just doing maths and she sort of wants to dictate a little bit because - this thing is we were in the flow but half the group aren't there - and those two that were engaged have been with me for longer. I think there is an element of trust but what is happening at the moment to the [school] is that we've got no money and literally every day we have mentors bringing in new people with massive problems. I am going to have to say something in the end - because some of them are not ready to learn - and then leaving because of that. But you know they worry about bums on seats - that's what's happening. We wanted to say that's the GCSE we would take no lower than an E but we are taking girls with U's –all sorts…

NS: one girl said the reason that she didn't pass her GCSE is it because she fell asleep in the exam, and I thought- yeah you did. There are lots of issues, I can't even begin to imagine the issues

C: one issue is… last week when she was being quite shirty, I gave her some breakfast and she was a different person - she doesn't eat before she comes and I thought you know that would really help, it would really help

NS: her starting point is to be angry, or defensive, or a bit of both - but she slid across her paper for me to look at and you know you're not going to do that if…

C: Now we are with hospital education - we've been taken over by them, they fund us, so we are falling in-line – so every term they have something like this [test paper]…A lot of barriers going on [with the students].

NS: A student stuck with a method that she is getting wrong but is unwilling to learn

C: She wants a whole load of short cuts only…she said to me that if you can't teach me how I was taught at JC – you can't be my maths teacher. And you know that doesn't sit well with me. But should I be teaching her the way she wants …?!

NS: No…RME research – students are so resistant to change… NS refers to The Tail…and styles of teaching for the most disaffected…

NS: you have put your finger on the nail of what teaching is - it is a relationship of trust and rapport. Those two girls trust you; the newcomers don't trust anyone…

C: … girls are in care, they have had a dark life, there is so much hostility they are not ready to learn. And this girl is adamant she wants to get straight on with the maths, she wants to do higher, she says what is the point of doing foundation - she is just repeating things she has heard teachers say. But she can't do simple multiplication

NS: and it is not the point that she can't do the multiplication or use the algorithm - it is the fact that she has no awareness that 12×32 cannot be 34.

C: that is a real challenge within my job. Bring anyone in, we have got to survive - but these people are damaged, are not willing, and don't want to be part of it, that's a challenge

NS: that is a challenge, you've got a really tough job, you've got a really tough job - but you should absolutely blow your trumpet when you have made breakthroughs, which you clearly have

C: I have made some

NS: you have, you really have - those two girls, H is nearly there

C: But with regard to the lesson - I think there was too much in there and I could have explored one part with more detail perhaps

NS: what would you have done if I wasn't here, I totally get an observation lesson can be -

C: yeah

C: do you know what I would've probably done - is close down most of the bits - and gone to the board and discuss starting from - I would have, I wanted to talk about different polygons and get the names from the girls - and then I wanted to look at how they made angles then you know - it would have been more of a chalk and talk and then I would have given them some exercises and then after the exercises [the new girl who C had referred to earlier enters and asks for a maths book to do some questions]

[heating engineer enters to do some maintenance work]

C: so yeah that was what I would have done

NS: so lots of questions are coming to mind from the research perspective - I want to play around with the idea of what happens when someone knows they are going to have a lesson observation so why…

C: that's a confidence thing, I don't know why -

NS: in terms of why the lesson is different?

C: No, I - the lesson content is not massively different but I probably put more in than I would, it would've been the same…I probably thought - and I'll use that, I'll use that - and then you - I could use that, and I don't want to drop that, and before you know it – too much
NS: it's almost as if you want to show all the bits…

C: …and I wanted to show - that is exactly it, that is exactly it. And there is the fact that this is an observation so you, that's it you want to have it all in there, but also there is an element of kind of, well actually I wasn't really nervous, but it wasn't going to go the way I thought it was - so the sense of - it wasn't how I planned, and in my head I had really got it planned so it was - disappointing

NS: so I wanted to pick up on whether it is stressful having lesson observations?

C: I think the more you have the better it is actually, it's just that they are too sporadic - and what a teacher never gets to do and what I think anyone deserves is the best professional development you could ever get is opportunity in your timetable to share good practice and observe other teachers and I am working completely in isolation here I don't have that and so - yeah that would be huge. And actually peer observations with other maths teachers, if you were in a department for example, not necessarily your head of department but another maths teacher … none of that opportunity is there. I would far rather do that than a day with the buffet of sandwiches, in service day learning something else, on Blooms taxonomy or whatever - I'd rather be watching other maths teachers

NS: that's a really, really useful observation

C: because when you are on the spot there you are not able to see it fully, to see it from your perspective like you did today would be totally different
NS: so the coaching and mentoring have come about almost accidentally from my research what I wanted to explore is whether you have any teaching and mentoring from anyone else

C: no, no - since the course - you know we were going to try and get a network going - I would have really valued that - so I am back floundering on my own really. Actually I suppose that's not quite true - because as we have merged with hospital education… but most of them are not - innovative - and don't need to be because they are not working in groups [they work on one-to-one], that someone's bedside - so I am not getting the mentoring I need - no I don't get anything

NS: so there is an idea for get future cohorts of TSST would get maybe a coaching and mentoring session as part of the programme after they have finished the course

C: I think that will be brilliant

NS: even if it was somebody you didn't know, say it was somebody coming who you didn't know

C: um, [long pause] yeh - even if it was somebody I didn't know. I mean - even though observations do you heighten your anxiety, ok less so because I know who you are– and I feel really comfortable with you - I think it is still really important to get the feedback and to evaluate and reflect sometimes - otherwise you just don't do it, you go from lesson to lesson - okay you reflect on the weekend but you don't have anyone else's feedback and I think if you're going to improve I'm be the best teacher you can be even going through that discomfort is definitely worth it even if you don't know the person mentoring

NS: okay that's great… and thinking about peers, and being reflective - you came on the course with a colleague - is she still teaching maths?

C: No… she has gone elsewhere and teaches art, but ironically we have a new teacher M who really, really wants to be on your course but she hasn't got a maths class

NS: but you can still come, she can still come - the rules have changed - yeah she can still come without teaching a maths class the rules have changed, it was only that one year that you were doing the course that you had to be teaching maths

C: any places left?

NS: yeah 1 or 2

C: she is really keen, really keen –

…

[discussion re enrolling – M subsequently joins the TSST group]

NS: So, subject knowledge - I think you said here that…
[same girl interrupts again]

So how do you feel about your subject knowledge development all does that link with what you said before about the lack of mentoring and coaching?

C: Um - … in terms of making it rich and pedagogy, that's where I need developing

NS: in chance we had previously you have often said that you feel like you are letting the girls down, do you still feel that way? Has anything changed? And why did you feel like that?

