Teacher capacity for change
the case of GCSE Mathematics

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Teacher Capacity for Change:

The Case of GCSE Mathematics

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Thesis submitted in fulfilment of the requirements for the EdD degree of the University of London

School of Social Science and Public Policy, King's College, London, 2014

Abstract

Deep implementation of valued mathematics education policy remains elusive in the western world (Spillane, 2004; Eurydice 2010). This thesis reports on a small study which aimed to illuminate our understanding of both teacher capacity for change, and how teacher characteristics interact with policy enaction. It followed two English mathematics departments enacting a new 14-16 mathematics curriculum: a potentially demanding change for teachers. The study used a constructivist grounded approach (Charmaz 2000) over nearly three years to incorporate teacher response after first examination results, employing semi-structured interviews, lesson observations and documentary evidence. I employ several theoretical lenses and consider the benefits and tensions inherent in that. Analysis is at two levels: that of individual teachers, and of departments; and supports an extension of Ball et al's (2011) 'policy players' typology.

The two departments formed a 'telling' sample (Mitchell 1984), appearing well-placed for a principled curriculum enactment. However, they developed divergently, with 'Greenways' participants over time achieving an increasingly principled enaction, whereas 'High Wood', while espousing this, in fact privileged accountability measures by adopting minimal change.

Responses appeared to both expose and generate differential depths of a range of professional competencies. Additionally, the importance of various affective and social characteristics emerged: Greenways developed a deeper professional community with distributed leadership, and exhibited a progressively greater self-efficacy in relation to the changes, whereas High Wood appeared to lose access to previously-exhibited individual and department-level strengths. The study supports an *extension* of Winch's (2010) construct of occupational capacity in three ways: applicable to a group, social and affective.

This small-scale study adds to our understanding of both barriers to deep change and the development of expertise; it also informs our understanding of the constraints and affordances of policy. Additionally, in line with the aims of the professional Doctorate, it served to catalyse a higher level of personal reflective engagement with the range of my professional functioning – as teacher, teacher developer, policy activist and researcher.

Acknowledgements

My thanks must first go to my supervisor Jeremy Hodgen, not only for his critical integrity but for his interest, encouragement, challenge, and apparent confidence in me. From him I have learnt an enormous amount about structure and clarity of writing, about the world of social science, and about asking questions. Thanks too to Chris Winch, my second supervisor. Many other colleagues at the Institute of Education, at King's and at BSRLM have also been generous with their support and challenge, and have personified the power of the 'professional learning community': by their wisdom, patience and professional curiosity I continue to be profoundly humbled.

I must acknowledge an enormous debt of gratitude to colleagues at Greenways and High Wood who so generously shared with me the trials, challenges and rewards of endeavouring to be better teachers of the young people in their mathematical care: their patience and tolerance have gone well beyond the calls of duty.

Finally, to Brian, and to Rosemary, Heather and Nicola, without whose support I would not have completed this thesis.

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EDUCATION IN ENGLAND: CONTEXT, TERMS AND ABBREVIATIONS

The study is focused on the enaction in England of one (challenging) policy change in 14-16 mathematics education, now superceded. I argue that the findings and theorisation developed have implications beyond this particular change; however, in order to understand the reported data it is necessary to appreciate the mathematics education context in which the study is set.

In England state-provided compulsory education is directed through the government **Department for Education (DfE),** previously known as the **Department for Education and Skills (DfES)** and the **Department for Children, Schools and Families (DCSF).** Such education is normally set in '**Primary schools'** for 5-11 year olds, and in '**Secondary schools'** for 11-16 year olds. These are usually all-ability schools (known as **'comprehensive'** in the secondary phase). At the start of the study, most state schools, including those in the study, were responsible initially to **Local Education Authorities (LEAs),** which provide a variety of support, monitoring and evaluation in return for retention of some funding; since then many schools have acquired greater autonomy as **'academies'** responsible direct to central government.

The curriculum is divided into '**Key Stages'**, with Key Stage 3 studied from 11-14 and Key Stage 4 from 14-16. This is currently the end of compulsory mathematics education, though now that all young people have to be in education, employment or training to age 18, there are moves to encourage near-universal participation in some mathematics education to 18. Formal summative assessment of Key Stage 4 attainment largely takes place through subject-based examinations at 16 known as '**GCSEs'** (General Certificate in Education), and outcomes, particularly in English and Mathematics, have considerable implications for both individual students and teachers/schools.

Within secondary schools, and particularly at Key Stage 4, it is common practice for students to be grouped for mathematics by prior attainment ('**setting**'), and subsequently to take slightly different GCSE examinations, at '**Foundation tier'** or **'Higher tier'**. Until recently some students undertook GCSE assessments in stages over two or more years (a '**modular**' approach); during the course of the study this facility was withdrawn, with a move to all assessment taking place in one examination series ('**terminal**' assessment). State school mathematics entitlement to age 16 is framed in centrally-produced national curriculum documents which outline aims, objectives and content, and GCSE examinations are provided by several competing '**Awarding Bodies'**, who produce specifications based on the national curriculum, and a range of specimen assessment and

other materials. Responsibility for interpreting the classroom implications of the curriculum, for choosing between Awarding Bodies, for selecting from a wide range of available commercially-produced textbooks and other supporting resources, and for translating the entitlement into classroom teaching, is usually delegated to individual **'departments'** of mathematics teachers (or in some chains of schools, groups of departments) under the leadership of a '**Head of Department'**. Intentions at classroom level are normally reflected in the creation of '**schemes of work'** of varying granularity, which are then used by individual teachers to plan sequences of lessons. Some schools until recently employed **'Advanced Skills Teachers' (ASTs)** as senior and experienced classroom-based teachers who spent a given proportion of their time developing teachers beyond their home school, often across an LEA.

The study (of first enaction of a new GCSE Mathematics, to be first taught from September 2010), refers to a variety of influential national bodies:

- **Ofsted**, the Office for Standards in Education, Children's Services and Skills, an independent body responsible for inspecting and regulating these areas.
- **QCDA** (The Qualifications and Curriculum Development Agency), a national body responsible to government at the start of the study for development of curricula and qualifications in England. These two responsibilities were split in 2010 between **QCA** (The Qualifications and Curriculum Authority), later disbanded and its responsibilities assumed by DfE, and **Ofqual** (the Office of Qualifications and Examinations Regulation).
- **ACME** (The Advisory Committee for Mathematics Education), an independent committee based at the Royal Society and operating under its auspices, that aims to influence Government strategy and policies with a view to improving the outcomes of mathematics teaching and learning in England and so securing a mathematically-enabled population.
- **NCETM** (The National Centre for Excellence in the Teaching of Mathematics), a government-funded body responsible for advising on and facilitating the provision of **CPD** (Continuing Professional Development - post-qualification development) for mathematics teachers.
- **CUREE** (The Centre for the Use of Research and Evidence in Education), at the start of the study an independent body funded by government agencies to explore education issues of interest to them.

December 2014

CHAPTER 1: INTRODUCTION

1.1: Why is the study important?

This study relates to a challenging but widely-embraced change in mathematics GCSE, a high stakes qualification for individuals, teachers, schools and the nation. Successive governments in England have espoused the development of high quality mathematics education as central to economic and social wellbeing (Wright 2009), and fundamental to that is the quality of teaching received by young people in the classroom (Barber and Mourshed 2007). Previous attempts at deep large-scale reform in this country, though, as elsewhere, have met with limited success (Millett, Brown, and Askew 2004, Spillane 2004, Eurydice 2011): classroom-level changes of the sort envisaged are clearly very demanding for teachers. Nor is reform translated to classrooms without active interpretation and response by, among others, teachers: I consequently adopt Ball, Maguire and Braun's (2012) use of 'enaction' rather than 'implementation' as a key construct. We know that a hiatus between policy and enaction routinely occurs even where teachers claim faithful implementation (Spillane, 2004), yet the literature largely does not tell us how or why.

In particular, we are challenged to characterise the capacity teachers need for such change: what is the range of attributes teachers need to draw on, and how do these frame the nature and depth of changes made? Given a social (and situated) understanding of teacher functioning as discussed in section 2.3, this question needs to be given meaning and answered at both individual and department level, since I argue the department is the natural social context for secondary teachers in this country: what might it mean to describe a department as exhibiting a characteristic usually attributed to an individual, and how does that characteristic then impinge on enaction of change? I show in chapter 2 that there is relatively little theorisation of, or empirical evidence for, these issues in current literature.

Existing policy enaction studies typically focus on individual teachers over a short timescale; they also, as in Ball, Maguire, and Braun (2012) and Supovitz and Weinbaum (2008), frequently stop short of analysis at classroom level. In contrast, this study tracked the apparent impact of teacher (individual and collective) characteristics on enaction of Mathematics GCSE 2010 in two departments over nearly three years, from January 2010 to October 2012. It goes some way towards addressing the classroom level through lesson observation and analysis of some student work, through serendipitous access to student questionnaire responses, and use of those to

inform subsequent interactions with teachers. It asks what the data then tells us about policy enaction at classroom level.

The two study departments ('Greenways' and 'High Wood') had recently worked together to develop and enact a fairly creative and problem-focused Key Stage 3 (11-14) scheme of work from September 2008 on, and appeared to embrace the new GCSE, so I anticipated that both would succeed in a principled enactment. My knowledge of them suggested key differences might be exposed through variations in teacher knowledge and beliefs, so those were initial foci. Recent years have seen considerable progress in our understanding of the knowledge drawn on by mathematics teachers (Rowland and Ruthven 2011, Ball, Thames, and Phelps 2008, Shulman 1987), and also of how their beliefs interact with practice (Leder, Pehkhonen, and Torner 2002), though little of that work is directly related to policy change. Emergent study data suggested the need also to consider wider teacher characteristics, including the roles they adopted in relation to the policy (Ball et al. 2011a), in order to account for observed differences in enaction.

In doing so, I was able to develop a grounded theory of '(mathematics) teacher occupational capacity' (for deep change) that accommodates a number of existing constructs, and has meaning for both individuals and the collective. This has implications for all stages of teacher development, especially in terms of supporting growth of professional potential for flexibility and adaptability over time. It extends our understanding of the complexity of policy enaction and the constraints of an 'implementation' model that ignores the limitations and affordances of the individual and collective 'policy players' involved especially at the final, classroom layer of enaction; and develops Ball et al's (2011a) theory of such roles.

1.2 Policy context

This study took place against a (national and international) background of the marketisation of education and an 'audit society' (Power 1997), but within the specific constraints of the English education system as described on page 9, and at a time of rapid and significant educational change. Catalysts include performance in international tables, with their concomitant claimed implications for successful participation in a global economy. Changes were made in response to the 14-19 White Paper (DfE 2004), with the aim of improved motivation and progression to post-16 mathematics, as recommended in Smith (2004), and for first teaching in September 2010. Following subversion of implementation of the 1999 National Curriculum in mathematics as described in Ofsted (2008), these changes are broadly aligned with both recent advances in our understanding of what is important in the learning of mathematics as synthesised in Bryant,

Nunes, and Watson (2009) and Watson, Jones, and Pratt (2013), and also a reconceptualisation of broader priorities in 5-16 education as reflected in the 2007 National Curriculum (DfES 2007). Noyes et al. (2011) show that classroom-level decisions are often driven by perceived assessment demands rather than curriculum requirements, and this was addressed in the study, but nominally the two are consistent, with GCSE the assessment of the 14-16 curriculum (Gorard 2009).

Both young people and end-users of mathematics education in this country had significant needs which were not being met by recent provision (ACME 2011a, b). The 14-16 curriculum that is the subject of this study represents an attempt to shift towards a mathematics education consistent with ACME's recommendations, and characterised by Noyes et al. (2011, 44) as 'engagement, attainment, progression and participation' (this last post-16). The intentions as brokered in the QCA Mathematics Pathways Advisory Group, of which I was a member, commanded widespread support among the mathematics community as well as more widely (Noyes et al. 2011), though as indicated, other similar attempts have shown them to be highly demanding. The teachers in this study, however, appeared well-placed for a principled enactment.

As with the broader educational policy environment (Ball, Maguire, and Braun 2012), mathematics-related changes have continued, including changes to both tiering and modularity. In the second year of the study, and before completion of the 2010 GCSE by the first cohort, a further review of the National Curriculum was launched, for first teaching from 2015. This again occasioned heated debates about curriculum content and attainment, reminding us that these are at least in part value judgments, not entirely researchable truths, although always framed by politicians in unexceptionable terms - 'master' (Ball 1993) or hegemonic rhetoric such as 'standards' and 'world-class performance'. These further changes mean that the value of the study is for the wider, rather than specific, policy situation.

Study developments took place in a context of multiple (and sometimes contradictory) central policy initiatives and Braun et al (2010) demonstrate how it is impossible to isolate the impact of any one. However, I shall show that the two departments studied had very similar policy contexts, so that any differential enactment of the new mathematics GCSE was likely to be due to other influences.

The new GCSE addresses 'doing things better' rather than changing fundamentals of who learns what, when, where and how – but then given a perceived imperative of completing change to political timescales, the latter is very hard to achieve. Ball, Maguire, and Braun (2012) found

that the teachers in their study rarely engaged in fundamental questioning of policy aims and values, though study participants were given the opportunity to comment on them, since those might impinge on enaction. Walshaw and Anthony (2007) show that reform at scale depends on successful negotiation, across the constituencies forming a professional community, of a new collective understanding of effective practice. At a national level, the genesis of GCSE mathematics 2010 suggests such a consensus among those involved, but this study probes the extent to which that is followed through to classroom enaction level.

1.3 The study

The above considerations of policy concerns and of gaps in the literature yielded the following research questions:

- ***What characteristics do mathematics teachers draw on when learning to enact a demanding policy?***
- ***How do these answers alter if policy enactment is modelled as distributed at department level, and what meaning can be given to 'department characteristics'?***
- ***What contribution does this make to understanding of teacher capacity for change?***
- ***…and to understanding of policy enaction at classroom level?***

Figure 1: Research questions

The focus of these questions developed over time in the light of emerging findings: in particular, what I had anticipated to be a study of the impact of small-scale differential knowledge and beliefs on essentially principled enactments, proved far from the case.

For reasons explored in chapter 3, the thesis employs a constructivist grounded approach (Charmaz 2006): construction of theory grounded in open analysis of the data, and focused on meaning developed jointly with participants. It analyses characteristics of three teachers from each of two departments considered to form a 'telling sample' (Mitchell 1984), over the course of nearly three years of first enaction of the 2010 mathematics GCSE, using semi-structured interviews triangulated by classroom interviews and documentary analysis to expose characteristics of a range of teacher knowledge as well as beliefs and other affective variables, including their development over time. Iterative coding and analysis using both complexity theory and activity theory as catalysts, and undertaken at individual and departmental level, expose the

importance of a number of variables at present unaccounted for in models of teacher capacity. Various candidates for an improved teacher capacity model suggest the appropriateness of Winch's (2010) construct of occupational capacity for reinterpretation and extension to accommodate both the affective and the social characteristics so identified, and a collective construct of 'departmental capacity', at least in the case of the study context.

For most of the study I was a teacher based at 'Greenways' while also working in a developmental role at 'High Wood'. I was therefore very much an 'insider researcher', with the corresponding opportunities and threats to validity of data, as well as associated ethical challenges. This study informs both the constraints of policy enaction and the needs of teacher development, so contributes to the range of my professional work, as a teacher, a policy activist (and recent member of ACME) and working in teacher development as well as research.

1.4 Key terms

The study draws heavily on several sets of key terms, notably those related to policy and policy enaction; teacher knowledge; learning; and capacity. The first is addressed above. Teacher knowledge, learning and related constructs have in recent years become understood at least in part as distributed, contextual and socially mediated, although only a small part of the literature reflects this. Teacher 'capacity' is often used interchangeably (and apparently unproblematically) with 'expertise', 'effectiveness' and other terms. Each set therefore merits further consideration as in chapter 2, where I justify my adoption of 'capacity' as (an individual or group's) potential for goal-directed accomplishment, my use of knowledge, beliefs and values as part of that, and 'learning' as goal-related changes in teacher competencies (often intended but sometimes also incidental and maybe tacit).