C: I do you think my confidence dips - I did feel that, I really did um [pause] I think I worked extra hard to get rid of that feeling by doing more work at home in order to prepare and revisit kind of how they learn and so I, to avoid feeling like that, because I do have high expectations on myself so I think that is partly it – yeh - but sometimes I do feel like that

NS: in what way?

C: I think what I think is that I will have taught topic and a few things, some activities, some fun things, some investigation exploration, some book work - leave it for a bit and come back to it and they don't know some of it, or they don't know any of it and I think that's when I feel I have let them down. How? Last week you could - where has it gone? And that's when I get that feeling I have let them down because why don't they remember that - you know it's not like I haven't had a - song in there - you know it's not all dry - that kind of teaching

NS: so it is almost like you asking what more could you have done?

C: Maybe [hesitantly]. And then if you think well if I had been a different teacher - you know I watched bits on you-tube and think - I bet you're brilliant

NS: Like Dan Mayer?

C: Yeh. But - why can't you remember that

NS: well I'll tell you a story about Charlie Strip - Head of NCETM. He had taught for years, worked his way up to the top, thought he would give something back to the community, decided to volunteer to work in the local college teaching a resit maths group. He struggled, he has struggled - he openly admits that – it is tough

C: that's great that he has done that, because he will immediately realise all the difficulties, obstacles, brick walls

NS: so what I am saying is but that even people who are well qualified, Maths specialists, experienced, maths educators - it is incredibly tough to teach a resit group. So for every Dan Meyer in the world, there are a squillion's of the rest of us. Resit groups are incredibly tough because we are dealing with the fact that they have faced failure, and sometimes numerous failures

C: well, all of these girls have

NS: exactly, exactly - so every single person you are teaching is carrying a big baggage of failure on their back - and so the way to cope with failure - because we are human beings - is to put up big barriers for self-defence. Our self-defence is to pretend that we don't care - so to break down some of those walls is an amazing achievement. It's a tough job that you have got. So you have often said you felt you were letting the girls down, but you feel less like that now because - because you said you were putting more work in?

C: yeah - sometimes the only way when you feel bad is to try harder or try and do something differently so yeah - more hours of planning

NS: how many hours do you think you plan?

C: hours, honestly-

NS: and is that sustainable?

C: no [C starts to cry/sob] Sorry!

[NS gives hug and moves to suspend interview]

C: No, no – this is reality, isn't it?

NS: okay - I think you need to do less work; I am telling you as your tutor to do less work

C: yeah sometimes when I haven't planned - I have a better lesson

NS: yeah, okay step one – less work

C: [still crying] I'm sorry… we are under such pressure - I am teaching at the R [another school] as well - I'm doing about three different science groups with different syllabuses

[C crying; NS offers to get another coffee; C continues to apologise; NS reassures her]

C: it's partly my fault really

NS: it is not your fault

C: you just try so hard to help them and if it means a lot of planning and… Then that is how it is
NS: but - it's about who cares for the carer, isn't it? You - I mean it's about - who puts their life jacket on first - you have got to put your own lifejacket on so you can help others with theirs

NS: do you want to stop?

C: not at all, not at all - its reality isn't it?

NS: it is probably good to be honest that you can't talk about it and let it out, and be heard. But tell me if you want to stop

C: and this is not even a mainstream school

NS: but these girls have immense problems and issues. You have a really tough job. You do an amazing job

C: the girls at R are all self-harmers… so I suppose what happens is that you take a lot of that [stress] on…

C: you know I probably do plan too much - and you know it's crazy - because you always think is something better – but sometimes it's better to just see what you have got in its simplicity and to develop that with the class… I do plan too much. Some days you could just go in with nothing planned - maybe I need to do that - maybe one day a week I do that

NS: that's interesting - because when I asked how it may have been different if I haven't been here - you pointed to the traditional whiteboard and you would have used that - well that is called live teaching - and that's good. In the moment teaching – you are teaching it live - rather than having everything prepared on slides and scripts.

C: I see what you mean. I do a lot more of that when I am not being observed. You know why you don't live teach though - is because you don't know what they are going to come up with. Whereas if you have lots of things planned and prepared- you feel like you know where it is going to go so you think nothing can go wrong with this observation because I have got it all planned – um - and with Live teaching it is a bit braver - because when somebody comes up with something and it's on a tangent - I don't know…

NS: so that is a really interesting observation. So from that would you say that live teaching would be - easier, I am not sure that is the right word - more manageable is you were more au fait with the subject

C: yeah, yeah, probably actually. I think the more confident you are and actually - since the [TSST] course Live teaching has increased in my lessons, definitely

NS: I think I have seen that in all my case studies

C: have you?

NS: Mmm for some in particular- gone from virtually a script – a slide after slide after slide. And now I'm seeing at the board - all getting kids to the board - so I am seeing Live teaching and that is very encouraging I think

C: I definitely do more of that - I feel more comfortable

NS: because I think the danger of using slides - and an observer can see this but not necessarily the teacher - and although it looks neater and better presented – there is a little bit of a danger to go too quickly or flick [through the slides]... The person who has prepared the slides are so familiar with it and you don't want the pace to-, you don't want to bore the class - but because you are familiar with it - if you are new to the slide you have got to orient yourself to it, what's the picture what's the information - so because you are orientating yourself - answers may be given and the slide moved on - Whereas if you are physically drawing the start, then that slows it down. I know there is always a balance-

C: and also people are more likely to pay attention to the unfinished, the piece in the making, rather than the finished piece

NS: so it is an interesting observation

NS: but then you see the Shanghai teaches - they have perfectly prepared slides. But they only teach two lessons a day –maximum - the rest of the day is for planning and research – and the slides they prepare - they may only prepare three? - not lots and lots - maybe three - and they are a superb. There's no doubt - I have never seen better slides

C: I have never seen them

NS: it is difficult to explain really because you think three sides is three slides but the thought process of how they interconnect going forwards and backwards, and they go backwards and forwards through the slides but the lessons they are teaching are very controlled. So like you were saying if something goes off on a tangent - well I can't in Shanghai lesson – because if it does - well it's like, we are not dealing with that today - so the lessons are very controlled by the teacher and very well prepared and I've never seen slides like it

C: is that always a good thing though?

NS: no. well I don't think so –no.

C: The Shanghai teachers - presumably they produce really good in maths students do they?

NS: well it's interesting - really good in maths students at a certain level. What China is really aware of- is not producing enough creative thinkers and they are asking themselves big question now - like do they need so many elite mathematicians as they've got - and would they be better off with some creative thinkers. So yes in China, in Shanghai they have some very good maths students at high School maths. But what you have got to ask yourself are what universities are there of renown in China? None. Not one. Fascinating isn't it. So they will create very strong high school students but they will all go overseas to university. It's just a different way of thinking about it isn't it, it's all let they're fantastic they're fantastic – but are they?

C: what about the Scandinavian teachers? Because they were up there weren't they?

NS: yeah well that's fascinating, because yes they are up there - not Sweden, because they went down the free school route which we are now emulating - but Finland is still doing incredibly well in Europe, incredibly well - even though they did not set out their stall to do so, they set out their stall about 30 years ago to create equity of opportunity - so they got rid of all private schools, Setting, streaming - there is no OFSTED, no external exams until 18, - so their intention was not to the top of any league table not that that was common in 30 years ago

C: I quite like the idea of being in that system

NS: it's incredibly relaxed, incredibly calm – I mean they have space, very small classes. I mean we are all crowded in this country, our schools are crowded, the classrooms are crowded, the corridors are crowded, we can have thirty-six in a classroom. You walk into a British classroom and it feels like a pressure cooker, you walk into a Finish classroom and it feels incredibly relaxed. I mean you can say we have more poor behaviour. But then again is it just the way of looking at it – you can ask what is poor behaviour. For us if someone is brushing their hair or chewing gum we would say that is poor behaviour, right or doing their nails - we would say that was poor behaviour. But if you don't think it is poor behaviour, if it is not considered culturally to be poor behaviour, then it isn't a poor behaviour - and therefore you don't have to to deal with it

C: and that's what I have to do here because otherwise you just wouldn't get anywhere

NS: of course, and that's what I found fascinating – turning around, brushing your hair, chewing gum wasn't a problem. It wasn't a problem because it wasn't considered a problem! They are still getting on and doing their maths, they're still engaged in whatever – I thought cor - that's fascinating, because for us it would be a big issue. You would have your name on the board, the zero tolerance, isolation, this is that the other, and then making - it just escalates and escalates. And I thought why have we not thought that this is not a problem. But I suppose you could say is all down to attitude – are they chewing gum with attitude, brushing their hair with attitude - I don't know, it's all a fine line

C:

NS: I think I know answers to a lot of these questions. Do you do collaborative planning? No. do you have mentoring in coaching? No
What about school support?

C: well on that question I didn't know how to answer it - in terms of if I was having a bad day for whatever reason or if one of my children was sick Then they are incredibly supportive. Everyone looks after everyone. In terms of supporting subject development, maths teaching - I would say that if I said to the [Head] I need to go on a course she would say I need to go on a course and be incredibly supportive – um but – what I would really love, what would really help anyone's maths teaching - it Would be to have half a day a week in another school observing - but how would that be – that would be essentially impossible financially but that would be really lovely. So they are really supportive as looking after me but in terms of maths development perhaps not really, not even having that awareness that it is needed actually, there is no awareness that it would be helpful or - then that is my fault - I need to tell them that I needed it maybe or, I don't know

NS: I suppose what I'm playing around with is that they were happy for you to go on the course, to be retrained as a maths teacher, they know that you are doing all the maths teaching, that you are solely responsible for maths - is it a sense of well you have been on that course, tick, you are done

C: kind of, a bit, yeah

NS: or should that be awareness that they send you on a course to retrain - that is only ever going to be the start

C: it is the beginning of the journey. It is the lack of awareness

NS: so what I am thinking as TSST providers we should almost give, - we shouldn't just - face to face sessions, here is your certificate, handshake, goodbye - but be giving you a script to take back to your senior management to say I have been very successful on this course, I have done very well and these are the next steps. Saying we almost tell you what are the next steps

C: I think that is brilliant I think that could be really useful. I think you should do that, definitely

NS: so we can say things like peer observation, - we couldn't make senior management do it, but if we gave you a prescription at least you would know yourself what you are asking for - I think was becoming aware of is that – you don't know what you need

C: no I don't think I do - no you're right - you know the time, two years have gone since that course now -

NS: I think peer observation would be-

C: I think I would gain so much from that, definitely

NS: especially considering your circumstances where you are being quite small setting, quite isolated

C: [emphatic] yes, yes. And you know the times when you are being concerns more often than not you are being observed by someone who has not taught before, and you start to get a bit cynical about it - all you know they have never taught maths, actually that bit it doesn't matter, that's probably better but um you start to Think well I don't mind being observed at all but where my opportunity to observe so that I can - you are learning loads watching me, good and bad, you'll take that away and that's nice for you- you'll record it on a bit of paper but I want that for me for my maths teaching so I'm the one that should be learning in a way, NS: well that's really reflective - because there's a whole bit on the least experienced teachers gets to observe the least and the most experienced gets to observe the most

C: yeah - what is all that about!?

NS:

C: and especially if you're the kind of learner like I am. I do like to experience things. I'm not very good with just reading a book and learning about the theory of something - I actually have to do it or see it. I do actually watch teachers TV and that kind of thing

NS: I was going to ask you if you had any other kind of maths input and that kind of thing

C: yeah what else do I use - I'm sort of in most things, I think I found I hope I have found the better quality maths resources now

NS: and how have you done that?

C: just hours myself - trawling - our use and nrich activities quite a bit, they're really good - but yeah it's just about - downloading stuff from the maths course, all that stuff that you showed me, anything I wrote down, the resources - which was sad when we didn't keep going, partly me - I think you just get so busy, everybody does - it would be great to have a bit of a re[union]

NS: I know it is tough and maybe that is something TSST need to put more emphasis on - getting groups running - independently from us because of course we are then onto another group - I think maybe we need to put more into the network thing

C: I think that would be really valuable - but I don't know what the others would think - maybe it's just because for me I need the support - but maybe others feel it too, I don't know.

NS: are you aware of the shortage of maths teachers?

C: no, because I have just been here really

NS: So - what do you think made people, what made you, volunteer to become a case study, because that's an interesting angle isn't it? This has been going on for three years, what have you got from it, or what made you sign up in the first place?

C: for my own personal development really, because I think there will be bits that you tell me that will help me um I don't know and I wanted to help you and I know that I am probably quite a good case study - here and different. I think you know it can only be a good thing. I don't know, why did I agree, for that really and I think - you tell me and in your probing questions I learn from…

NS: and how is it felt over the three years? I know I haven't seen you as much perhaps are some others

C: … fine, good, you know, I have been really happy to take part, it hasn't felt uncomfortable, it's kept me thinking about that time I had on the course and how valuable it was, that you know it is ongoing, yeah positive

NS: do you remember when we did the mini teach, the joint collaborative planning on the course?

C: I thought they were brilliant, I really enjoyed those - I wanted more of that actually, I wanted to increase the practical content - but there was a mass to get through in a very short period of time and you know some people needed subject content but then you had people on our course who definitely didn't need that, and you know I was definitely in the middle I think, I needed some topping up with that but the bits I was learning the most from where you know when we would all sit and watch each other and you would say why did you do it, and did you think about that, and… definitely useful. It's a shame you couldn't put a package of all those mini teach together so we can get the curriculum - because that would be brilliant way of – you know they're only certain lessons I remember, and I didn't record enough of the lesson to take back and use again - I remember the lesson you did on statistics, the one where were given an envelope to open - I loved that - and I thought if all that was in one place, poor maths teachers or teachers who were not specialists could have access-

[NS shares quality resources with C – to reduce trawling time]

NS: I just want to say thank you. And please work less.