1.5 The local research setting

The study took place in two 11-18 mixed comprehensives (pseudonyms 'Greenways' and 'High Wood') in a single rural/small town local authority in England. Intake of both is largely white, English-speaking and with average socio-economic intake and level of special educational needs. Prior attainment on entry is slightly above average. Until recent years, local authority support was generously available to schools, and the mathematics departments in both had taken advantage of this both conjointly and as individual departments. Students in both typically achieved at an

above-average level in absolute as well as intake- relative terms, with mathematics headline results, unusually, exceeding English results, so that the departments were well-regarded locally. Both were staffed almost entirely by 'mathematics specialists' in Smith's (2004) terms, with a small part of the mathematics teaching undertaken by those with responsibilities outside mathematics.

For most of the study 40% of my role was across the authority as an 'Advanced Skills Teacher' (page 9). As such, I had led classroom-based research, as well as curriculum projects, with the two departments together, and for the second full year of the study was directed into High Wood at local authority request, following an unexpected dip in GCSE results. I was therefore familiar with daily working in both departments, though to a greater extent in Greenways.

1.6 Theoretical perspectives

Among a plurality of definitions (or none) in the literature, I understand 'theory' to mean an organised and coherent system of concepts in a field, which can be used as a tool to conjecture and predict, describe and explain. Theoretical perspectives frame what one sees and how one interprets that, though as Lerman (2010) suggests, there is also a danger that theories can be bent to fit evidence, or data stripped of contextual richness to serve theory.

As a candidate for a theoretical lens, 'enaction' incorporates both policy and practice facets of my enquiry and appeared a natural approach to a practitioner. However, as Ball, Maguire and Braun (2012) argue, it is relatively undeveloped as a theory; further, as a familiar lens it was unlikely to support a breadth of sensitisation to new ideas or unexpected outcomes. Working broadly within a socio-cultural framework, I therefore adopted additionally both complexity theory and activity theory lenses since each has aspects apparently appropriate to the study: they offer complementary affordances, similar to those described in Beswick, Watson, and de Geest (2010), and in the event each proved fruitful, in very different ways. Further, the department as a unit features naturally in each. As I describe in Section 4.1, each seemed in different ways to identify aspects of department functioning I recognised. Even so, together they offer only a limited range of 'sensitivities': this underlines an understanding of the study as representing a partial account of enactions, and of data collection and interpretation, no matter how probing, as highly subjective. Schoenfeld (1998, 619) argues strongly that getting at 'what counts' in education research requires multiple lenses, methods and perspectives. Possible challenges with this approach are discussed in 1.6.3.

1.6.1 Activity Theory

Activity theory is a top-down framework, totally structured and deterministic. It produces a dynamic account of activity, including learning, with a focus on mediation by tools, an aspect of enaction to which I was already sensitised by Spillane (1999). A key paper is Engeström (1987), centralising context and the social, and giving a holistic account. In the western version, the activity provides the initial meaning and motivation, where meanings are about social understandings (and includes cognition, culture and affect). There is a basic purpose shared by a community, undertaken by subjects who are motivated by the solution to a problem, and that is mediated by tools (artefacts or instruments) in order to achieve the desired outcome. The activity is then analysed in terms of actions, operations, tools, social setting, motives and goals of all subjects. The possibilities are constrained by cultural factors including the prevalent rules or conventions, and social structures, as well as framed by broader social frameworks. Although sometimes described as 'atomistic', Engestrom (1999, 2001, 2005) progressively develops Activity Theory as holistic.

Watson and de Geest (2010) develop the model further by identifying connecting vectors with the ways in which participants perceive relationships between nodes. Engeström (2001) argues that the dynamics of the system result from contradictions between its elements – and conversely, that without such contradictions or tensions the system is stable. The 'third-generation' activity theory expounded in this last paper suggests how the interaction of two or more activity systems with common 'boundary objects' can be modelled: here, for example, the classroom learning system interacts with the teacher learning system, with a new scheme of work as a common boundary object, whether activity is modelled at single teacher/classroom or department level. Development of these ideas in e.g. Engeström (2005) focuses on the learning of systems rather than components of systems, so is appropriate to this study, conceptualising both groups of teachers and individual teachers as (interacting) systems drawing on a variety of characteristics. He conceptualises expansive transformation as a collective journey through the ZPD of activity. Further interacting activity systems such as the school, the central policy-making apparatus…. could be envisaged, but are not the prime focus of this study.

Learning arises from destabilisation which causes tensions that have to be resolved by new tools and rules, or division of labour, to re-acquire stability. Alternatively, reconceptualisation of object and motive can give rise to a more fundamental, 'expansive' transformation. The collective work model for teacher learning in this study, although subject to empirical validation, might be:

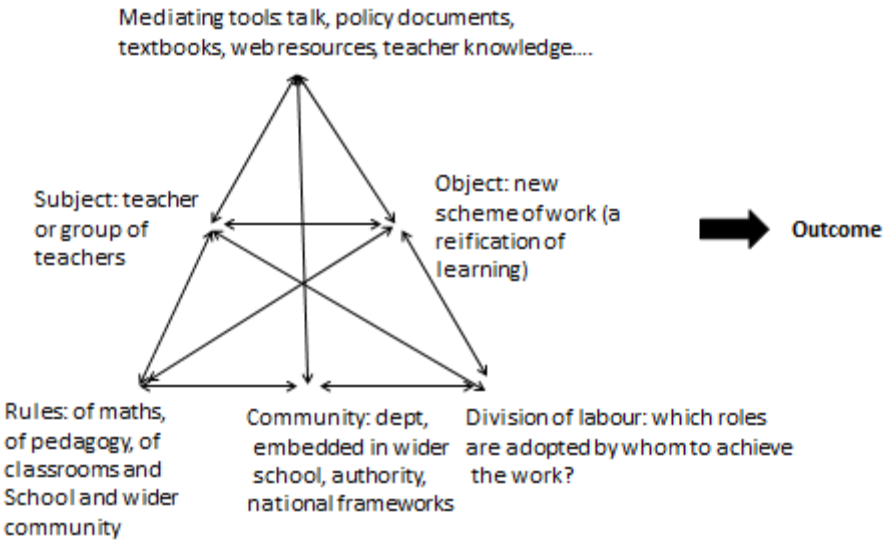


Figure 2: Activity system for department learning

(Adapted from Engeström (1987, 78)). However, as a system that would be linked, minimally, to a classroom learning system.

An activity-theoretic approach incorporates the diverse histories of teachers in part through division of labour, but also through the tools available, as in Jaworski (2006). It allows 'expansive transformations' of the system when individuals (or the group) challenge norms, so that object and motive are reconceptualised to incorporate radically new possibilities (Engeström 2001). This is developed by Fuller and Unwin (2003) into a construct of 'expansive learning environment', expanded and exemplified for secondary departments by Hodkinson and Hodkinson (2005), as described in Appendix 5.

For my purposes, activity theory assumes existence of a range of different aspects of the social context whose interactions and tensions, and those with other activity systems, can then be tracked over time, and directs attention towards those features. The Head of Department (or leadership) role is conceptualised as one of structuring systems so as to destabilise in the direction of desired change; policy roles could be conceptualised at least in part as division of labour.

1.6.2 Complexity theory

In contrast, complexity theory privileges the emergent, apparently non-deterministic and dynamic aspects of teacher learning, focusing on collective behaviour and embodying both the contextualised and the non-contextualised. Within mathematics education, the key paper is Davis and Simmt (2003), who describe a *complex system* as self-organising, adaptive and emergent, with change happening not in a linear and deterministic manner, but in a 'bottom-up' and unpredictable way through the interactions of its agents. The system is thus in some way 'greater than the sum of its parts' (Davis and Simmt 2003, 138) and constrained by dynamic contexts. They show that complex systems are typically 'nested', so that here, I conceptualised individual teachers nested within departments, each as potential complex systems, and explored the consequences of that. Enaction of departments is nested structurally within schools, which are themselves further nested – but here, more importantly, department work is also nested within the whole policy-related system, potentially complex also. However, the study will focus on the levels of teacher and of department.

Kurtz and Snowden (2003) suggest that enabling constraints are 'attractors' that introduce a degree of order around them, so increasing the likelihood of the desired response: the study will suggest from fieldwork what those might be in this case, and one role of leadership would be to seed such attractors. A further characteristic of a complex system is that it has memory, so that history of agents is important and needs to be probed in fieldwork.

Davis and Simmt (2003) propose that ambitious 'expansive' (and non-deterministic) possibilities, as required in this study, occur only if the complex system exhibits, among other characteristics,

- *Internal diversity*, which builds up the range of constructive and creative outcomes as well as the valuing of other agents;
- *Internal redundancy* (e.g. common language and setting, compatible power profiles, common responsibilities), which builds robustness and an ability to cope with stress;
- *Neighbour interactions*, where here the important 'neighbours' are ideas and questions rather than necessarily people;
- *Decentralised control*, so that individual contributions matter and there is a degree of distributed authority.
- *Enabling constraints* which limit the possibilities of adaptation: these may arise from above characteristics or elsewhere.

Although their own work is on a limited scale, it is part of a much larger literature of education-related complexity theory, as referenced in Davis and Sumara (2006). A complexity framework model would explain how, for example, capacity at department level can compensate for, and interact with, individual competencies so as to produce a system that functions as 'greater than the sum of the parts', and - with individual teachers as the system - how different characteristics can interact to produce a creative and effective teacher. The study therefore probed not only teachers but context in relation to such characteristics, in a multi-level approach, and this proved particularly helpful in addressing some of the unexpected differential characteristics discussed in chapter 6. Initially, I had thought that complexity theory would provide a purely descriptive tool for differential characteristics of teachers, but discussion in chapter 10 shows how it in fact suggests ways of facilitating a range of outcomes with enhanced validity; however it does not explain why the same constraints appear to enable some teachers but not all. Since unpredictability of impact is inherent in a complexity model, the potential is limited if the goal is understanding of ways in which policy can be framed so that outcomes are deterministic. In this case, though, I argue that the goal is one valid outcome among a range of possible such.

These two approaches conceptualise learning differently: as an integral characteristic of a complex system with emergent adaptation by players, or as a disruption which necessitates reconfiguration of deterministic relationships. The study considered whether departments, and individual teachers, were characterized more by emergence and adaptation, as in a complex system, or a totally structured entity: each lens offered insights into differential characteristics, as described in chapters 6 and 8. In both cases the role of leadership is highly influential: either as a facilitator of goals, seeding 'attractors' that act as enabling constraints, or structuring for destabilisation of a system so as to support the desired change. I therefore sought Heads of Department as key participants, and was alert to other indications of 'leadership' activity, with the two models affording complementary insights. I suggest in chapter 8 that for most of the study, the complexity model better fits the (subjective) data, especially with regard to the characteristics necessary for expansive change, but that the adoption from Activity Theory of the notion of 'tools' proved particularly helpful.

1.6.3 Commensurability of theoretical approaches

As well as analysing overall developments through these two lenses, I drew on theoretical concepts of community of practice and professional learning community (PLC); of policy 'roles';

and of competence/expertise/occupational capacity, and I shall claim that each, through framing of methodology, asking of questions and sensitisation to outcomes, offered insights into enaction of the GCSE. As theories they differ in granularity, and originate in different fields, but can they be subsumed one within another, or are they at least commensurable, and if not, does that matter? Lerman (2013) and Prediger et al. (2008) argue that the complexity of mathematics education suggests that a theory-of-everything is unattainable, but that the diversity of theories current is a rich resource, as well as allowing for triangulation of evidence. Prediger, Bikner-Ahsbahs, and Arzarello (2008) suggest that this also brings threats to communication and the integration of empirical results, as well as for 'progress', but that if satisfactory ways can be found for theories to 'network' this might expand communication and capitalise better on research, as well as support aggregation/accumulation of understanding. She synthesises different ways in, and extents to, which this has been done, as below. Clearly, there are difficulties if the implications of theories (say of learning) are contradictory rather than complementary, but otherwise different degrees of networking can be envisaged.

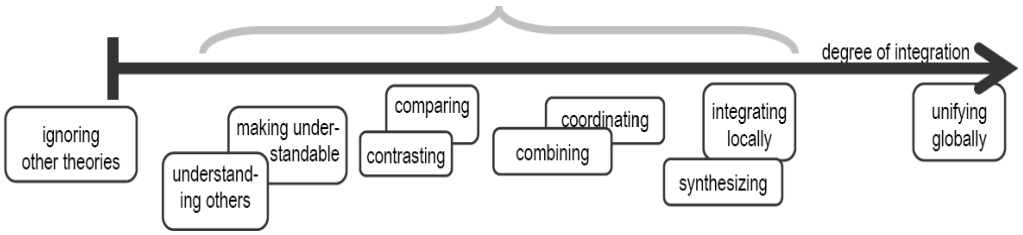


Figure 3: Networking strategies (Prediger 2009)

In a given situation some aspects of networking can be argued in general; others require the contextualised operationalisation to be taken into account, so substantive discussion is placed in later discussion. In this case, there is clearly a dissonance between teacher learning as emergent, and as structurally determined. However, I anticipate there will be some features of enaction conforming to each, enabling at least a small degree of 'combination' in Prediger's (2009) terms. I further show that the study supports the *development* of theories of both occupational capacity and policy roles.

Appendix 1 sets out some two-dimensional comparisons and relationships between the different approaches drawn on, showing that the core lenses of Activity theory and Complexity theory can be expected to enable at least comparison and contrast, whereas the other theories addressed are susceptible to local integration into either. Engestrom (2005) shows a move towards more commonality with complexity understanding: multi-voicedness ('diversity'?) has a higher profile, expansive learning emerges unpredictably in culturally new patterns of activity, and organisational learning is not resolvable as the sum of individuals' learning. In Section 8.2 I show

that for each of the departments studied, there were times when their functioning seemed better modelled by complexity theory, with internal coherence, and emergent learning and related variables; and other times when leadership activity in particular seemed to support an activity-theoretic model. At other times still, there were different aspects of their functioning exposed by each. As complex systems in situations of decentralised control, departments' learning is conceived as unpredictable, holistic and emergent adaptation in response to enabling constraints such as opportunities for interaction and centrally-provided documentation and resources, and opportunity and valuing of both shared and diverse knowledge and context of all kinds, and leaders can seed further to 'attract' desired responses. As earlier versions of activity systems, learning is the deterministic and atomistic accommodation of actions, roles, rules and tools to a destabilisation of (tensions or contradictions within) a system arising from the pursuit of a valued outcome. They thus privilege a focus on different aspects of functioning, which served to expose complementary aspects of the data.

1.7 Thesis Development and Structure

This thesis was, as appropriate for a professional Doctorate, developed in and around what were my own institution and professional roles - as teacher, teacher developer and policy-active professional - and over a period of five years, including three as a member of ACME. My professional situation highlighted to me the tensions and gaps between widely-supported 'good' intentions of policy, and what was being enacted in the classrooms I worked in and by the teachers I worked with, which, so it seemed from my knowledge of the research, was not untypical of a wider hiatus. As an experienced professional whose working life was focused on 'improving' the mathematics education received by young people, whether in my own classroom or others', this disjunct appeared to warrant further investigation. My understanding of the spirit and purpose of a professional Doctorate is that it should integrate academic and professional knowledge and so make a contribution to both theory and practice, in particular developing professional practice by making a contribution to professional knowledge. In addition a Doctorate requires a distinct and original contribution to knowledge (ESRC 2005). That contribution is summarised in chapter 11.

The thesis structure to some extent mirrors the development of the study, with a background survey setting out the policy setting and initial literature scope. The methodology adopted, including its ethical basis, is described and justified, and the outcomes of the fieldwork described and analysed for each department, at both individual teacher level and, where it makes sense to

do so, at department level. This analysis exposes the need for significant probing of (individual and collective) teacher characteristics beyond knowledge and beliefs, for further theorisation of teacher policy roles, and for theoretical constructs of teacher capacity beyond the original literature scope: this is reflected in chapters developing these ideas, as justified in chapter 2. Discussion of the findings follows, leading to reflections on the implications of the study at each of theoretical, policy and teacher development levels.

At times through this thesis I deliberately refer to 'the profession' and 'professional', despite a body of literature which questions whether teaching is in fact a profession (eg Beck 2008, Winch 2004). I question the helpfulness of such debate: my study suggests a critical role for positive self-efficacy for mathematics teachers in relation to more demanding aspects of their occupation, and the use of 'professional' terminology implies a respect and a value for teachers which can only support the development of that.

CHAPTER 2: RELATED LITERATURE

2.1 Use of the literature: Rationale and Approach

2.1.1 Role of the literature in a professional Doctorate thesis

How have I approached the literature underlying this study? Boote and Beile (2005) address its role in the Education Doctoral thesis, arguing it should display one's knowledge of the bigger field, so that the review chapter should go further than it would in setting the scene for a paper. Maxwell (2006) critiques them on the grounds of conflating the needs of reviews *of* research, with reviews *for* research, and I suggest also they overstate the case for the irreducibility of a doctoral thesis to producing a good research report, particularly as a professional Doctorate thesis is comparatively short.

Maxwell argues for the centrality of 'relevance', with the literature a 'conceptual framework for the study': a model of the studied phenomena that informs and supports the research in an ongoing relationship. I would argue that a thesis should additionally demonstrate and justify the selection and *genesis* of that framework. For this study I have attempted to show how various framework affordances supported the 'noticing' of different aspects of the available data, and enabled complementary understandings of the observed enaction, leading to the development of theoretical constructs that are consistent with a range of lenses.

Boote and Beile (2006) characterise a thesis as a demonstration of a cultural epistemology. However, in a professional Doctorate there are necessarily epistemological tensions, in this case reflecting my multiple identities as teacher, teacher-developer, researcher and policy-influencer. These inevitably, and constructively, impact on methodological choices made, but also on selection, interpretation and communication of evidence, as well as its embedding in wider understandings: I try, nevertheless, to maintain a sense of the research community as audience, to an *analytic* and *synthetic* rather than purely *descriptive* narrative.

The preparation for, structure of and initial stages of enquiry required a familiarity with the literature described in the current chapter, with a grounded depth developed in parallel with and in response to analysis of fieldwork data. As the study progressed it became apparent that additional areas were in fact pertinent: I argue that the necessity for these should, for sense-making, be demonstrated before they are drawn into the thesis. Chapter 6, for example, deals

with unanticipated emergent differential teacher characteristics, at both individual and department levels, and situates the study findings within an expanded range of literature.

2.1.2 Selection of literature

In line with Maxwell (2006), the literature considered here is restricted to key writing in focus areas: what do we know about (mathematics) education policy enaction (2.2); about what comprises teacher capacity for such change (2.3); and about the conditions under which teachers learn (2.4)? Finally, what does the literature tell us about these issues if they are considered as distributed socially (2.5)? Outcomes formed the basis of my conceptual framework, together with the theoretical underpinnings discussed in chapter 1. Appendix 2 outlines search terms and selection and rejection criteria, but with large returns inevitably 'relevance' becomes highly subjective.

2.2 Policy

Lingard and Ozga (2007, 2) define school-related education policy as 'dealing with all texts … which seek to frame, constitute and change educational practice', although Ball (1993) includes wider communications. I take **(curriculum) policy** to be the range of intentions as expressed in central communications, from the mandatory written curriculum to its interpretation in centrally-authorised supporting materials. This is the 'intended' curriculum. Beyond that are the (transformed to various extents) 'interpreted', 'enacted', 'received' etc. curricula at different levels (Andrews 2011), including through textbooks and assessment materials: these exhibit a range of consistencies with the intentions of the curriculum writers. By **teacher 'curriculum use'** I mean the ways in, and extents to which, teachers select, adopt, and adapt the curriculum, sometimes by the choice of such proxy materials. This is predicated on an assumption that teachers are active agents and users of curriculum as interpreters and translators (strategic/tactical respectively) - and that a range of valid uses can be made.

As in 1.1, I conceive **policy as being enacted** through 'iterative refraction' (Supovitz and Weinbaum 2008) at a variety of individual, social and organizational levels, often increasingly deviating from original intentions: here, Mathematics GCSE 2010 was initiated by a government quango (QCA), approved by ministers, operationalized by curriculum writers, and then interpreted and translated by, successively, and typically, a variety of people in Awarding Bodies

(moderated by Ofqual), local authority personnel, Heads of Department, and individual teachers; it is then received in different ways by students in the classroom. This is not the complete picture of course, since each of these 'players' is influenced by others. In common e.g. with Ball et al. (2011a) I therefore use the word 'enaction' rather than 'implementation', which suggests a lack of agency. I shall use **'interpretation'** as 'making meaning of', whereas **'translated'** is a much more active process of applying, extending and often moderating that meaning as considered appropriate to a particular context; this differs slightly from Braun, Maguire and Ball's (2010) notions of interpretation as 'decoding' and translation as 'recoding', which suggest rather less latitude, and almost inverse operations.

2.2.1 Policy Enaction

In an environment of 'policy hyperactivity' (Dunleavy 1987), teacher development takes place amidst constantly changing parameters that serve to absorb teacher energy and focus, and frame that development in sometimes unplanned ways (Ball, Maguire, and Braun 2012). Further, principled change of the sort envisaged appears very demanding. Although GCSE 2010 is not to be equated with 'reform mathematics' as understood in the USA, it has much in common: Spillane (1999) suggests teachers need deep subject and pedagogical knowledge to access core 'reform' ideas. He argues teachers can only revise their core practice dependent on the extent to which their 'enactment zones' are social, involve rich deliberations about the substance and practice of the relevant ideas with both other practitioners and experts, and have access to material resources which support their deliberations and enactment. He later (Spillane, Halverson, and Diamond 2004) develops this by arguing that teacher practice is *partially constituted* by the materials they draw on, the institutional constraints that they attempt to satisfy, and the formal and informal sources of assistance available, implying a social and contextual distribution of capacity. They also need motivation and (Johnson and Millett 1996) good quality time. I shall show that most of these apparently necessary conditions initially appeared available to the two participant departments, though the supply of relevant materials for some aspects was thin.

More recently, Cobb and Jackson (2012) suggest that 'policies that are effective in supporting consequential professional learning will involve some combination of new positions that provide expert guidance, ongoing intentional learning events in which tools are used to bridge to practice, carefully designed organizational routines carried out with a more knowledgeable other, and the use of new tools whose incorporation into practice is supported.' They conceive a degree of external support not available in the study, and surely not easily scalable; they were, however,

working with U.S. middle school teachers with generally less subject-specific knowledge than my teachers. A number of studies suggest that teachers' enactions are significantly affected by their knowledge and beliefs (available tools/content for interactions) in a variety of domains (Ernest 1989, Romberg and Carpenter 1986, Clark and Peterson 1986), which was the basis for the pilot study supporting this thesis (Golding 2011). The literature probing this area is described in 2.3 below.

The enaction lens adopted allows consideration of the degree to which policy should be well-defined. Clarity of intent would seem to be necessary for valid enaction, yet tight definition both increases the risk of policy being incompatible with contextual restraints and restricts potential for agency: in complexity terms, some decentralised control and both presence and accommodation of diversity are necessary for expansive transformation. Putnam and Borko (2000) suggest there are tradeoffs between fidelity to and adaptation of development programmes necessary for successful impact on teacher and student learning, so that there are arguments for ill-definition of policy, as well as a range of valid meanings to 'successful enaction', and it might be that the optimum degree of 'writerliness' available, in Barthes' (1974) terms, varies between individuals or groups of individuals. Ball et al (2012) use these terms as well-defined, though I would suggest such descriptions are highly subjective and contextual. Matland (1995) found that the 'degrees of freedom' *perceived* in a policy depend on a number of factors, including the clarity of communication at different levels, the 'ownership' perceived by players (though that perhaps is a circular argument), the available support and expertise, and its apparent reasonableness, the last not an issue here.

Fullan (2001) sees the above 'problem of meaning' as central to the understanding of change in schools, and Maguire, Hoskins et al. (2011) likewise foreground this sense-making as integral to enaction at any level, so that the role of language is critical to communication of the principles inherent in policy. Remillard's (2005) review, similarly, demonstrates both that not all curriculum interpretations are equally valid and that 'fidelity' in the use of curriculum materials is ill-defined. She recommends curriculum developers are clear about the layers of intended meanings and complexities inherent in their intentions, and make efforts to signpost core ideas unambiguously. Spillane (1999) probed the change process in those teachers who claimed 'successful reform', yet within that found enaction of multiple interpretations as well as translations, many of them of limited validity.

Profound change takes time, as shown in Stein, Silver, and Smith (1998), and that is a challenge for any comparatively short-term study. Fieldwork was undertaken over nearly three years, but that is still only through the first two-thirds of a second cohort of students; I was able

to access some 'update' information about enaction in Summer 2014, some four years after first fieldwork (Appendix 24). Franke et al. (1998, 68) show that for the teachers in their Cognitively Guided Instruction (CGI) study deep (what they call generative self-sustained) change also required understanding *why* a particular practice works and how teaching practice related to student learning, which makes further demands on teachers involved.

2.2.2 Policy Players

Spillane, Reiser, and Reimer (2002) show that much policy interpretation work conceives all actors in the policy process, with the exception of school leaders, as equivalent, and to be working on and with policy in comparable ways - as receivers and agents. They suggest, in contrast, that even if all actors construct understandings that are similar to policymakers' intent, they may not have the resources, including a range of necessary individual capacities (here, meaning a range of practical and theoretical knowledge), to implement what they understand the policy to be asking of them. Ball et al. (2011a) propose that individual teachers at any one time predominantly adopt one of a small number of roles in relation to any given policy, and, further, suggest that in principle such roles may be adopted by groups of people. The idea is summarised as a (non-exhaustive) typography of 'policy actors':

Table 1: Policy actor typology (Ball, Maguire and Braun 2012, 49)

Policy actors	***Policy work***
Narrators	Interpretation, selection an enforcement of meanings
Entrepreneurs	Advocacy, creativity and integration
Outsiders	Entrepreneurship, partnership and monitoring
Transactors	Accounting, reporting, monitoring/supporting, facilitating
Enthusiasts	Investment, creativity, satisfaction and career
Translators	Production of texts, artefacts and events
Critics	Union reps: monitoring of management, maintaining counter-talk
Receivers	Coping, defending and dependency

As such it is purely descriptive rather than predictive in any way, but it was initially used in this study as a means to identify differences between teachers' relations with policy. I later extend it

with an additional role exposed in my data, and suggest links between the above two pieces of work by identifying the capacities apparently drawn on in adopting the roles seen in this study, as well as tracking the role combinations and changes seen over time, in chapter 7. I also develop a meaning for a group typology, and discuss how the roles adopted at each of individual and department appeared to 'mediate' enactions in this case.

In relation to policy, teachers can productively be conceptualised through multiple lenses, depending on the activity system or complex organism envisaged. They are also both subjects and objects; they are producers of enacted policy and actors in it; and how the policy is 'played out' on the ground varies with policy but also through time. I therefore adopt the term *'policy player'* rather than *'policy actor'* as suggesting rather greater agency. Ball et al. (2011b) describe twin ontological roles of teachers in relation to policy, depending on whether that policy is being construed as 'discourse' (with teachers as subjects) or as text, when teachers can be conceptualised as agents of policy, interacting with possibilities for interpretation or creativity; further, they argue that both lenses are needed if teachers' relationship with policy is to be understood. In common with Bandura (2001) I, and they, use 'agency' to mean the capacity of individual teachers to make choices and act on them, though those choices might have a range of influences, including the social and contextual.

2.3 Teachers' knowledge, beliefs and wider capacity

In much of the literature 'knowledge', 'beliefs' and 'values' essentially represent an individual's mental construct in relation to, here, their work: I argue, in common with Askew (1999), they may be held with varying degrees of certainty, with 'knowledge' at one end of this spectrum. However, in complexity terms knowing is contingent and adequate rather than absolute. The relation of these ideas to practical knowledge **('know how'**) is often either implicit or absent from consideration, as discussed in 2.3.1: I adopt Ryle's (1946) use. I use **'values'** to indicate deeply-held, persistent beliefs high in that hierarchy. In common with the bulk of the literature, I initially consider knowledge and beliefs as individual constructs; I later expand to the group.

2.3.1 Knowledge and Beliefs

Teachers exhibit a wide variety of knowledge and beliefs over a range of domains, and there is good evidence (Peterson et al. 1989, Thompson 1984, Romberg and Carpenter 1986) that their enactions of curricula are significantly affected by these. Work lies in three categories: exploration

of knowledge and beliefs per se, typically treated as purely cognitive constructs; the implications of those for the classroom; and the way in which they can change. Because of the difficulty in measuring cognitive constructs directly, evidence for the first is frequently inferred from the second.

A foundational paper in western work on teacher *knowledge*, held as propositional, case or strategic, has been Shulman (1987). He postulated seven (intersecting and interdependent) fields of teacher-specific knowledge, of which subject and pedagogical content knowledge[1] have in mathematics education been built on in particular by Ball, Thames, and Phelps (2008) and by Rowland, Huckstep, and Thwaites (2005) in their 'Knowledge Quartet' of mathematics teaching knowledge exposed in the classroom: the comparisons are addressed (not always convincingly[2]) by Turner (2012). This study probed aspects of each of these frameworks, predicated on an assumption that a teacher's knowledge in a range of domains is likely to circumscribe, at least, the options available to draw on in any curriculum enaction. In terms of epistemology, both typologies fall short of fully addressing the practical knowledge considered by e.g. Winch (2010).

A variety of knowledge is clearly central to any construct of teacher capacity. Li and Kaiser (2011, 3) say 'it is now commonly accepted that experts are knowledgeable about what they do and they have a more structured knowledge than non-experts' - though as yet we have no codified body of knowledge for teaching equivalent to that which may be argued for in e.g. medicine or law as professions. They cite evidence (p345) that expert mathematics teachers have a deeper representation of mathematical knowledge, and are able to structure teaching and learning processes in a more organized, coherent and goal-oriented manner, organizing their knowledge by process or situation rather than smaller elements: it is clearly not just *what* knowledge teachers have, but *how* it is held and used, that matters.

Teachers need both 'know how' and 'know that', i.e. both procedural and propositional knowledge. 'Know-how', in Ryle's (1946) terms, goes beyond being able to describe how to complete a task, to implying that under normal circumstances, one is able to complete such a task (with intentionality and normativity), whether the means to its accomplishment is tacitly or explicitly held. Much work on mathematics teacher knowledge, though, while not ignoring 'know how', assesses it by a variety of means removed from the classroom: for example Baumert et al. (2010) use formal written tests and structured interviews, student and teacher ratings and sample instructional materials to infer teacher (content and content pedagogical) procedural knowledge.

[1] The other areas postulated are general pedagogical knowledge, knowledge of students, of curriculum, of aims, purposes and history of education, and contextual knowledge.

[2] For example, connections between schema are far from complete, and claims for acceleration towards Ma's (1999) 'profound understanding of fundamental mathematics' apparently over-stated.

This is in contrast to e.g. The Knowledge Quartet, developed around knowledge exposed in the classroom and building on 'foundation knowledge' of both kinds.

Experienced teachers often refer to individual classroom contexts and experiences in justifying *beliefs* about education (Guskey 2002), suggesting those are situated and inductive. Further, Leder and Forgasz (2002) argue that beliefs may form inconsistent systems, and are held in a hierarchy of importance to an individual. Varying degrees of consistency between espoused beliefs and practice are reported (Thompson 1984, Lerman 1990, Lester 2002), with divergence occurring for a number of reasons, but I adopt Leatham's (2006) view, seeing teachers' beliefs as 'sensible systems' and trying to explore and explain apparent inconsistencies as they arise. Triangulation through the dual use of interviews and classroom observations is therefore important. However, it remains the case that much knowledge and belief is held tacitly, and further, that in interviews and even in classroom observations, the teacher to some extent chooses what to expose. Partial access may be available via individual self-reports and observations, as well as a tool I developed that related particularly to this enactment, as discussed in chapter 3.