Appendix F

Semi-Structured Interview Questions for Senior Staff:

- What is your current staffing situation in your mathematics department?

- Have you ever had any issues regarding recruiting mathematics teachers?

- Why did you send [name of participant] on this Post-ITT SKE mathematics course?

- What benefit, if any has this been to your school?

- In your opinion was it value for time - regarding professional development versus disruption caused to school by staff absence?

- Would you recommend this course to other head teachers/senior staff? Why/Why not?

- Many head teachers/senior staff are reluctant to release staff for this type of all day, fully funded (including cover costs) professional development. Your thoughts?

- Would you release staff to this course if cover costs were not funded?

- The course could be in entirely ‘twilight’ hours? What do you think?

- For newly ‘retrained’ maths teachers - would you consider reducing the teaching ‘load’/timetable to allow new training to become embedded/more time for planning etc.?

- Would you release [name of participant] for an annual refresher - say a one-day course?

- Would a similar Post ITT SKE course be worthwhile for some ‘specialist’ mathematics teachers?

Appendix G

Exemplar Lesson Observation: Harvey

(with Ted Graham, PhD supervisor, also present for triangulation purposes)

24/03/2016 11.20-12.20 Year 8 set 1 out of 3 30 students (out of 32): 14 girls,16 boys MUFTI day

11.17 students arrive early

T: Good morning, come in....morning, morning... Students file in

T: [loud and clear] - come on in... sit down...mufti ...normal lesson...get your books out...

T: One iPad per pair.... open DESMOS folder Two boys handing out exercise book; T hands out iPads

T: Starter- inequalities between pairs of numbers/fractions T: Start with those pairs ...you may need to manipulate them...especially question 6

11.22: Class silent, working

A boy arrives late

T: Come on...you get here on time in this group... T checks with newcomer he knows what to do

11.23:

T: 2 mins left... Boy asks T a question about simplifying question 6

T(to whole class): Come on....just fraction work....you know how to do this...

T: Show all your workings in book...

Boy queries need for workings...T talks to him individually about converting mixed numbers

Girl has hand up; And another girl

11.25:

T:30 secs ...if unsure chat to person next to you very quietly

11.26:

T: Ok pause there...pens down, eyes up

T: Harry first one....

H: Crocodile…

T: I think we can be more sophisticated than...

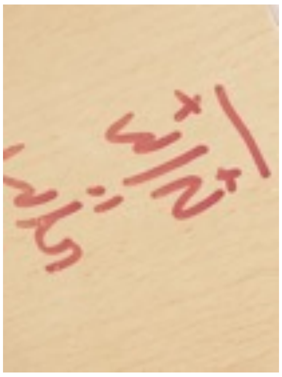
T: lets start getting our terminology correct

T: Elizabeth?

Boy (Jo)says 5/6 = 7/8

[as he has spotted that each is one 'bit' taken away] [See Ted's point: saying 1/6 is greater than 1/8...missed opportunity for discussion? Taking away is another approach here, taking away a bigger piece...for those who like to visualise. Logic required: If a bigger piece removed, then a smaller one remains...]

T: go on Katie...why? K converts them to have common denominators with 48 .....40/48   42/48



T points out could also use 24 as common denominator

T: If you haven't done 5 and 6 - give you one more minute...quick look I am going to show you how...

T briefly demonstrates procedure to convert from mixed number to improper

1 2/3   1 4/8

T quickly talks through and shows procedure at board...3 x 1 + 2 = 5/3....8 x 1 + 4 = 12/8

*[*Note: don't need to slog through this...just compare 2/3 and 4/8? Or possibly choose example where makes sense to need to convert mixed numbers to fractions]*

T: that was for me to see how far you could go with fractions and to recap inequalities...

Harry points out my above Note* i.e. ...just compare 2/3 and 4/8

T: BUT it is important for us to show working...

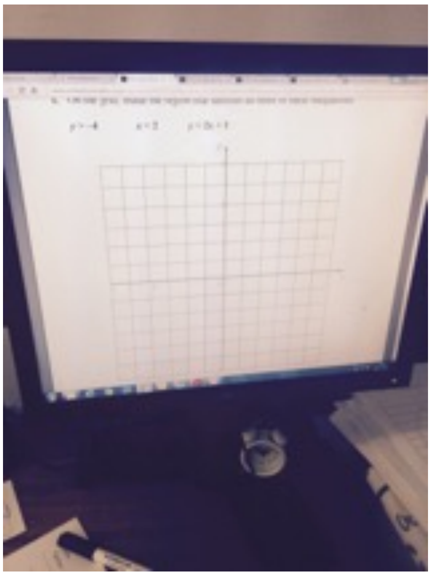
[*Note: Important for students to see different approaches. And which is more efficient?]*

11.33: T: Ok we are going to need iPads Axis displayed on OHP

T explains what to do [some confusion about what to plot...equations or inequalities]

Students ask for clarity..."so basically change inequality to equals"

T: Anyone feel confident to come up to board and draw lines on?



Class: No!

T: Go on [to a boy]

Boy does so

Lela asked to do next one

She writes y=2

T asks for refresh of gradient and intercept

[Note: good connection/links between topics]

Harry does 3rd

T changes Lela's to: x=2

[Note: would be good to use this as teaching point; T later explained that L was asking him to do so. Nevertheless a 'gifted' teaching opportunity?]

11.41:

Class discussion re. which side of line satisfies each inequality

Elizabeth says 'I don't get it...'

T asks her to come to board

...discussion at front of class including whole class...about which side satisfies inequality

E: Ahh I get it..

Lockland asked to come up - but gives his answer from his seat

[A few students notably more vocal...Lockland, Harry, Elizabeth...]

y > -4 and x < 2 are dealt with as whole class. Students asked to decide for y < 2x +1

[Note: Try: 'Decide as a pair....' - pair share would have worked well here.]

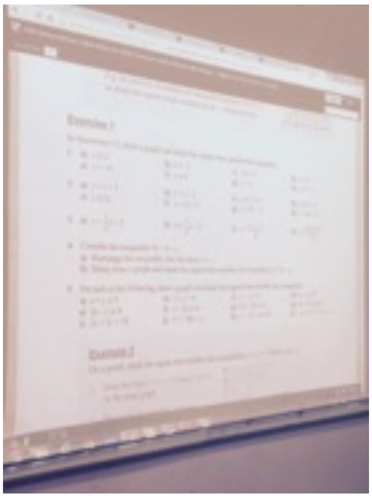
Lockland asked to come to board to show his answer....some confusion/banter

[Note: although good use of L to front - as he had previously struggled - unfortunately he got in a muddle. I think I would have pursued this until he was successful - as otherwise students may be less likely to come to front another time. And it is tricky articulating at board; takes practice and sense of success.]