Thompson (1992) demonstrates that beliefs about mathematics itself, in particular, are influential in determining 'desirable' ways of teaching and learning mathematics. Skemp's (1976) dichotomy relating to the nature of mathematics is still very influential: *relational mathematics* is characterized by the knowledge and use of flexible and emergent conceptual structures in relation to one another, whereas *procedural or instrumentalist mathematics* consists of a closed, finite and ready-made list of definitions and procedures which are progressively mastered and utilized. These are often reflected in 'connectionist' or 'transmissionist' approaches to teaching respectively, in Askew et al's (1997) terms. The 2010 14-16 curriculum appears to be predicated on the former; however, national assessments have largely focused on the acquisition of a high degree of technical (procedural) skill, and Brown (2011) suggests one may be bought at the expense of the other. Evidence from Williams (2011), Swan (2006) and Askew et al. (1997) suggest that mathematics teachers in compulsory education in England are largely transmissionist, implying deep-seated belief tensions: in this respect I initially considered that my sample was 'telling' as described in chapter 3.

Where beliefs are not aligned with new curriculum, some belief change may be necessary for principled enactment. Theoretic models for belief-change relationships vary through to cyclical and multi-layered models: Tirosh and Graeber (2003, 673) claim 'changes in beliefs and practices occur in mutually interactive processes', but some studies evidence changes in the classroom practice of experienced teachers *preceding* corresponding deep change in beliefs, with alignment

only achieved after several years (Guskey 2002, Anderson and White 2005, Raymond 1997). Hunter (2010) shows positive effect on student learning catalysing a shift from teacher enactment to teacher belief, and that is a relatively slow process likely to become more apparent as time proceeds: it supports the benefit of a longitudinal study through at least to impact of first GCSE results. Lloyd (2002) shows that a requirement to reform, together with the provision of curriculum materials alone, is insufficient to change beliefs, though engaging with materials as a learner can help. Hodgen and Askew (2007) go further, arguing that the opportunity to *develop* lesson materials is particularly crucial: this was probed in the study. Implicit in belief change is the need for an inclination and capacity to doubt, reflect, reconsider and refocus (introducing tensions, in activity-theoretic terms), drawing on deep knowledge on a variety of fronts.

Recent years have seen a move from broadly constructivist models of learning towards socio-cultural models which reconceptualise teacher knowledge and beliefs as situated, social and distributed in origin, and accommodated by both Activity theory and Complexity theory, yet the literature largely persists in referring solely to individual cognitive constructs. That this is not a sufficient model is demonstrated by e.g. Berliner's (2004) account of changing context derailing what had appeared established teacher knowledge, and Hodgen's (2010) description of distributed knowledge clearly exceeding what was available to a teacher in isolation. I understand beliefs and knowledge to be partly situated within social practices, and that framed methodology, yet certain knowledge, more an activity-theoretic than complexity notion, remains a useful idea, representing reified practices (Wenger, 1998).

There is though a challenge, raised by Williams (2011), in interpreting 'collective knowledge' (or beliefs, or…), other than it being that which is available for use in social contexts but not necessarily by individuals in isolation: what does it mean to ascribe a typically psychologically-held construct as being held by a group? For complexity theory such questions are unproblematic as group emergence of characteristics is fundamental, being conceived of as adaptation to new circumstances, but outside that framework I could find little in the literature to address these problems, so attempt to suggest some grounded solutions in the study.

2.3.2 Teacher capacity

Given the clear challenge of the sort of change envisaged in the study context, any identification of teacher characteristics that might support that change will have implications for our understanding of teacher 'capacity', and that construct acquired greater significance as the study progressed: my understanding of 'capacity' is the potential to hold or receive, or as here,

the potential for development or goal-directed accomplishment. The words 'capacity/expertise/effectiveness' are often used interchangeably, or unclearly, in the literature. I shall use **'effectiveness**' to mean the extent to which practice positively impacts on goals: here, student outcomes that are valued by society (though even this is problematic, since 'society', students, parents, mathematicians and other stakeholders might vary in this respect). These might include a mathematically confident population, so a widespread inclination to engage in mathematical functioning at a 'reasonable' level and ability to do so with confidence, accuracy and reasonable efficiency; and might also include high levels of inclination to engage in mathematics-based education post-compulsion. I use **'expertise'** to mean the range of characteristics which have the potential to impact effectiveness in the primary occupational domain, including an ability and willingness to employ them. I conceive expertise as being on a scale with 'experts' at one end, and **'competence'** to represent a threshold level within that, involving a certain degree of both autonomy and responsibility. However, what teachers *do* should not be equated with the characteristics that make that possible.

I use (teacher) **'occupational capacity'** to mean a wider range of teacher's current characteristics, sometimes apparent only beyond the principle domain of practice, that have the potential positively to affect expertise at a local or perhaps wider level. Thus, a teacher might have knowledge about national assessment procedures that are over and above that which directly benefits their teaching: this I am not considering part of their current 'teacher expertise' although it would be part of their 'capacity' since it conceivably might inform their thinking about assessment in a school context at some point in the future. Or they might have mentoring knowledge and skills which go beyond their own individual effectiveness, although still within the bounds of, here, 'mathematics teacher'. It should include engagement with wider issues such as the role of education in relation to society, and with the syntactic, as well as substantive nature of occupational knowledge.

With this use, we have

$$\textbf{competence} \subseteq \textbf{expertise} \subseteq \textbf{occupational capacity}$$

For any of the models in the literature, e*ffectiveness* is inferred from (possibly a range of) student outcomes (although establishing a teacher's unique contribution to outcomes is difficult), although many models of expertise fall short of testing against outcomes; o*ccupational capacity* is more difficult to observe, since it includes both these but also wider professional attributes as well as potentials for contributions to effectiveness given a change of context – for example, as

here, a challenging curriculum innovation. Inferred capacity therefore changes with opportunity and demand, and at any time only a lower bound to capacity can be evidenced.

In Activity-theoretic terms capacity acts as a tool, as well as providing rules; for a complex system it frames the possibilities for interactions, for redundancy and diversity, as well as some enabling constraints, within the whole, though both ideally require a more socially-developed construct than is commonly available in the literature. That any meaningful definition of occupational capacity (or effectiveness, or expertise) is culturally dependent is clear: for example, in China 'expert teachers' are not only good at teaching processes, but also have to exhibit effective roles as researcher, teacher educator, scholar, examination expert, and exemplary role model (Li, Huang, and Yang 2011). English Teaching Standards (DfE 2012) draw only on the first and (to some extent) last of these categories. Further, Schoenfeld (2007) argues outcome measures of effectiveness are intrinsically a function of enacted values.

Glaser and Chi (1988) cite evidence confirming expertise constructs as profoundly domain-specific, and also context-specific, e.g. a mathematics teacher who is recognized as expert in one context will not necessarily be able to function as expert in a new school, with unknown students. Berliner (2004) does, though, building on Dreyfus and Dreyfus'(1986) influential model of expertise development, make a convincing case for the existence of exceptional 'adaptive experts' who can very quickly harness pre-existing practice to new situations.

There are available several different kinds of model for teacher occupational capacity, each of which incorporates professional knowledge and (sometimes implicitly) beliefs and I would argue that each has something to offer, though for different purposes. An *analysis of necessary component teacher characteristics* at a reasonably high level of granularity (to allow for context-dependent variation) seems plausible, and is the basis for much of the work on subject-related or wider knowledge (Shulman 1987, Ball, Thames, and Phelps 2008, Rowland, Huckstep, and Thwaites 2005). Such a structure has the benefit of specificity, but there is as yet a way to go in completing such an analysis, and while e.g. the last has been successfully operationalized to support classroom-focused initial teacher education (e.g. Turner (2012)), it represents only part of a teacher's 'capacity' so such an analysis is as yet far from complete and likely to be complicated.

A second approach is to develop *a set of descriptors of valued practice*, reflecting how occupational capacity is drawn on - as in the English Teacher Standards. These are generic, and largely framed in terms of observable teacher behaviours, so overlapping one another in scope, and drawing on some wider expectations for students' 'well-being' and (vague) civic and moral responsibilities. They include culturally-valued aspects of teaching proficiency including some

acknowledgement of affective outcomes, and the western valuing of the individual is embedded. There is limited attention paid to the needs of the 'whole child', to beyond-classroom education or to longterm implications of school classroom experiences.

Similarly, the NBPTS Framework (1998) exemplified by subject area, and the InTASC Framework (CCSSO) which claims to subsume those, are focused on what the teacher does, though presented to imply clear values. Bond et al. (2000) show performance on these Standards correlates with teacher curriculum challenge, deeper representations, and expertise in monitoring and feedback – and also, importantly, correlate (weakly) with student outcomes of better grades, more integrated, coherent conceptual understanding, and higher levels of abstraction. More detailed analysis for mathematics teachers has been attempted by Schoenfeld (2013) building on his (2011) framework of teacher knowledge, goals and beliefs, but there are again questions not only of completeness (and if finished, does the whole equate to the sum of the parts, or is teacher capacity the synthesis of interdependent and connected aspects?), but of use in real time and for teacher development.

European researchers have developed models of teacher development and competence, more akin to the first type, which derive from a socio-cultural approach, and which do address some of the exposed study characteristics, additionally overtly valuing the collective. Llinares and Krainer (2006) suggest that teacher learning should be placed within an individual, social and organisational framework, with Krainer (2006) arguing specifically that the relevant variables are content, community and context. His four-dimensional model of practice addresses action, reflection, autonomy and networking, and draws in particular on the COACTIV project described in detail in Kunter et al. (2013), which suggests a dynamic interplay between professional knowledge, beliefs, motivation and self-regulatory skills. Their work admits only indirect evidence of classroom know-how; however, unlike much work on teacher expertise, they not only link (reported) characteristics with student outcomes, but acknowledge a need to go beyond short-term summative assessment of student performance in doing so, giving consideration also to engagement and attitudes towards mathematics in the students studied. However, their study does appear to assume that e.g. the cognitive demand made by teachers (though generally low) functions independently of the prior attainment of students, which seems to compromise some of their claimed results. This is not to say that there is an easily-identifiable direct link between teaching practices and student outcomes: this is clear from both Vieluf and Klieme's (2011) TIMSS 1999 video study and Silver and Mesa (2011).

An understanding of many teacher characteristics as contextually situated and socially mediated suggests that definitive, atomistic models of teacher capacity will inevitably be limited,

and McDiarmid and Clevenger-Bright (2008) include a stated limited range of knowledge, craft skills and dispositions (beliefs, attitudes, values and commitments) of an individual, but this is inevitably incomplete even within that range. Higher level models might better support completeness, but they are unusual in the literature, and where they exist, usually focus on school-level capacity, as in Stoll (1999), although she begins to consider the implications for an individual teacher. The Winch (2010) construct, which employs a definition of capacity similar to mine, if less tightly defined, is conceived as being at individual level. I conjecture each of these high-level constructs might usefully be developed as a *profile* of characteristics, different ones of which are most salient in different situations.

2.3.3 Winch's theory of Occupational Capacity

As the study progressed, it became apparent that none of the above entirely accommodates the differential characteristics exposed by the study, though the structure of Winch (2010, 72-73) could be expanded to do so. Influenced by the German "Beruf'' conception of occupation, he develops a generic model which accommodates the range of characteristics needed for a multi-layered capacity requiring the exercise of *task-specific skills*, underpinned, synthesised and developed into '*project management'* level by *transversal abilities* such as planning, coordinating, communicating, and evaluating. Each level draws on occupation-specific systematic and theoretical knowledge as well as a set of normative moral and civic dispositions necessary for its effective exercise: these last enjoy an expanded profile in his recent work (2014, 54-55). He labels this complete set of skills, abilities, practical and theoretical knowledge 'occupational action capacity' (Winch 2013b, Winch 2013a), construing this as a (minimally) high level of occupational exercise, rather than (as I prefer) an occupational characteristic which may theoretically be held at a range of inadequate to outstanding levels, depending on its potential to impact valued outcomes, and with a wide variation: I make no assumption that a unique profile of teacher occupational capacity is necessary to support a particular outcome. His model has something in common with both those above; implicit within it is a notion of 'epistemic ascent' from small task-driven skills through to full occupational capacity, and for both teacher development and policy this is useful. Repeated searches of the literature have suggested nothing similar elsewhere: the closest I can find is Stoll (1999).

Winch's profile of components is recognizable to me in each of my roles of classroom teacher, teacher mentor and teacher educator and, while being at a higher level than the English or American Standards referred to, includes a complexity which seems necessary to discriminate different aspects of a teacher's practice, especially if that is being interpreted as merely

representative of professional expertise. It allows for valuing a bigger scale of functioning, in terms of time, space and people, while maintaining a central role for classroom practice. It is not easily operationalisable as a classroom observation tool, but has potential as a structure for planning teacher initial and continuing education, whether at policy or teacher educator level, which is my current purpose. I therefore use 'occupational capacity' to cover (at least) the range of the characteristics Winch considers, but as a synthesis which may be held at a variety of levels: a teacher might have poor occupational capacity across the range of their work demands, or might have variable occupational capacities in different contexts, or might largely have very well-developed occupational capacity. Winch's construct is summarised in Figure 4, including 'know-how' in a range of scale and scope, but with a very clear role for 'know-that'.

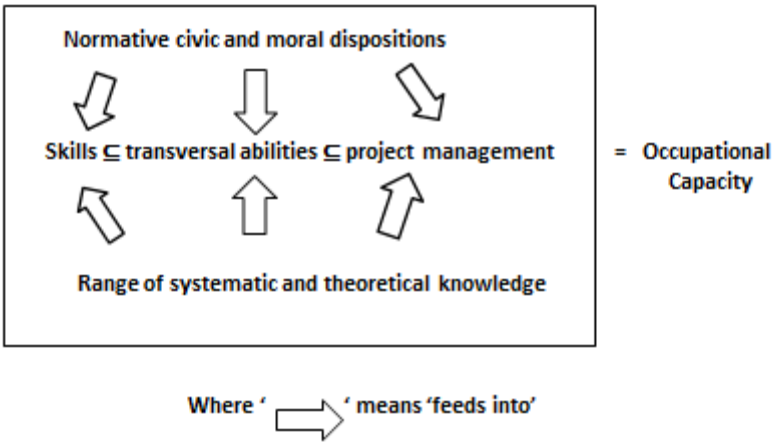


Figure 4: Winch Occupational Capacity interpreted

His theory thus appears to offer a useful framework in which to consider teacher capacity – here, for deep change. An exegesis of the theory for mathematics teachers is developed below. Winch's construct, though, is intended to operate at an individual level, and I had reason also to focus on the collective: none of the above theories fully accommodates that.

2.3.3 Winch's occupational capacity: an exegesis for mathematics teachers

If Winch's construct is to be further explored for the study situation, it is important that it can be clearly applied in the case of mathematics teachers. I would suggest *'skills'* includes both

general pedagogical skills (writing on a board, remembering names, monitoring use of time, use of a variety of tools…) and subject pedagogical skills (paraphrasing a definition, analysing a part of the curriculum in relation to prerequisite understandings, identifying standard misconceptions, choosing representations and examples for a particular group of students with a particular learning objective…). *'Transversal abilities'* for mathematics teachers would include successful prediction of the outcomes of acting in a certain way with different groups of students; two-way communication with students, parents or colleagues; link-making across the mathematics curriculum and beyond; evaluating learning both concurrently and post hoc; reflection before, during and after teaching; structured planning at perhaps lesson or small lesson sequence level.

For teachers, Winch's *'project management'* would involve synthesis of skills and transversal abilities with systematic and theoretical knowledge at a bigger scale - to plan longer sequences of lessons, to develop schemes of work, to drive one's professional learning, to establish and maintain productive working relationships with students and with colleagues over extended periods... Many of these tasks are iterative, and Winch notes that they will usually develop the agent personally in the undertaking, through the activity and subsequent reflection on it. Winch's *'occupational capacity'* is then one for 'project management', together with a grasp of, and engagement with, the wider occupational field. It requires the systematic knowledge necessary to grasp the full scope of teaching including its relationship with cognate occupations. It encompasses an understanding of evolution within education, assessment and evaluation of one's impact, and engagement with ethical issues, within an 'appropriate set of moral and civic dispositions' (Winch 2010, 76). As such, for teachers it could be considered a development of Shulman (1987); Appendix 23 shows how the expanded construct developed in chapter 9 accommodates e.g. The Knowledge Quartet (Rowland, Huckstep, and Thwaites 2005), and similar analyses were made for all of those parts of the above models which relate to knowledge: I shall consider in chapter 9 what else might be needed to supplement it. A model of this nature does not set out to list desirable teacher behaviours, but rather to analyse the sorts of characteristics that teachers need to draw on in order to function effectively.

The operationalization of such a model is non-trivial, and we would want it to accommodate at least all those aspects of teacher knowledge (of all kinds) that have been clearly identified in the literature. There are challenges, though: e.g. the establishment of professional routines, which Tenorth (2006) building on Shulman (1986), shows result from well-established and experienced action schema, can be at a variety of levels from straightforward skills in accomplishing small tasks, to sophisticated multi-faceted approaches to curriculum development, so belongs at each of Winch's levels. Similarly, Eraut (1994) claims that fundamental to any claim to be a professional, is the (practical) capacity to use specialized knowledge to make work-related

judgments: in Winch's schema, he suggests such *judgment* (a key and contested idea in work-related learning theory) can be seen as an extension to skills/transversal abilities/project management, though I prefer to conceptualise it as a transversal skill that draws on knowledge (propositional and procedural, including domain-specific), via the range of reflective skills identified in this study, themselves transversal abilities.

Further, any typology of skills/knowledge/abilities rapidly encounters teacher actions which employ an amalgam, or which appear to be constituted differentially between different teachers, depending on their experience or context perhaps. For example, writing clearly on a board so that a whole class can both see and read the content, might be termed a skill: it's a technique which is intentionally applied and can be improved with practice. However, propositional knowledge feeds into improved enactment: students with sight impairment will be better served by green ink rather than black; at a more sophisticated level an individual teacher might use a raft of occupational knowledge to conjecture that students' development is well supported by the inclusion on the board of metacognitive statements in a different colour and consistently do that, evaluating its effect on learning. The point is that such an action draws on a range of occupational capacities at different levels, and represents only a very small part of a teacher's operationalization of their occupation that lesson.

The exercise of such capacity certainly presupposes a certain degree of self-determinism in relation to work actions. It involves the exercise of psychological and philosophical judgments (are the students at a stage where they can benefit from this action? How does it relate to the learning goals?). It is dependent on a social construction both within the class (what is student reaction? Do they choose to let it colour their learning?), as well as a professional one (Is this a known and respected tool in mathematics teaching? If so, then the teacher might persevere even though reception is equivocal; if not, then only a teacher confident in the learning outcome of their innovation might continue with it). Moral judgments might enter into the situation: if the students have a high-stakes assessment next week, the teacher might decide that, valuable though the approach is, now is not the time to introduce it. Conversely, if the approach is highly valued, its introduction might be postponed if a particularly vulnerable subset of the class is absent that day.

Such contextual considerations gave me confidence to further explore application of Winch's construct to study data: as shown in chapter 9, significant extension was required in order to accommodate the range of salient characteristics, but the core structure supported that.

2.4 Teacher Learning

2.4.1 Learning, development or change?

Teacher literature often uses the terms 'learning', 'development' or 'change' interchangeably, typically referring to transformation of internal cognitive processes (knowledge, understanding or beliefs), or in the case of 'development' or 'change' maybe practice. In the context of imposed (either structurally or other external) goals, though, it is often focused on practice. I use 'development' to imply a sustained direction of travel (whereas change can be temporary and inconsistent), and 'learning' to be individual or social embedded change in knowledge, beliefs, understanding or behaviour: Schoenfeld (1999, 6) defines learning as 'coming to understand things and developing individual capacities to do what one wants or needs to do'. We seem reluctant to try to apply our thinking about student learning to teachers, or even to ask if what we understand about the learning of students might apply also to teachers: I wonder if this is a line of enquiry that might prove fruitful. One notable exception is Cobb and Yackel (1996), who attempt to adapt their thinking about collective classroom learning of students, to teachers.

The relation of these constructs to theoretical lenses is clarified in Appendix 1. However, much of the literature focuses on change in teacher practice (and 'learning' is implicitly cognitive), with relatively little consideration of what teachers need to enable that. There are few accounts of autonomous or informal teacher change (Adler et al. 2005), and despite the 'social turn' of research (Lerman, 2000) much of the literature still adopts an individual, decontextualised approach.

2.4.2 What supports teacher learning?

With socio-cultural theorists such as Lave and Wenger (1991) conceptualising individual and social as inseparable, existing 'technical rationality' (Schon 1983) theories of occupational learning have in some circles been reconceptualised as process and participation, of growing and adjusting in and with a changing environment and changing participation in a community of practice, and susceptible therefore to both activity- and complexity-theoretic models. Wenger (1998) suggests identity, community, meaning and practice as interrelated components of learning, defining these as ways of talking about learning, rather than their more common usages; however, little of the literature appears to pursue Wenger's use. Graven (2004) adds confidence to this quartet, although not only is her evidence based on psychological rather than claimed social practice

notions of confidence, but she is working in a transformative learning situation which might be expected to privilege the 'confidence as mastery' she claims as generalisable.

Attempts have been made to synthesise cognitive and social practice approaches: for example, Sfard (1998) argues the participation metaphor includes both product and process and develops an extension as 'commognition', arguing that all thinking, and so learning, is discourse, although that suggests a wider definition of 'discourse' than is often used. Hager (2004) presents a convincing argument that to participation (in the social) and acquisition (the social/individual interaction) should be added (re)construction at individual level – perhaps Sfard's self-communication? Once within a socio-cultural paradigm, the role of colleagues becomes more fundamental. Winch (1998) argues it is not reasonable to expect a single theory to account for the range and depth of occupational learning, and indeed I found different theories offered complementary affordances.

Goldsmith, Doerr, and Lewis (2014) claim to synthesise the research on teacher learning, though because of the large scope of their paper their analysis seems even more superficial than the state of our knowledge; they do, however, as well as arguing for more consistent reporting of research if effective understanding is to accumulate, make use of Clarke and Hollingsworth's (2002) iterative model (change in any one of the individual teacher's external, personal, practice or consequence domains interacts cyclically with the others through reflection or enaction), arguing it reflects their synthesis and placing teacher learning firmly in a social and contextual framework. The implication here is of a system more akin to an activity model, yet it is also true that one to some extent finds what one looks for.

The literature identifies some claimed desirable characteristics of learning opportunities, based on (usually self-reported) teacher learning outcomes, although rarely linked with change in student learning, which perhaps ought to be the hallmark of effectiveness. However, Opfer and Pedder (2011) point out many of these studies have not proved replicable; they do not explain the mechanism of learning, and conclusions are often based on a presence/absence model of associated characteristics (e.g. sustained and intensive, practice-embedded, collaborative): these outcomes are summarised in Desimone (2009) and for mathematics teachers in Joubert and Sutherland (2008); Borko et al (2010) summarise the literature from a situated perspective. Nuthall and Alton-Lee (1993) whose 'Goldilocks principle' highlights the fact that the *degree* of each of these variables apparently necessary for effective learning to take place appears to vary by teacher, by context, and by activity, additionally show linear, aggregational, deterministic and individual theories of teacher learning appear inadequate. Opfer and Pedder (2011) address this

problem by a use of complexity theory I found compelling, and this supports the choices described in 1.6, complemented by attempts to extend to the collective.

2.4.3 Change in practice

Teacher practice and beliefs interact in cyclical ways, often mediated by student outcomes (e.g. Guskey 2002, Clarke and Hollingsworth 2002), so change of practice cannot be considered in isolation, although I have shown the focus policy enjoyed widespread support in principle. However, this small study follows large-scale studies of attempted practice change not only in this country but across the western world, few of which can claim to document embedded large-scale improvement of the kind hoped-for: one exception to this might be CGI. Some of these, e.g. the QUASAR project (Stein, Silver, and Smith 1998), while focusing on cognitively complex and challenging tasks so having something in common with this study, used external expert support to an extent which makes scalability prohibitive.

Similarly, Cobb and Smith's (2008) district-level initiatives aimed at 'ambitious instruction', while adding to the evidence base about the importance of informal, job-embedded teacher learning and of teacher networks, rely on intensive researcher input at both school and District level, and used coaches and school leadership in ways which do not generalise to my study. Further, despite the claims of Cobb and Jackson (2011) and the extensive resources available to them, the problem of scale again remains broadly intractable. Llinares and Krainer (2006) identify three themes in growing awareness of conditions for teacher change: individual teacher characteristics and particular their professional reflection; social dimensions; and organisation contextual resources: my study supports those findings. Eurydice (2011) shows challenges of change endemic across much of Europe, and in this country e.g. Ryder and Banner (2013) show they are not confined to mathematics: transformative teacher change is known to take time, and supportive personal, contextual and systemic contexts. I argue in chapter 3, though, that the teachers participating in this study initially largely enjoyed such a situation.

2.5 A departmental lens

I use 'mathematics department' as a label for the group of teachers teaching significant amounts of mathematics in a school. For study purposes I exclude specific consideration of the Teaching Assistant working in each department: although both were involved in department

discussions and meetings, and used for in-class support, small group extraction and the development of materials and records, neither had a major input to the development of schemes of work, nor long-term responsibility for any GCSE groups: that was delegated from teachers. Both activity theory and complexity theory naturally accommodate consideration of 'the department' as a group.

Literature searches in this area were extensive and iterative as analysis of fieldwork exposed fresh issues relating to the department: they are outlined in Appendix 2.There appears to be considerable literature about how teachers develop *in* groups, but comparatively little about the learning *of* groups, which acquires meaning with learning conceptualised with a socio-cultural and distributed lens.

Siskin (1994) shows the department to be a natural distinctive unit in USA High Schools: that is further enhanced in English departments by typically even greater autonomy and responsibility. I have argued teacher knowledge and beliefs to be in part situated and socially held, and a widely-evidenced social embedding of teacher actions and learning, so that the subject department is in some sense not separate from the individual teacher, and often represents both a well-defined *community of practice* in Wenger's (1998) terms as discussed below, and a natural immediate 'zone of enactment' as further probed by Millett, Brown, and Askew (2004), though members of a department might not be equally active in that social unit. McNicholl, Childs, and Burn (2013) in their work on the learning cultures of subject departments, additionally show that a shared *physical* department space is critical for the sharing of professional knowledge: it serves as a tool supporting neighbour interactions, or an 'attractor'.

Theories of teacher learning vary in their units of analysis, with many focusing either on the individual teacher influenced by the variety of social contexts in which they operate (Beckett and Hager 2002), or the individual in a variety of relationships with e.g. tools and rules as well as people (Engeström 2001). In contrast, Wenger (1998) sees learners as an inseparable part of their social context, building on Lave and Wenger's (1991) notion of learning as intrinsically 'legitimate peripheral participation' in a 'community of practice': this latter a variably-defined term, within which Hodkinson and Hodkinson (2004a) distinguish two different intensities, although their analysis can apply across a continuum. In general it represents a group of (here) teachers interacting together with the purpose of achieving a common goal: learning how to achieve it is then as much a social as an individual enterprise, with learning emerging from participation. Wenger (1998) further incorporates ongoing learning within the community by established teachers who align with the norms of practice, though Jaworski (2006) suggests this is complemented by an individual critically questioning norms (an activity destabiliser), so serving to

develop community learning. Kanes and Lerman (2008) characterise Wenger's 'community of practice' as rather more structured and aligned with a theory of learning than Lave and Wenger's (1991) ethnographic version, which conceptualises participation and reification as complementary and leading to shared ideas and concepts.

The middle school QUASAR project, conceptualises learning as a changing trajectory of participation (and of participant teacher identity): learning is an inseparable and integral, dynamic part of that practice. Similarly the work discussed in Cobb and Smith (2008) and elsewhere draws heavily on Wenger's (1998) structure in identifying boundary objects, boundary crossers, and brokers as critical to their proposed theorisation of US district-level change. Cobb, Zhao, and Dean (2009) is unusual in attempting to theorise the group, as opposed to individual, teacher learning occurring in that middle school project. They document the evolution of communal norms and practices they claim frame learning, identifying four interdependent developing 'norms' (of general participation, pedagogical, mathematical and institutional reasoning), in which individual teachers participate differentially. While arguing that both these situations draw heavily on a particular systemic structure and pre-existing expert community of practice, so could be expected to have limited direct transfer, this last analysis is revisited in chapter 8.

A 'professional learning community' (PLC) of teachers is a more restrictive term described in Newmann (1996), and developed more widely in Hord (1997). Vescio, Ross, and Adams (2008) give a very clear review of the evidence of impact of such communities on teacher practice and student learning. Broadly, such groups of teachers exhibit communities in Gellert's (2008) terms (he distinguishes between a group, a network and a community of teachers, in increasing order of both interdependence and shared goals); shared values and norms with respect to the goal of improving student learning; clear, consistent *and structured* focus on developing practice to improve that learning; reflective dialogue that leads to extensive and continuing conversations among teachers about curriculum, instruction and student development; deprivatisation of practice for the purposes of improving practice; and a focus on collaboration to achieve all that (Vescio, Ross, and Adams 2008). Although expressed slightly differently, Bolam et al. (2005) deal with essentially the same construct in an English context.

Most of the PLC literature focuses at school level, rather than at bigger or smaller scales: I argue that with the study focus, the appropriate scale is the department, and that the construct transfers directly, provided sufficient delegation of autonomy is made: I would consider this construct less appropriate for the QUASAR (1998) or Cobb and Jackson (2012) work. Note that in common with Visscher and Witziers (2004), Vescio, Ross, and Adams (2008) identify intelligent use of data as an essential contribution to monitoring, and responding to, resultant student

learning: this is not part of the definition of PLC used, but might well contribute to defining an 'effective PLC'. In an English secondary school the department naturally features in all of these as a critical unit of social context.

Theorisation of teacher activity using groups of teachers as a unit of focus, though, is scarce. As well as Siskin (1994) I draw on Watson and de Geest (2010, 2014) for their analysis of autonomous change in well-placed mathematics departments initially showing much in common with mine. Their three departments studied achieved sustained (but not permanent) change through grounding in classroom practice and participants working together equally and informally with a focus on the development and discussion of classroom tasks, as in Spillane (1999). They identify the challenge of developing shared meaning of the desired change, and demonstrate the importance of teachers being willing to compromise their own ideas in order to further collective change. They also develop the idea of a departmental 'critical professionalism': engagement with a range of current research, use of outside experts to challenge and inform, and the maintenance of quality intra-departmental dialogue focused on teaching and learning – suggesting this is necessary for deep change. My study considers to what extent the participant departments met this description over the course of the study, and further, to what extent departments appropriated principled enaction of the new curriculum as autonomous.

Hodkinson and Hodkinson's (2003, 2005, 2004b, 2004a) work describes the ways and depths to which a variety of (non-mathematics) secondary departments operate as communities. They demonstrate clearly the impact of department level cultures and leadership on teacher workplace learning, and the probing of these was therefore included as part of the study, initially for their relationship with knowledge and beliefs. Departmental structures in English secondary schools are relatively strong (Hodkinson and Hodkinson 2003) and departments are the unit of analysis in much school accountability work; however, the very limited literature on the learning of departments means I sometimes used work focused on student learning as a catalyst for analysis (see Appendix 1). Corresponding risks to validity are discussed as they arise.

One challenge was to seek and evidence a robust construct of department 'knowledge' (posited by Williams (2011) as more than 'distributed' or 'aggregated', and similarly for other characteristics at department level, and these issues are explored in chapters 6 and 8. I refer to Visscher and Witziers' (2004) large-scale study of Dutch mathematics departments, which although not in an entirely parallel context, offers reminders about the need both to ground research in valued outcomes and to seek both necessary and sufficient conditions for progress. Millett et al's (2004) large-scale study of the implementation of the Primary National Strategy in England concludes that the roles of subject lead and Headteacher in Primary schools undergoing

imposed change in mathematics is crucial: again, while this is not directly transferable, I used the findings to catalyse questions for and from my fieldwork, as in Appendix 3.

Historically both departments had appeared to be supportive communities where developing, experimenting with and evaluating new ways of teaching was a core valued activity, often undertaken in partnership with the other department. Such exploration had, usually, been catalysed by outside 'expertise' of some form as required by Spillane (1999) - in person, via web sources or hard materials. Spillane (op cit) and others suggest such classroom experimentation is further nurtured by its embedding in a supportive professional community, the leadership for which should ideally be strong and distributed (Dufour and Eaker 1998). I shall describe in chapter 8 the fit of the above models to the functioning of the study departments.