11.50:

T: Pushing for time now...half an hour left...don't mind as long as we understand...

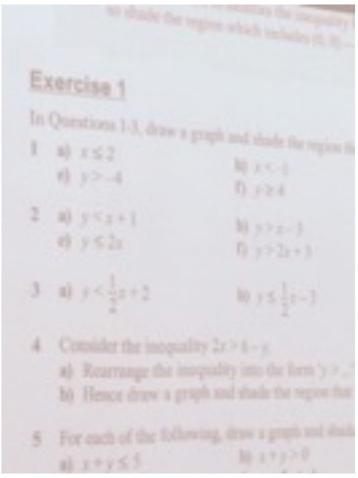
T recaps and draws in region that satisfies



T: You graph, you screen shot, put into notability, shade in region...then at end of lesson I will give you time to save into own folder

T: we haven't talked about...'or equal to'...will do next lesson

[Will have to back track from solid line limitations of Desmos? - possible to change to dashed line? or use Ted's idea and start with only 'or equal to' examples with bold line and then have class discussion later about what to do if not 'equal to'/included]



11.53: Students work on iPads from questions on board from CGP online editions

T moves between pairs. Some technical issues with iPads.

12.07: T input re. 4 finger slide to go between apps

12.08: T: Ok we seem to be getting hanging of this...but struggling with concept... of which side to shade

T: 9 mins left so let's push through....

T: 4 mins left of work and then have to save to folder...

12.15:

T: pass books down and we will finish the lesson

T: Obviously that was an extension...some of you were getting confused ...but we will re- cover that....Some of you were probably expecting to do no work...watch videos....so well done ...you did really well.....

12.20: Class standing behind chairs

T: When you are quiet...

T: Please be safe over Easter [ref to social media....]

T: Some of you bright [humour]

Two girls stay behind to complete report card for 1

Reflection from teacher:

- I think it was a stretch for them

- I wanted to use iPads as they don't get much opportunity....

- I had one extra lesson and didn't want to move onto something new...

- iPad to screen didn't work - which is why I had students up to draw it on board [Ted thought: use 2 students each time; immediately increases participation but also to support each other]

- It was OK

- A little bit disjointed

- Best bits? When the kids were 'getting it' in their small groups

- Least best bit? Technology! iPads didn't work for 1 or 2 - so they had to do it in their books. To be fair they did just get on with it.

- What would I change? Probably go slower through the inequalities bit

- I am still learning - and don't feel...being put on spot. Am getting better but...

- The bigger picture is coming...

Strengths:

- Great teaching style/approach

- You get them talking about their mathematics

- All are expected to progress

- The expectation /aspiration is that all will understand (i.e. **not**: ‘All/Most/Some’ approach)

- You really explored the topic

- Harnessing the power of technology: Obviously students familiar with using iPads/Desmos/ Saving work -> great

- All the time, looking to make connections: Connections are being made throughout the lesson: Fractions connecting with something else; equation of straight line linking with inequality;...

- Noted by Ted: Classroom looked like a ‘proper’ maths class room - equipment out, interesting displays, stuff on whiteboards around the room..

- Clearly a strong rapport with students

- Learners keen, enthusiastic and motivated to learn

- Ownership of ideas encouraged

- Learners feel encouraged and all were able to access task and make progress

- Learners cooperate, and collaborate with peers

- Learners on task

- Teacher listens to learners

- Teacher enjoys teaching mathematics

- Teacher orchestrates activities

- Teaching is aspirational in terms of activities set

- Teacher has control of the class

- Non-confrontational ethos in the classroom

Issues and Suggestions:

From Ted:

- Starter with a ‘variable’ would have been useful...and would then link better with later parts of lesson. For example: A game with $2<x<5$ where, going around the class, everyone has to say a value of x, not previously used.

- Perhaps do ‘...or equal to’ first? Use bold line and then decide how to handle ‘less/more than’.

- Come up with reason for doing inequalities in the first place (Otherwise can seem all quite abstract.) Imaginative examples could involve: a sample of students from this class with various constraints; translate into inequalities; identify region; and note - in this scenario - only integers within this region are relevant (unlike starter suggestion - where all values within range are possible).

- Lesson went downhill with exercise on board; the overcrowded screen with simple, repetitive questions - seemed like a backward step

- Instead choose (or highlight) a few ‘meatier’ problems

- Perhaps scaffold this by having two students at your computer doing the problems which can then be referred to by whole class. Perhaps also have a few groups working on mini whiteboards around room to compare/ contrast what is being projected onto screen by those at your computer. (NS: This would be an excellent way for the less vocal/forthcoming students to participate in discussions - give them the mini w/b’s!!???.)

- Ted: I struggle now *not* to give an exercise which *requires* students to *find out* something. Suggestion: Give them a picture - a defined region and then they have to say what the inequalities are i.e. go backwards and forwards, ‘do and undo’ the maths

Other notes - from the discussion between the three of us:

- Working in pairs is natural. This is the norm.

- Engagement with thinking about the teaching: T is noticing issues; he is reflecting/thinking about his teaching

- Clearly T likes lesson observations - takes on board developmental lesson feedback

- T buys into TSST ethos - wants to develop along these lines

- Looking at the A level material will benefit KS3/4 teaching

Further thoughts from H:

- Re. immersion idea: I wouldn't have done as well - if I had been drip fed into maths. You learn quite quickly. I definitely agree with the immersion idea. You can try things out...

- Collaborative learning...[Research note to self: repeatedly referred to]... Sharing resources....Testing them out...

- I now enjoy people coming into my lessons [Research note to self: repeatedly referred to]

- This is an opportunity to get feedback

- I want to develop; I want to get better

- KS3 books are rubbish; I use stuff from KS4 books - I think they are much better thought out

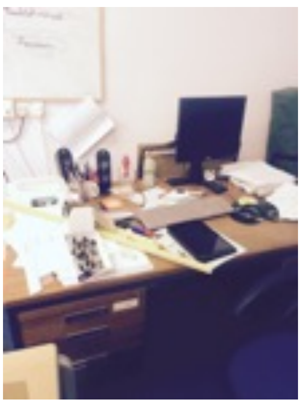
- I use CM resources with Year 11: [Research note to self: i.e. connecting Problem Solving approach with a more stimulating experience for Year 11 students]

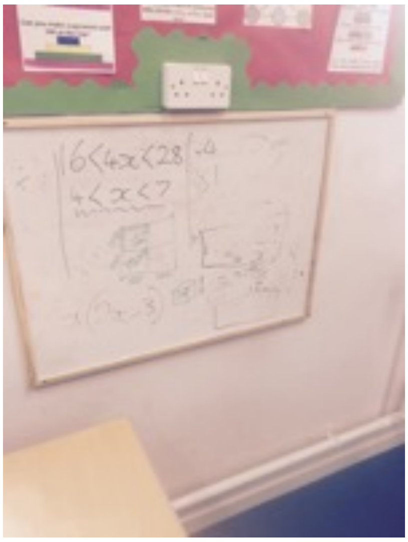
- Immersion idea - trying stuff out [Research note to self]

- My two year 7 groups are 2 years apart. NS told of SW approach: The lower attainers only work/focus when they have someone alongside them - Challenge is to break this mould. Ted suggested having the 17 of them in a crescent shape around a whiteboard. All then expected to contribute/come up to board/discuss/...