Gellert (2008) suggests that most profound teacher change actually takes place through informal talk, and attempts to capture that, in a process of reformulation/reflection/focusing/comparison, but he derives no evidence directly from the classroom, which I would argue is a limitation to his theorization. He also argues that there exist collective orientations resulting from biographically collective experience (in teachers' own school experience, in training, in department, school and wider cultures) that support meaningful communication and a degree of consensus. He suggests that the genesis of such orientations is critical to the mutually interactive process of changing beliefs and practices, but also that existing collective orientations might be an obstacle, and that active (group) self-reflection is critical to maintaining a constructive role for such collectivity. Group functioning is complex: groups often perform better than individuals, even if those individuals share the same knowledge set (Pfister and Oehl 2009, Haussman, Chi, and Roy 2004). Further, a group of individual experts neither implies nor is implied by a group which performs and learns expertly (Edmondson, Bohmer, and Pisano 2001).

Finally, the department is not the only sphere of influence for teachers' development: as well as for example local authority influence, here shared by the two departments, individual schools also have distinctive affordances and constraints, including the nature of the whole-school professional learning environment (Hodkinson and Hodkinson 2005), so this too needed to be probed.

The above ideas are foundational to the methodology, to which I now turn.

CHAPTER 3: METHODOLOGY AND RESEARCH METHODS

3.1: Introduction and Overview

Because the theoretical lenses employed were within a social practice framework it was important to acquire data from teachers talking in and about their work, and with a dual scale focus also to include either direct or proxy evidence of group functioning. My understanding of enaction-related learning as situated meant that details of context were also critical. Further, the potential of a small study lies in part in its relationship to existing findings, and also on a reasonable degree of rigour. As a result, I employed a constructivist grounded approach (Charmaz 2006) to expose the emergence of a theoretical framework within which enaction of the new GCSE developed, using 'telling' (Mitchell 1984), if also convenient, samples at both individual and departmental levels. I used a variety of ethnographic methods – interviews, classroom observations, and a variety of documentary evidence – to build up a triangulated 'story' of enaction over a period from first planning for teaching of the new GCSE, until impact of first results: Hunter (2010), among others, demonstrates clearly the dependency of teacher change on student outcomes. I tracked and probed enaction in two departments, focusing on three teachers in each, in the construction of longitudinal case studies at both levels. During most of this time I was clearly an 'insider', working regularly in both departments although largely teaching in one. During the later stages of data collection and analysis I changed my professional role, acquiring a little more 'distance' from participants. These two situations presented different affordances and constraints, including ethical challenges, as discussed below. Whilst this was an in-depth study, it remains on a small scale, grounded in particular time and contexts, so its strengths and limitations, including the issue of generalizability, without which it would be of limited interest, need careful consideration. The initial preparatory study, reported in Golding (2011) was based on the first two sets of interviews and intervening observations at Greenways.

In this chapter I present the theoretical background to methodology followed by an outline of data collection and analysis. Challenges to validity, methodology and ethics are then considered, followed by an evaluation of the study's strengths and limitations.

3.2: The Samples

The sample is clearly an issue if findings are to have any significance beyond their immediate context. Whereas Maguire, Perryman, et al. (2011) went to some lengths to target 'ordinary' schools, I used what Mitchell (1984) calls 'telling' cases, that is, those whose atypical characteristics suggest that findings might have disproportionate richness and significance, so lending themselves to the generation of theory, similar to Flyvbjerg's (2006) 'critical' cases. The sample then acquires a strategic significance; however, Flyvbjerg points out that identifying a critical case beforehand requires experience, and even then there is no certainty available. I aimed to construct a sample unusually well-placed for a principled enactment of the new GCSE and from our experience working with Key Stage 3 development, anticipated practice would be differentiated by knowledge and beliefs; in the event the differentiating characteristics appeared to lie beyond those, and only one of the departments achieved a reasonably 'principled' enaction over the timescale of the study, at least.

The two departments used were 'convenient' in that I had access to both during the course of my work, being based in one and working in the second on a regular basis following a request by the school to the local authority. However, both seemed unusually well-placed to deliver a principled enactment of the new GCSE, having worked together to transform Key Stage 3 teaching, and they had much in common, so that I expected a comparison might identify relevant variables comparatively easily. School-level residuals showed both departments were relatively successful at GCSE, so not under undue pressure to conform to 'survival strategies' (Ofsted 2012) for boosting attainment, yet with shared community and local authority aspirations for continued 'effectiveness'; additionally, both were, relatively unusually (Ofsted 2012), staffed by mathematics nominal specialists. Substantial overlap of other facets of the policy context – small rural town situation, mixed intake but largely supportive communities, stable staff, successful but not exceptional reputations – was thought to further support the isolation of potentially illuminative characteristics.

This approach has something in common with that of Maguire, Perryman, et al. (2011) except that it is not targeting 'representative' enactment but rather 'well-placed' enactment since as discussed in chapter 2, it is known that a principled enactment of this policy is likely to be demanding. Similarly, the selection of this policy might be considered 'telling': enaction was not clouded by fundamental disagreement in principle, as was very clear from initial data in both departments. In comparison with Maguire, Perryman, et al. (2011) then, I expected a more limited range of differential characteristics to be exposed. They struggled to get beneath the 'presented image' of participant schools, but both my departments were well-known to me:

however, familiarity can breed assumptions and misconceptions that have the potential to undermine the validity of a study, and I discuss below the steps taken to try to minimize those.

In a similar way, within departments, a 'telling' sample was constructed: as justified in chapter 2, Heads of Departments together with two other contrasting teachers (in background, personality and experience) were approached in order to provide a range of characteristics. As the study progressed, some compromise of these criteria emerged, particularly with respect to the replacement of one participant: the corresponding ethical issues are discussed below.

Throughout, pseudonyms and some gender re-assignments were used for both schools and participant teachers (Nigel, Dan, Carol and eventually Gillian at 'Greenways'; Kathy, Norman and Heather at 'High Wood').

3.3 Grounded Theory

In contrast with a liberal humanist perspective which assumes teacher consciousness, transparency and intentionality, allowing direct knowledge from teacher narrative of unambiguous 'truth', I considered, as in chapter 2, that teacher knowledge and beliefs are often held tacitly; and that there might be some 'selection' of interview response arising from my background relationships with participants. I therefore attempted an approach in which triangulation and *an* authentic account was to some extent co-constructed with participants. Following Charmaz's (2006) interpretation of the original tenets of Glaser and Strauss (1967), data gathering, analysis, and construction of substantive (as opposed to formal) theory proceeded concurrently, within the limits of available time: I developed codes and categories iteratively and by constant comparison of data with theoretical categories. This entailed multiple revisits to the data in order to achieve suitable distancing, and 'memos' (e.g. Appendix 6) in a research diary (extracts in Appendix 5) were used to note emerging ideas and questions, together with theoretical links or hypotheses.

I do not claim a single 'truth' from the study, but rather one valid meaning – though sometimes more than one possible meaning is surfaced, using memos as a 'reflexive conversation' (e.g. Appendix 6). Memos sometimes allow clarification of incipient thoughts or possible meanings, can expose flaws and over-generalities in reasoning, at least in retrospect, and occasionally form the foundation for the generation of a theoretical advance, as in Appendix 22. I attempted to note 'uncomfortable', if fleeting, aspects of the data that lay outside current coding, in an effort to avoid a bias towards verification, and similarly, to actively seek other dimensions or

theoretical explanations as the analysis progressed. For example, the codes developed for the preparatory study proved inadequate as the study progressed and I moved beyond my initial focus on knowledge and beliefs: Appendix 9 shows both original knowledge/beliefs and overlaid affective/departmental level codes. In this way I followed through implications of putative emerging theories in an effort to expose inconsistencies in the data, and was informed by those possibilities in designing subsequent interviews.

The case study is, as Flyvbjerg (2006) points out, well-placed for direct testing of emerging theory, enabling revisiting from different directions and in this case, through the different milieus of interviews, of observations, and sometimes of documentation. For example, data suggesting perhaps that the department at High Wood were less aware of nationally produced support materials than teachers at Greenways were, could relatively easily be refuted and a refined understanding amounting to a differential perception of such practical support, substituted, leading to questions of what underlay those differential perceptions, and the drawing in of 'self-efficacy' as a pertinent construct. Nevertheless, my relationship with the data remained subjective and interpretive: colleagues were used to challenging validity of selection and interpretation, and the longitudinal nature of the study further supports that, but the outcome in terms of proposed grounded theory remains one possible such interpretation. Furthermore, not only the theoretical frameworks adopted, but the questions asked, 'sensitise' the researcher to privilege some aspects of what is exposed over others, and hence affect e.g. iterative questioning. For example, my original focus on knowledge and beliefs meant that I was not initially looking for evidence of self-efficacy. The nature of grounded theory is inductive, so it is vulnerable to inadequate or idiosyncratic sampling or data collection, as well as highly susceptible to 'tunnel vision' once a line of thought has been identified. This threat was addressed by actively looking for other possible ways to view the data; testing out the implications of competing theories in interviews; talking through emerging interpretations with informed colleagues including in seminars and sometimes with participants; and on occasion soliciting independent interpretations from the teacher who piloted interviews for me.

However, within this paradigm I used *theoretical sampling*, defined by Glaser and Strauss (1967, 45) as

> ..the process of data collection for generating theory 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,

in so far as successive interviews, and observation foci, were constructed to probe theoretical ideas emerging from data previous rounds of data analysis. An example of this would be the

emergence of quite deep knowledge of pedagogy for metacognition, and of the importance of that and of confidence for students:

> 'you have to build the confidence first. I also think if you talk about it, you can talk specifically about what they choose to do, and noticing that actually this isn't working, so their skills of… understanding their feelings, and recognize where they are in the problem, so that they see it again and know what worked last time, they can think about the little steps that might take them a bit forward, and they have the confidence to keep going if that doesn't work, they know there are other ways they can try.' *Kathy ,High Wood, interview 3*

This enabled subsequent fieldwork to have a focus on the profile of these characteristics in classrooms, and teachers' thoughts on that. However, the wish to track developments over the full first cycle of enaction, and constraints on availability of researcher and participants, meant there were times when this approach was compromised. Analysis to saturation was achieved; I am less confident about theoretical saturation, but the variety of theoretical lenses employed does mean that findings have a richness attributable in part to that variety.

I endeavoured to follow the principles of *abductive inference*, defined by Charmaz (2006, 188) as entailing '…considering all possible theoretical explanations for the data, forming hypotheses for each possible explanation, checking them empirically by examining data, and pursuing the most plausible explanation'. This was supported by continuing to actively engage with a range of current literature, as well as with a range of colleagues, in order to identify new lines of thought in relation to the study. There remained, though, tensions between the core grounded theory principle of theory generation being led by the data rather than by preconceived notions of appropriate theoretical models, and the limited range of theories (and therefore, limited 'theoretical sensitivity') on which a relatively inexperienced researcher can draw.

'Openness to being surprised by the data' is often described as a key feature of grounded theory (Dey 2007). My initial hypothesis was that the sample teachers would expose different knowledge capacities, in range or depth, and that those would explain key discrepancies in enaction. However the data did not support this in any consistent way, with the result that fresh theoretical frameworks needed to be drawn on in order to provide plausible explanations for differences observed. Other researchers would have drawn on a different range of theories and no doubt have had a different story to tell as a result of their interpretation of the data: Dey (2007) points out that validation of any such theoretical explanations should be with fresh data beyond the original source of grounding, which has not yet been done. I conceptualise both data and analysis as social constructions rooted in their temporal and cultural situation with data dependent on (both teachers' and my) values and resulting in a 'plausible account' (Charmaz 2006, 132) rather than an objective theory.

However, some degree of 'surprise', or unanticipated findings, was achieved, as above: I had anticipated that High Wood's greater experience and pedagogical knowledge would result in a more informed enaction, given their apparent commitment. Instead, social and affective characteristics emerged as primary exposed differences, with the possibility of related underlying belief structures only appearing as secondary constructs. I had also assumed that as an 'insider' I would be aware of ambiguities in shared language, yet I was well into fieldwork before I realised that in fact 'problem solving', a core construct for GCSE 2010, held significantly different meanings for different teachers, especially when related to their classroom practice. This arose initially from informal discussion of observation 2, when questions with a range of structure and familiarity were described as 'problems': interview 3 and observation 3 allowed further probing of those discrepancies, catalysing quite deep discussion in a subsequent Greenways department meeting.

Theoretical frameworks which provided an initial orientation to the study and from which I anticipated drawing are described in chapter 2 and they proved useful in particular as catalysts for successive theoretical samplings. For example, the notion of utilization of tools arising from Activity Theory afforded increased sensitisation to differences in perceptions of available materials, but remained inadequate for a compelling *explanation* rather than *description*. To achieve that, theoretical constructs of affect appeared to be needed. Similarly, Complexity Theory (Davis and Simmt 2003) offered a lens that focused on leadership roles within departments, as potential attractors to support intended outcomes; as the study progressed it became useful to draw also on their notions of the necessity of both diversity and redundancy (at both individual and group levels) for transformative change. Further probing of those in subsequent interviews suggested they could usefully be subsumed into a notion of a professional learning community with distributed leadership - a theoretical construct which then needed further foundation from the literature.

3.4 Fieldwork and Analysis

I consider fieldwork and analysis together, since grounded theory requires that data gathering, analysis and theory-building proceed in parallel, with iterative theoretical sampling and constant comparison of emerging data with previous data, analysis and theory. I indicated in chapter 2 that the initial review of clearly-linked literature was also developed and expanded in parallel and symbiotically with analysis and emergent theory.

The initial proposal anticipated using questionnaires to elicit background information from participants, as a time-efficient approach; on reflection I incorporated these into interviews in order to provide a neutral and accessible introduction. The schedule for the main fieldwork events is given before section 3.4.4.

3.4.1 Documentary and serendipitous evidence

Prior to any interviews, as well as intermittently throughout the study, I identified and considered a range of *documentary evidence*, sometimes in response to emerging issues (e.g. specimen assessments), and sometimes serendipitously (e.g. both departments sought student views of their GCSE experience, which were available to me). For High Wood these included visit records as required by the local authority who were funding my time there. Initially I had anticipated that a different second department would be used; given my re-direction in Autumn 2011, formal tracking of High Wood's initial preparations and enactions was not available, but earlier documentation and GCSE-related discussion was available and I was able to draw on joint work between Greenways and High Wood to inform thoughts about the nature of the sample. For example, they had worked jointly to trial, refine and reflect on their approaches to innovative problem-solving materials (2010) and so inform reflective probes. Related reciprocally observed enactions had shown teachers making considerable changes to their practice, consistent with the teacher support materials used, and adding weight to the claim that they were well-placed for a principled enaction of the GCSE.

Such data is of course not a systematic or unbiased account, and similarly, department meeting minutes are not primarily intended for research purposes, so comprise serendipitous secondary data which are social constructions. However, as a starting point for probing, rather than an end point in themselves, they formed valuable tools, particularly helpful for an insider researcher whose situation required perpetual validation of assumptions and interpretations.

During the course of the study, further documentation became available or was probed; this included student work, for example in book scrutinies or moderation undertaken by departments. I could then draw on this in interviews. Similarly, student perceptions of the new course were sought by both departments (Appendices 17, 18) and teacher responses to that could be further probed in interviews. Additionally, I admitted informal interactions within both departments: where appropriate as catalysts or probes for subsequent interview questions, but sometimes as contributing to post-hoc reflection, in which case they were subject to participant scrutiny at a draft stage. This last approach was taken with reflections made in informal encounters in Summer

2014, when contacts with Nigel, with Carol and with Kathy enabled more longitudinal lenses to be applied.