16<4x<28
4<x<7

Appendix H

Feedback *on Feedback* from Lesson Observations!!

The feedback you received from me, from the most recent lesson observation was - *in my mind* - more rigorous than for previous lesson observations in this study. I am interested in capturing your thoughts, opinions and feelings - having now experienced this more demanding version. The questions below relate to:

the post-lesson verbal feedback experience;
the written feedback some days after the lesson;
a comparison of the verbal and written experiences;
a comparison of feedback from this lesson with feedback from previous observations (*with me*).

Please circle/indicate whatever you feel best fits, and add comments whenever/wherever you like.

The <u>Verbal</u> feedback immediately after the lesson was:

1	2	3	4	5
irrelevant - to the lesson observed				very relevant to the lesson observed

Comments:

1	2	3	4	5
not constructive/ helpful/ useful helpful/ useful				very constructive/

Comments:

1	2	3	4	5
not instructive - for subject knowledge				very instructive - for subject knowledge

Comments:

1	2	3	4	5
not instructive - for pedagogy for maths				very instructive - for pedagogy for maths

Comments:

1	2	3	4	5
a very poor use of my time				a very good use of my time

Comments:

1	2	3	4	5
a very unsatisfactory experience… I would not like to repeat.				a very satisfactory experience… I would like to repeat

Comments:

The <u>Written</u> feedback sent within a few days of the lesson was:

1	2	3	4	5
irrelevant - to the lesson observed				very relevant to the lesson observed

Comments:

1	2	3	4	5
not constructive/ helpful/ useful				very constructive/ helpful/ useful

Comments:

1	2	3	4	5
not instructive - for subject knowledge				very instructive - for subject knowledge

Comments:

1	2	3	4	5
not instructive - for pedagogy for maths				very instructive - for pedagogy for maths

Comments:

1	2	3	4	5
a very poor use				a very good use

of my time | | | | of my time

Comments:

1	2	3	4	5
a very unsatisfactory experience… I would not like to repeat.				a very satisfactory experience… I would like to repeat

Comments:

Comparing the ‘Verbal’ and ‘Written’ versions of feedback:

Please tick/indicate whatever you feel best fits, and add comments wherever appropriate.

I preferred the verbal feedback because….

I preferred the written feedback because….

They were the same, no preference either way.

Actually, I didn’t like either because…..

Comparing this feedback (incorporating both verbal and written) with feedback from previous lesson observations:

Please tick/indicate whatever you feel best fits, and add comments wherever appropriate.

This feedback was less preferable because….

This feedback was more preferable because….

They were the same, no preference either way.

Thank you so much for your thoughts, time and input!

Appendix I

MASTERING MATHEMATICS WITH PLYMOUTH UNIVERSITY

Name .... **Male / Female**

Course Centre .... **Date** ....

Mathematics Attitude Questionnaire

1. At school, was Mathematics the subject

a) which you enjoyed most	*Yes / No*
b) in which you excelled most	*Yes / No*
c) at which you worked hardest	*Yes / No*
d) which you thought was the most important?	*Yes / No*

2. At school, how often did you

a) help your friends with Mathematics	*Often / Occasionally / Never*
b) seek help with mathematics from your friends	*Often / Occasionally / Never*
c) seek help with mathematics from your family	*Often / Occasionally / Never*

3. Do you regard Mathematics as a creative subject?	*Yes / No*
4. Is the correct answer to a mathematical problem more important than the method?	*Yes / Sometimes / No*
5. Is it important to learn multiplication tables and formulae by heart?	*Yes / No*
6. Are you confident that you can be a good teacher of mathematics?	*Yes / No*

---

7. a) From the list provided, choose 5 attributes, in order of importance, which you think are the key qualities of an effective mathematics teacher.

Sympathetic Humorous Patient Strict Well-prepared Explains clearly Hard-working
Friendly Excellent subject knowledge Enthusiastic Kind High expectations Approachable
Encouraging Punctual Well-organised Respected Sets challenges Supporting

1. ______ 2. ______ 3. ______

4. ______ 5. ______

c) What other attributes which are <u>not</u> included on the list above do you consider to be important?

…….

8. Which aspects of Mathematics do you think are the most important to pass on to your pupils?

9. Which area of Mathematics are you least confident about teaching? Please circle below.

Fractions Decimals Percentages Factors and multiples Prime numbers Algebra Geometry Trigonometry Statistics Probability Problem solving Applications

Other: ………..

10. Which main concerns about teaching mathematics do you hope this course will address? Please circle below.

Class management Discipline Planning Management of resources Using IT
Forming relationships with other teachers Forming relationships with pupils Challenging able pupils
Supporting less able pupils Teaching strategies Assessment Pedagogy Mathematical knowledge
Linking Theory and Research to classroom practice Identifying good practice I have no concerns

Other: ………..

11. For how long, from now, do you expect to remain in the teaching profession? Please circle below.

1 year 2-3 years 4 – 7 years 8 – 10 years 10+ years Working life

Other: ………..

12. What will you do differently from the way in which you were taught Mathematics?

13. What impact would you like to make on your pupils in terms of mathematics learning?

HOW DID YOU HEAR ABOUT THIS MATHEMATICS SKE+ COURSE?

PLEASE RETURN THE COMPLETED FORM TO YOUR COURSE TUTOR

Appendix J

Subject Questionnaire for Mathematics SKE+ Evaluation

Section A: *To give us an idea of the progress you made, please use the 1-5 scale (below) to give an indication of your mathematical competence ON EACH TOPIC (i) at the start of the course and (ii) at the end:*

6. **Excellent Understanding**: (I am confident and proficient in all aspects of this topic)
7. **Above Average**: (I am reasonably confident with this topic, but with some gaps)
8. **Average**: (I have a reasonable understanding of the basics of this topic, but need lots of help with more challenging questions)
9. **Below Average:** (I can just about cope with the basics of this topic, but need a lot of help)
10. **Poor Understanding**: (I really do not know much about this topic at all)

Name: ___________________________. Course Venue Attended: _______________________.

TOPIC	***At the start of the course***	***At the end.***
Decimals		
Fractions		
Percentages		
Ratio and Proportion		
Factors		
Indices		
Number Bases		
Number Sequences		
Areas		
Volumes		
Probability		
Data Collection and Presentation		

Averages (Mean, Mode and Median)		
Standard Deviation		
Algebraic Formulae		
Algebraic Manipulation		
Solving Linear Equations		
Solving Quadratic Equations		
Coordinates		
Straight Lines		
Curves (quadratic)		
Angles, Circles and Tangents		
Line and Rotational Symmetry		
Constructions		
Loci		
Congruence and Similarity		
Transformations (Reflections, Rotations, Enlargements)		
Pythagoras' Theorem		
Trigonometric Problems (sin, cos and tan)		

Please complete the following questionnaire, clicking on the appropriate 'Yes/No/Not Sure' box, and then providing further information where appropriate (the 'Feedback' boxes below each question will expand if necessary):

Section B: Teaching Skills :

1. Do you feel that the course has helped you to (significantly) improve your mathematics teaching skills?

Yes	***No***	***Not Sure***

Feedback:

2. Would you have liked a greater focus on teaching methods related to the topics studied?

Yes	***No***	***Not Sure***

Feedback:

3. Has your teaching practice changed as a result of the on-line teaching resources provided?

Yes	***No***	***Not Sure***

Feedback:

4. Did you have any impact on the work of colleagues in your own schools as a result of attending the course?

Yes	***No***	***Not Sure***

Feedback:

Section C: Course Evaluation:

1. Have you enjoyed the course?

Yes	***No***	***Not Sure***

Feedback:

2. Has the course inspired your enthusiasm for mathematics?

Yes	***No***	***Not Sure***

Feedback:

3. Do you believe that the course enhanced your subject knowledge and confidence to teach to up to and including Higher Level GCSE Mathematics?

Yes	No	Not Sure

Feedback:

4. Did the way in which the face-to-face teaching sessions were run work for you?

Yes	No	Not Sure

Feedback:

5. Was the e-learning component of the course helpful and effective in your opinion?

Yes	No	Not Sure

Feedback:

6. Was the iPad useful as a resource for the SKE course?

Yes	No	Not Sure

Feedback:

7. Was the timescale for completing the units realistic for you?

Yes	No	Not Sure

Feedback:

8. Were you able to resolve any problems you had on the course to your satisfaction?

Yes	No	Not Sure

Feedback:

9. Did you find the Audit tests useful?

Yes	No	Not Sure

Feedback:

10. Please use this section to add any additional comments or suggestions you have for improving the course.

Feedback:

Many thanks.

Appendix K

REFLECTIONS ON THE COURSE QUESTIONNAIRE

The SKE+ Maths course:

Why did you come on this course? And who initiated it?

Did you feel: nervous/ worried/ concerned/ pleased/ excited/ indifferent/ none of these*
about starting this course? *please circle any relevant options
Could you expand a little?

Have you noticed (and if so, can you describe) any changes:

- in your own maths teaching?
- in any other ways, for example: expectations; aspirations; outlook; beliefs; understandings; new knowledge;…?

In your opinion: Is the ‘SKE+ course’ a good way to increase the number of mathematics teachers? If so, why; If not, why?

Implementation of ideas from SKE+ course back in school:

Have you been able to share or feedback anything from this course to colleagues in your maths department? If so how, how often, when, to whom…? And if so, was that useful/worthwhile/…?

Is there a tension between the way things are done on the course and the way your school expects things to be done? If yes, can you expand a little?

Teaching:

If you could picture your perfect maths lesson, what would it look like?

How does this compare with the best maths lesson you have ever taught?

And one not so good (perhaps your worst)?

Shortage of mathematics teachers:

Do you consider that there is a shortage of specialist* mathematics teachers in your school?

If so, can you describe the situation?
**Specialist mathematics teachers are defined as qualified teachers with a mathematics or mathematics related degree (i.e. engineering, physics)*

Some non-specialist maths teachers have said to me that they feel like second class citizens in their maths department. Do you, or any other non-specialist members of your maths department, feel inferior in any way within the department? Perhaps you could ask your colleagues how they feel?

Other information:

When/how are maths groups set or steamed throughout your school?

What maths groups/set(s) did you teach last year (2013-2014)? And this (2014-2015)? And for how many lessons a fortnight?

What type of education did you have yourself? *
Private/State/Co-ed/Single sex/Boarding/11-16/11-18/Other - please state
**circle all relevant options*

Can you briefly describe the predominant maths teaching style you experienced as a pupil?

Appendix L

Pre-Interview 2 Questionnaire

Shortage of maths teachers:

Do you consider that there is a shortage of maths teachers in your school?

Do you have qualified and experienced maths teachers in your department? Please comment.

Do you know the proportion of non-specialists (maths graduates or equivalent) teaching maths? And what this is?

Some teachers have said to me that they feel like second class citizens in their maths department. Do you, or any members of the maths department *without* maths degrees, feel inferior in any way within the department?

Could self motivated non-specialists be more effective maths teachers than poorly performing specialists?

The SKE+ course:

Why did you come on this course? And who initiated it?

Did you feel scared/worried/concerned about starting this course?

Would you recommend this course to others? If so why? If not, why?

What has been impact of attending this course on you and your teaching?

Do you feel that the pedagogy for teaching maths is any different than that for other subjects? Is a different type of training required?

Have any of your beliefs or 'understandings' regarding teaching maths changed?

In your opinion: Can you 'retrain' teachers to become effective maths teachers by way of this SKE+ course?

There is a wide spread opinion that the best form of CPD is to observe other maths teachers. Can you describe something you have gained by observing someone else teach maths? Give an example of something particularly significant you have observed. Can you 'translate' this to your own practice? Have you observed poor practice?

And:

- What was most/least useful?
- Has anything that's been a revelationary moment/ Eureka moment?
- What do you think about the pedagogical/mathematical balance?
- What really did help you develop?
- What have been the problems/pitfalls?

Implementation of ideas from SKE+ course back in school:

Have you been able to share or feedback anything from this course to colleagues in your maths department?

Is there a tension between the way, say I do things and the way your school does things?

Do you feel pressure relating to pupils getting certain exam grades? If so, where is the pressure coming from? How do you feel about this?

I have often heard "pupils are not interested in learning - just in the grades they can get." Any comments?

Teaching:

Describe a lesson that has gone well for you and your students. Or gone really badly. And explain why.

Do you think you have 'developed' as a maths teacher? Why?

Are you now an effective maths teacher? Explain why.

How do we know if a maths teacher is considered effective?

What - if anything - are you bringing to maths department that someone with a maths degree hasn't got?

What do you think about when planning a lesson?