3.4.2 Interviews

I used ***semi-structured interviews*** as one of three main research instruments, because of their potential for addressing participants' perceptions of their experiences, reflections and thoughts directly, together with the potential to probe those. Interviews are appropriate for an activity theory lens since they assume teacher consciousness and agency; with a complexity-theoretic lens I hoped to capture both indicators of learning and of unpredictable and emergent phenomena. Gellert (2008) argues that for an analysis at group level, such as I proposed, data should be collected at group level – he used 'phenomenonological group interviews' which he claims partly replicate the affordances of insider researchers in accessing professional talk. In my case I was already an insider, and in any case felt that existing power relations within each of the departments would bias what was exposed in a group situation. Sets of interview questions (Appendix 7) were piloted with a volunteer teacher from another school, and sometimes edited as a result. Each comprised 4 or 5 lead questions addressing the main planned foci for the interview and allowed some broad areas of comparison, with planned prompts to trigger further response. Within that structure, I allowed participant teachers to take the discussion in their preferred direction, as a strategy more likely to expose their key thinking, and where this was of an unexpected nature, to follow it up, for example in relation to 'problem solving'.

An interview lasted between 40 and 55 minutes; it was recorded and fully transcribed as soon as possible afterwards, together with noted non-verbal responses. Transcriptions were then returned to participants for validation, and also for adjustment if they so desired. I felt that allowing participants to modify their responses might both enhance the validity of the data and improve the ethical basis of the study: respect for the participant, and an opportunity to withdraw or change responses after reflection, for whatever reason, were felt to be important affordances. Additionally, elaborations or interview-related comments offered between formal interviews were admitted as data: these were often offered as 'I was thinking about what we were talking about, and…' or similar. These were not audio-recorded, but were noted as soon as possible after the event, and again, checked by participants. The inclusion of such data might be considered a threat to validity, but equally might enhance that; in fact, offered edits of twenty-eight interviews amounted to no more than four or five elaborations, though these might have been limited by

shortage of time; additional comments were offered rather more frequently, and eleven such are recorded.

Early interviews sometimes resulted, at least in retrospect, in some over-generality and perceived superficiality of response, even with fairly persistent probing, but over time participants generally appeared to relax into the role, though I also increased structure in later interviews. For example, the penultimate set of interviews included questions around specific 'new style' GCSE questions (Appendix 8), that is, questions which were both to some extent aligned with my interpretation of the principles of the new GCSE and judged by me to require approaches which were relatively challenging pedagogically. I explain in chapters 4 and 5 how specimen and early GCSE papers in fact showed very limited change in the direction intended, so that unless aiming for the very highest available grade, it was easily possible for students to avoid altogether the more challenging, less structured questions. However, available papers did include some moves in that direction within a small number of questions, and it is those I drew from. Teachers were probed for their pedagogical responses to these, in an effort to expose the extent and depth of particular content and content pedagogical knowledge. Because participants had been teaching students working at a variety of levels, it was not possible to use the same GCSE questions for all participants: even where examinations targeted common grades, a given question will typically provide different pedagogical challenges for the most academic student, than for a more average one. However, structures of interview questions and probes were in common, and comparisons of responses were possible within these constraints, in fact proving quite revealing.

3.4.3: Observations

Full lesson classroom observations (1 hour) were used as indicated in the schedule below. Their purpose was to add to and deepen the data and to allow talk to be understood in context, in line with the situated nature of theorisation, but also to take the study into the final layer of policy enaction, where students were receiving and interpreting the curriculum: it was anticipated that this might expose aspects of enaction not obvious from interviews, as well as raise issues for triangulation, and indeed this proved to be the case. Because I had worked extensively as a teacher developer and occasional inspector, I was experienced at 'reading' classrooms for the teacher 'capacity' exposed, though that remains subjective. Clear foci were used for each observation, based on the overall focus as indicated in Table 1 below, in an effort to maintain 'distance' from my usual teacher development role in observations. The teacher remained the focus, with student response noted in order to inform further interaction with teachers. However,

I did sometimes interact with students, supporting and challenging them in a low-key way as is my normal practice during observations, as justified in section 3.8. Appropriate explanations and permissions, including student opt-out facility, were therefore sought and gained; no student is identifiable from written accounts of the study. Observations give access to physical, human, interactional and programme settings (Morrison 1993), and given I was an insider, the most critical of these was the interactional. My substantive professional role had the added advantage that students were familiar with, and tolerant of, my presence in the classroom. Observations also afford access to tacit aspects of practice which can be so familiar that teachers do not articulate them. They allow access to the final layer of enaction, triangulation of data and exposure of inconsistencies within it, as described e.g. for Dan in chapter 4.

I was experienced at adopting different foci according to the purpose of the observation: nevertheless, the literature, e.g. Schoenfeld (2013), is clear that the richness and complexity of classroom experiences is such that reliable, let alone valid, analysis of the situation is highly problematic. Further, teacher knowledge and beliefs can often only be *inferred* from observations, so their role in this study was initially largely to triangulate and to raise questions. For this purpose I felt that the potential gains from video-recording lessons were outweighed by the greater intrusion into the 'normal' classroom and the time necessary to analyse from video. Fieldnotes were made during observations and clarified as soon as possible afterwards, and these expanded versions were available to participant teachers for validation and for use as the basis of both probing and theoretical sampling. Observation notes were then summarised and annotated using current codes, making comparisons with other data, and identifying areas for further probing: an example is given in Appendix 7.

Chapters 4-6 show observations were largely consistent with other data, although exposing a variety of understandings of 'problem solving', for example, as well as interpretations of emergent schemes of work; the key exception to this was observation of Dan's teaching, which exposed tensions between normatively-held beliefs espoused by him, and his classroom practice. This is discussed in Appendix 10c and his role theorised in chapter 7.2.

Observations were largely informed by preceding interviews and fed into an interview taking place shortly afterwards. Each had two or three 'awareness foci' from previous interview(s) as in the table below, designed to increase their usefulness to the study, and an additional personalised focus negotiated with the teacher. This, and the role I adopted in-class, were ethically-based choices, affording some benefit to both teacher and students of having another

specialist teacher in the room, though it does mean that lessons did not always develop in quite the way they would have had I adopted a more passive role. I sought a low profile, avoiding student sight-lines during whole-class work, but engaged in circulation, active listening and low-key interaction during independent work, the object being to balance richness of information with minimal disturbance. Observations can present a challenge in meaningful recording, being rich in actions of thirty-plus people, most of which is open to interpretation. I therefore concentrated on recording facts; any interpretations were marked as '?' and subject to later probing where warranted. Notes, and writing, from observations were available for participant scrutiny, but a major role was to inform subsequent interviews, and where it was possible for that to follow after a relatively brief interlude, detailed teacher memories of the lesson proved remarkably good, though video recordings might have proved helpful. I attempted to maintain an open mind about interpretation of teacher action: the object was to enrich understanding of teacher viewpoint.

A summary of the main fieldwork events is given below, with initially planned foci: these were developed iteratively, as described above. The preferred fieldwork timetable was adapted due to insufficient time allowed for ethical approval process.

Table 2: Summary of fieldwork events

Pre-Spring 2011, and ongoing: gathering of various documentary evidence and informal data to feed into interviews			
Greenways: 16interviews, 12 observations – of Nigel, Carol, Dan (1 of each), Gillian (4 interviews, 3	**Interviews (x3)**	**Interview Focus**	**Observation (x3) focus**
	1. January 2011(introductory)	Background and beliefs (+ one extra for replacement teacher, Spring 2012, prior to 'problem-solving' observation of her); early ideas re GCSE 2010, including preparations and challenges	1..February/March 2011 (of year 10): new pedagogy
	2.May/June 2011	Probe observation; emerging ideas re GCSE 2010	2..January/February 2012 (of students then year 11): problem solving

	3.March 2012 (post observation)	Probe observation, especially of interpretation of 'problem solving'. Considered ideas re GCSE 2010, especially in light of achievement to date, and of second teaching to year 10. Responses to particular 'new' exemplar questions in terms of curriculum, pedagogy, students, with questions framed to illuminate various aspects of teacher knowledge.	3..May 2012 (of year 10): 'functional' maths
	4..July 2012	Probe observation of year 10. Reflection on first full cycle, including with reference to learning of year 11 students at June 2012, and of year 10 students after their first year at GCSE; use of metacognition. Responses to particular GCSE questions June 2012, in terms of curriculum, pedagogy, students.	4..September 2012 (of new year 11): established new pedagogy
	5.October 2012 (post observation)	Probe observation. Reflection on GCSE 2010 in light of first set of results and continued experience with new year 11 (second cohort). Current knowledge and beliefs (any change?). What changes to practice have been made (and why?); what have still to be made?.....	
High Wood: 12 Interviews, 9 observations – of Kathy, Norman, Heather	1/2.Nov 2011 (introductory)	Background and beliefs; current ideas re GCSE 2010 and how these have developed since first thinking about implementation; informed by, and probing, informal observations and documentary evidence collected during previous communications.	1/2..Jan/Feb 2012 (of year 11): problem solving
	3…March 2012 (post observation)	Probe observation. Considered ideas re GCSE 2010, especially in light of achievement to date, and of second teaching to year 10. Responses to particular 'new' exemplar questions in terms of curriculum, pedagogy, students, with questions framed to illuminate various aspects of teacher knowledge.	3…May 2012 (of year 10): functional maths
	4….July 2012	Probe observation of year 10, especially re interpretation of 'problem solving'. Metacognition? Reflection on first full cycle, including with reference to learning of year 11 students at June 2012, and of year 10 students after their first year at GCSE. Responses to particular GCSE questions June 2012, in terms of curriculum, pedagogy, students.	4…Sept/Oct 2012 (of new year 11): established new pedagogy

	5…..October/ November 2012 (post observation)	Probe observation. Reflection on GCSE 2010 in light of first set of results and continued experience with new year 11 (second cohort). Current knowledge and beliefs (any change?). What changes to practice have been made (and why?); what have still to be made?…..	

3.4.4: Analysis

As suggested above, analysis of interview and other data was by means of open line-by-line coding and categories constructed from the data, using constant comparison at each stage and memo-writing to elaborate emergent analysis. Openness was achieved by the use of general and flexible research questions, limited initial reading of the literature with subsequent reading driven by emergent analysis, and 'trusting to the sensitivity of the researcher and the emerging theory' (Gibson and Hartman 2014, 31); additionally, a constructivist approach of involvement of participant teachers in analysis allowed a breadth of socially-constructed admissible meaning, although the resulting theory is necessarily *an* interpretation. Initial derivation of codes and categories is described in Golding (2011), but proceeded from use of open descriptive phrase via initial codes, to derivation of categories by the grouping of codes as in Table3.

Figure 5 (page 60) for example analyses an excerpt from Carol's Interview 1 focused (Table 2) on teachers' background and beliefs. The right hand side shows open coding (phrases), together with initial allocated codes relating to beliefs – here I, S, U, F indicating valuing of independent and social learning, of understanding, and of a teacher's role as facilitator respectively, as in Table 3 (page 61). Note it also open codes reflection and a teacher learning disposition, beyond the initial focus. The top of the excerpt notes questions about the policy role suggested by the data, and the profile of reflection awareness: the whole shows the fruit of several successive visits to the data. What Figure 5 does not evidence directly is the alternative codes tried and abandoned, and revisits made to address confirmation bias, when I tried to re-read the data in another light: what other interpretations were possible? And how did interview transcriptions compare with other data such as observations?

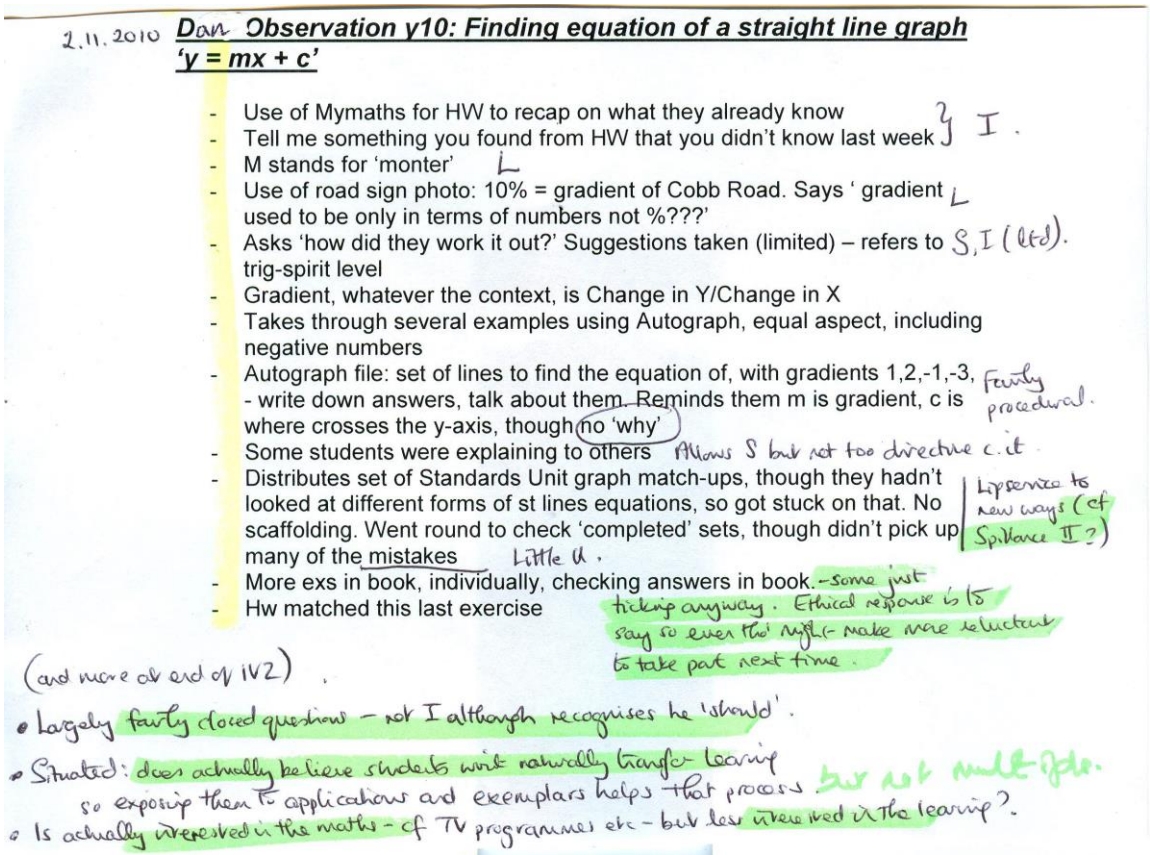
Knowledge/beliefs	Introduction: You've very kindly agreed to be part of this project, which is probing the way that teachers here have set about implementing the new KS4 curriculum. What we say will as you know be recorded, so I can concentrate on what you're saying without having to write it down simultaneously. Just to re-iterate, you're very welcome to withdraw from the project at any time for any reason, but I do hope that you'll actually find it stimulating and that you feel you benefit from the reflection involved. Are there any questions you'd like to as at this point? (pause) OK....
Experience	Can you give me a rough outline of your teaching background I about 5 years ago decided to explore the longheld wish to teach and did a year as a cover supervisor to get back into school. Then I qualified nearly 3 years ago after doing a PGCE at Exeter and then I've been working nearly 3 years at Woodroffe, with a full range of classes, although this year it's been more 9 to 13, years 9 to 13.
Mathematics	And your mathematical background? I did Maths, Further Maths ALs and a Maths S level at school, then I did Natural Sciences at university with a maths module in the first year. Then I specialized in Chemistry, large because I got better results in that subject – one of those opportunistic decisions. Then after university I did a Ph D because I thought Pure research was absolutely wonderful. Then when I found I wasn't really very good at doing practicals I went into accountancy – there was a little bit more Statistics in that than I'd done previously – not a high maths content, but a little bit of using it in the work place. Then I went through various jobs, in 2 of which I did to some extent use maths, one of which was a data mining experience at FirstDirect, then a bit of modelling at Nominet – but fairly minimal use of maths, I mean. Do you find your knowledge and understanding of maths is enough for you for teaching? Laughs. No, I've found that I've had to do quite a lot of revision. I don't think there's anything I'd genuinely not seen before – perhaps a bit of decision – but there has been a lot I've had to remind myself of. But you've got enough mathematical confidence that you can learn and remind yourself of those things that you need when you're teaching? Yes, to be honest, yes. So do you ever make mathematical mistakes in the classroom? *Laughs.* Yes. Tell me. There's the basic arithmetic mistakes that I make everywhere, and that's OK, in the sense that I'd expect that anyway. Yes, there's an example from today, actually, in mechanics. It wasn't a mistake as such – it was Tom's question, he'd put 2 simultaneous equations on the board with T and k where you have a frictional resistance proportional to the masses on the 2 connected bodies that's where k came in, and you resolved the 2 to get a tension and I jumped in and said why isn't the tension dependent on k, and got in a bit of a muddle because of course there's a peculiar tension value for each value of k and I got myself in a muddle. In one way we got to talk about it and talked about what simultaneous equations mean and in another I'm uncomfortable because I couldn't see through it and actually thought I was seeing something else. I thought the structure of the question was such that there was only one value for T, which there wasn't, and I think that's about me because I can see it now, I dunno, it's about jumping to – I think it's probably not doing enough, though that's the third time I've done Mechanics. So what is it that bothers you – the knowing the mathematical answer (no) or messing up their learning? Slightly messing up their learning - if they'd all gone away slightly confused, which they might be but they didn't say, mostly I think I looked a fool I thought – I thought I wasn't completely in control – but mostly I think cross with myself, that I'd slightly jumped to a wrong assumption. But if you think of the positives in that situation – well, can you think of anything that they gained from seeing you struggling with that? I suspect they did – it just makes me feel a little bit insecure. I don't feel bad about what they experienced and I certainly don't feel bad about asking the question. I would in future phrase it slightly differently – I would have been more open-ended with the question, I think, so instead of saying why is T not dependent on k, I think I would rephrase it so we could explore it without me giving an indication of what I thought was going on. So does that mean you could say something like does that mean that T is independent of k? Yes, yes.... I was saying things like, what if k=0.5, to be honest I think I'd gone slightly off on the wrong track. On the other hand, they're seeing you thinking through the implications of what's on the board. Yes, that's what I'm not uncomfortable about. To be honest, they weren't really struggling with the question so I'm not uncomfortable them having to think round it more. I'm not uncomfortable that it's thrown them off completely – or as you say, that they've seen me stuck, which they have. I admitted to being wrong about what I thought was going to be the issue in the question.