Some have said "When they [the pupils] behave better, I can do something more interesting." What do you think about this statement?

Other information:

When/how are maths groups set or steamed throughout your school?

How many maths lessons (classes) did you teach last year (2013-2014)?
And this year (2014-2015)?

What set(s) did you teach last year (2013-2014)?
And this (2014-2015)?

Do you know how many pupils opted for AS level Maths/ A level Maths/ Further Maths?

What type of education did you have yourself?
Private/State/Co-ed/Single sex/Boarding/11-16/11-18/Other - please state*
• *circle all relevant options*

Can you briefly describe the predominant maths teaching style you experienced as a pupil?

Appendix M

Final Questionnaire

Your participation in this final (hopefully!) research questionnaire is HUGELY appreciated. Thank you!

The SKE+ course ended two years ago. **Two years on**, do you [in terms of your maths teaching]:

(Please use a 5-point scale, where 1 = *not at all* and 5 = *to a great extent*.)

- Feel you have time for planning maths lessons?
- Have access to suitable resources?
- Have time/opportunities for discussion/sharing of ideas?
- Share learning (for yourselves) within the department/team?
- Team teach?
- Receive developmental feedback on your maths teaching (other than from me)?
- Observe other maths teachers teach?
- Feel well supported within the department/team?
- Feel your subject knowledge is increasing?
- Feel you are able to enact a SKE+ approach to teaching mathematics?
- Feel motivated?
- Have a sense of efficacy? (i.e. feel you have the ability to achieve as a maths teacher)
- Perceive that your lesson planning for maths lessons is developing?
- Have a better understanding of the 'end' point for your students in terms of what they need to achieve in maths?

What do you wish – if anything – was done differently within your setting?

Can you rate the following elements of the **SKE+ course** in terms of usefulness:

(Please use a 5-point scale, where 1 = *not at all* and 5 = *to a great extent*.)

- Learning the maths, i.e. developing my own subject knowledge; I learnt maths that I simply didn't know beforehand.
- Learning how I could teach the maths (that I did/did not already know) to students.
- The collaborative planning and mini-teach sessions.
- Observing other teachers teach students (NS, other SKE+ teachers, video of lesson).
- Discussing maths and sharing ideas with others on the course.
- Doing maths. Working things out and solving problems.
- Networking.
- Discovering resources.
- Talking about educational research.
- Other. Please state…

I wish we had also…

Can you indicate the degree to which your knowledge and skills were enhanced as a result of participation on the SKE+ programme in each of the following areas:

(Please use a 5-point scale, where 1 = *not at all* and 5 = *to a great extent*.)

- Curriculum knowledge – i.e. the content of KS3/KS4/GCSE syllabus
- Teaching methods/strategies
- Strategies for teaching diverse student populations – e.g. different attainment groups
- Use of technology in teaching
- Use of other resources
- Deepening knowledge of mathematics

As a maths teacher:

What, if anything, are you doing the ***same*** **as the way you were taught** maths?

What, if anything, are you doing ***differently*** from the way you were taught maths?

What, if anything, do you **wish** you were doing differently from the way you were taught?

What, if anything, do you enjoy teaching most/least?

If you can, please share some brief thoughts on: how best do students learn maths?

What do you think are some key attributes of an effective mathematics teacher?

Any other thoughts/comments….

Please state:

- Original subject qualified to teach
- Highest qualification in maths
- Number of years teaching
- Number of years teaching **maths**
- How long, from now, do you expect to remain teaching maths?
- SKE+: Distinction/Merit/Pass/Fail?

Appendix N

Observation Framework Using Guidelines to Identify Effective Teaching of Mathematics Part 1

	Observed (with notes)	Not Observed (with notes)
Learners keen, enthusiastic and motivated to learn		
Ownership of ideas encouraged and active participation expected: including for example, demonstrating and articulating at the board		
All leaners feel encouraged and are able to make progress		
Learners cooperate and collaborate with peers		
Learners on task with no one idle		
Teacher encourages creativity and discovery		
Teacher listens to learners		
Teacher is a good communicator, loves mathematics and likes teaching		
Teacher orchestrates activities and responds to outcomes		

Observation Framework Using Guidelines to Identify Effective Teaching of Mathematics Part 2

	Observed (with notes)	Not Observed (with notes)
Teaching is aspirational and challenging		
Teacher gives clear explanations; can select and instruct efficient and effective methods		
Teacher can see the 'big picture' and promotes mathematical content connections		
Teacher promotes deep thinking (For example: Why? How? What if? Questioning techniques)		
Emphasis on why the methods work (as opposed to simply emulating worked examples)		
All mathematics written by teacher clear, correct and precise; mathematical language embedded throughout		
Considered interactive questioning techniques to involve all pupils, and to reflect and evaluate progress		
Teacher has control of the class		
Non-confrontational ethos in the classroom		

Appendix O

Teacher subject specialism training (TSST) minimum specification

Lead school	

Programme overview
This should include high level, key information about the programme such as: • *Title* • *Programme subject (i.e. secondary mathematics, core maths, physics, modern foreign languages)* • *Focus (eg key stage)* • *Delivery or strategic partners (e.g. higher education institutions (HEIs) or subject associations)*

Programme elements	
1	**Clear learning outcomes** *These should set out:* • *Expected impact on the participant* • *Expected impact in the classroom*
2	**Audit of participant needs or baseline assessment** • *This should explain how you will establish participant's prior knowledge or experience to inform differentiated approach to meet participant's needs* • *Details of tools/approaches used*
3	**Monitored learning (minimum 30 hours)** *This must include:* • *A minimum of 12 hours face-to-face learning* *In addition, this could include:* • *Monitored online learning* • *Mentoring*
4	**Lesson observation or classroom experience** • *This will form part of your monitored learning 30 hours* • *Detail how this will be provided, eg for returners or participants not currently teaching their TSST subject*
5	**Independent learning** *For example:* • *Accessing resources, research, publications, etc.*

	• *Reflective journal*
6	**High quality facilitators** *These should be/could include:* • *Experienced in delivering adult training/professional development* • *Outstanding practitioners* • *Specialist leaders in education (SLEs)* • *HEI colleagues* • *Professional development leads*
7	**Access to high quality resources** • *Provide a brief overview of what resources you will use and how they have been developed/sourced, eg, in-house, in partnership with HEIs/strategic partners, external supplier/providers*
8	**A focus on both pedagogy and subject knowledge** • *A brief description of how your course will offer this*
9	**Programme evaluation** *Briefly describe the tools and/or processes that you will use to measure or identify:* • *Impact on participant (progression)* • *Early impact evidence (outcomes for pupils)* • *Future CPD needs/ongoing development*
10	**Certification, professional award or Masters credits** • *This should be in addition to a certificate of completion and a recognition of the learning undertaken, progress made or level achieved*

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