Figure 5: Exemplar interview coding, pilot study

As described in section 3.4.3, field notes from observations were summarised and further analysed as memos, as a basis for further probing and triangulation. Codes and categories used for this analysis were those current across all data: for example, the summary observation shown in Figure 6 shows the early open commentary on and analysis of one of Dan's lesson observations, using the codes then current, as in Table 3 on page 61. The subsequent interview probed his views on challenge and probing of understanding, following up the comment in Figure 6 'no why'; it also probed his views about learning (following last Figure 6 comment 'less interested in learning?'), finding, as summarised in section 4.3 and detailed in Appendix 10c, that he claimed

Table 3: Codes and categories developed in pilot study

Code	Meaning	Category
Af	Affect	How students learn
C	Challenge/expectations	
D	Depth of learning	
E	Enjoyment	
I	Independence (of students)	
S	Social learning	
Sit	Situated learning	
V	Variety in learning experiences	
P	Performativity	Limitations
T	Time	
A	Algebra	Mathematics
L	Links (within or beyond)	
U	Learning for understanding	
TB	Textbooks and other materials	Support
PC	Professional community	Support/teacher ID
Ex	Role of experience in teaching including as learner	Teacher identity
F	Teacher as facilitator	
R	Receiver – passive teacher role	



2.11.2010 Dan Observation y10: Finding equation of a straight line graph 'y = mx + c'

- Use of Mymaths for HW to recap on what they already know
- Tell me something you found from HW that you didn't know last week
- M stands for 'monter'
- Use of road sign photo: 10% = gradient of Cobb Road. Says ' gradient used to be only in terms of numbers not %???'
- Asks 'how did they work it out?' Suggestions taken (limited) – refers to trig-spirit level
- Gradient, whatever the context, is Change in Y/Change in X
- Takes through several examples using Autograph, equal aspect, including negative numbers
- Autograph file: set of lines to find the equation of, with gradients 1,2,-1,-3, - write down answers, talk about them. Reminds them m is gradient, c is where crosses the y-axis, though no 'why'
- Some students were explaining to others
- Distributes set of Standards Unit graph match-ups, though they hadn't looked at different forms of st lines equations, so got stuck on that. No scaffolding. Went round to check 'completed' sets, though didn't pick up many of the mistakes
- More exs in book, individually, checking answers in book.
- Hw matched this last exercise

(and more at end of IV2)

- Largely fairly closed questions – not I although recognises he 'should'.
- Situated: does actually believe students will naturally transfer learning so exposing them to applications and exemplars helps that process
- Is actually interested in the maths – of TV programmes etc – but less interested in the learning?

Figure 6: Exemplar observation summary

good reason for the limited level of demand made of his students, though this was not consistent with the approaches he apparently espoused during department meetings. Such inconsistencies are discussed in section 7.2.

In chapter 6 I describe how over time, although these codes were still useable, reflection suggested other possibilities were needed to capture the richness and thrust of the differential data, resulting in new coding and categories as exemplified in Figure 7 overleaf, with codes and consequent categories defined in Table 4. Figure 7 shows an excerpt from Gillian's Interview 3 in March 2012. The original codes are shown on the right, with (on the left) overlaid affective-departmental codes as defined in Table 4. Again, I revisited this later coding on several occasions with the specific aim of addressing confirmation bias: if these new codes were 'disqualified', how else could the data be analysed? In an attempt to address 'occupational capacity' independently of the new codes, rather than shoehorn them into an emergent theoretical structure as cautioned by Lerman (2010), I then independently coded data for indications of aspects of 'occupational capacity' I wanted reflected in any construct developed: such coding can be seen on the right of Figure 7, superimposed on original coding. Such occurrences were then compared with the new set of codes to check for completeness and consistency of emerging analysis, in an effort to approach analytical as well as theoretical saturation.

Table 4: Codes and categories developed in final study

IM	Intrinsic motivation			AFFECT
EM	Extrinsic motivation			
Mast	Mastery			
SE	Self-efficacy			
+Em	Positive emotion			
RC	Risk and challenge			
Res	Resilience			
LD	Learning disposition			
Refl	Reflection, later split into (see Memo 10.07.2012)	ReflP	Reflection for/in/on practice	Reflective palette
		Lang	Language for reflection	
		NA	Noticing or attention	
		List	Active listening	
PLC	Professional learning community			PLC

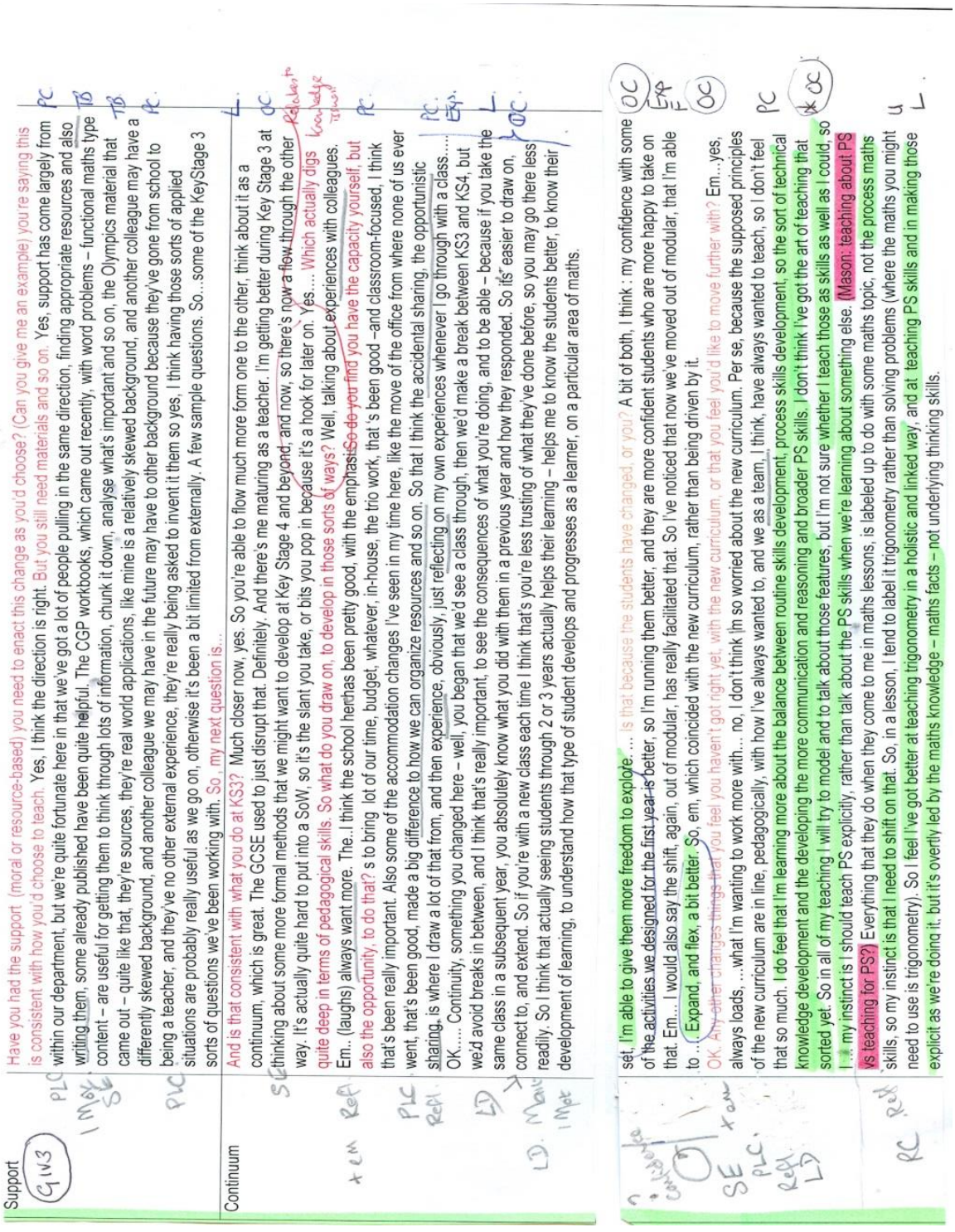


Figure 7: Exemplar interview coding, final study

In parallel with this analysis, and in keeping with the grounded theory approach, I explored and used areas of the literature suggested by the data, often making links between the two through use of memos. My use of these was varied, going beyond both Charmaz (2006) and Gibson and Hartman (2014) by incorporating not only 'constant comparison' of data with the literature, and different parts of the literature one with another, as in Appendices 4, 17, 21, 22

and 24, but also, given a paucity of existing literature relating to some emerging characteristics of interest, development of 'what if' ideas about how findings arising in other contexts, for example relating to school students' learning rather than teachers' learning, might manifest themselves if they were to extend to the study context: such memos are exemplified in Appendices 3, 18, 19, 20. Such approaches were particularly useful for 'sensitising' me to possible interpretations of the data. For example, Appendix 17 shows emergent thinking about teacher response to challenge, for which searches suggested there is little evidence available. However, the Curee/QCDA Challenge project (2009) drew together existing literature on school students' response to challenge, and I used this to catalyse thinking about what corresponding teacher response might look like *if* the Curee/QCDA summary extended to teachers, following this up with data searches in that area. An obvious risk is again confirmation bias, which was addressed by seeking counter-responses from both teaching and academic colleagues. File evidence across different points in Appendix 17 remained of very variable strength, though sufficient for the purposes of this study.

Additionally, memos were used to draft emerging theoretical ideas, as in Appendix 22 and described in chapter 9, and to explore and justify the route taken. For example, I discuss briefly in 1.6.3 some of the issues surrounding commensurability of theoretical lenses: grounded theory lends itself naturally to such an approach (Gibson and Hartman 2014) and is enriched by it, but emergent ideas need to be internally consistent for plausibility. The thinking reflected in Appendix 1 assured me, using Prediger's (2009) terms, that later Activity theoretic, and complexivist, thinking enabled a minimal comparison and contrast, while often offering complementary understandings; and that other theoretical tools employed such as PLC, occupational capacity and enaction theory, were locally integrable with either.

The range of memos was then developed iteratively with data collection and use of the literature, to support the development of plausible theory with an 'emergent fit' as in chapters 7, 8 and 9, and having (Charmaz, 2006) grounded characteristics of usefulness, conceptual density, durability, modifiability and some explanatory power. Such theoretical developments are presented in chapters 7,8 and 9.

3.5 Validity

3.5.1 General issues of validity

I distinguish *validity*, as in a truthful bridge between a theoretical construct and the data, from *authenticity* of data: I wanted my data to give a fair, honest and balanced account of the teacher's lived enaction.

Issues of authenticity in the use of interviews is pervasive: in seeking to access the lived worlds of another's experiences, thinking and responses, in this case to a curriculum innovation within their professional world, there are a number of obstacles, one of which is that the participant may have responded tacitly in many respects. For example Bromme (1987) shows that much teacher expertise is held at the tacit level, and necessarily so, given the extraordinary complexity of teacher classroom operation (Eaude 2012). Direct access to teachers' worlds may not be possible, and teachers will in response to questions select from their awareness and understandings, as interviewers will select for probing from the wealth of response given. Further, Baker and Johnson (1998) show how interviews can actually be instrumental in the development of thinking, so that thoughts exposed may not have existed as such prior to an interview. Lerman (2001) argues that the ability to think outside the situation is limited by the language available, which is itself situation-embedded, so that accessing teacher perspectives is necessarily both selective and partial. This social and language-dependency was mitigated to some extent by my 'insider' role; additionally, apparent limitations changed over time, e.g. Greenways teachers' articulation of issues and enaction became much more sophisticated as the study progressed, apparently contingent on changes in their professional environment (chapter 4).

Additionally, power-centred issues are not unproblematic, and are addressed with other ethical considerations below, but the more autonomously thinking participants appeared to come to conclusions in consciousness of the power base and hierarchy (and probably context): apparent degrees of thinking autonomy varied. Further, I show in Appendix 10 that Nigel was skilled at 'rehearsing a preferred presentation' (Ball et al. 2011a), with an obvious threat to authenticity. However, it is also clear that the interviews themselves were sometimes the site of new constructions of articulated meaning, for example:

> 'We give them some preferred direction, at least by inference. At least, I think we do – it's the first time I've articulated this, so it's really emergent thinking on my part.' *Gillian, Greenways, interview 5*

This does not invalidate the data, but it does suggest an 'uncertainty principle' in that those meanings, and consequent developments, might not have emerged in the absence of the study: indeed, part of the ethical justification for the use of participant time, was the value of the hypothesized ensuing professional development.

Assumptions of teacher consciousness and transparency, together with co-construction of narrative to reveal an authentic representation of the experience, are therefore limited: Brown and McNamara (2011, 92) argue that another's experiences are unknowable, and that 'identity is created rather than revealed through narrative', so that what emerges should be interpreted as one version of lived experience. Geertz (1974) argues that it is necessary for authenticity to see and report the situation through the participant's eyes: however, as Lave and Kvale (1995, 220) point out, the necessity of engaging a sufficiently complex instrument – a human - in order to attempt understanding of another human experience, means, paradoxically, that attempts to do so are laden with risks of error. I attempted to minimise this by developing a 'sensitivity' to a range of informal and formal data, as well as seeking participant validation of my accounts and interpretations, but the very limited feedback suggests teachers' attention to this was not a priority for most participants. Participant editing of interview transcripts has been described; teachers did not have the *right* to edit other scripts - Hammersley (1992) suggests that any individual participant does not have a monopoly on interpretation – and where discussion of those arose I tried to triangulate interpretations.

'Validity' here would match abstract concepts such as knowledge and beliefs (as well as the characteristics exposed later in the study) to the data in a plausible (to knowledgeable others) and persuasive way (e.g. Sanjek 2002). Prolonged engagement with the field, in this case over nearly three years, is argued by Lincoln and Guba (1985) to add support to credibility, and this was enhanced by exposure of interim analysis and discussion to a range of researcher and teacher peers. However, an unreasonable scale of fieldwork for either researcher or participants can also threaten validity, so I sought to make that manageable. I also attempted in Brock-Utne's (1996) terms, to 'make the familiar strange', in an effort to reduce cultural blindness: this appeared easier once my everyday working situation was removed from the research sites, but before that was supported by my fairly wide experience of interacting and observing in a number of other schools.

However, there remained threats to ecological validity – I have for example already discussed the apparent construction of changed perspectives during interviews - and also to external validity in terms of both setting and historical effects (Lincoln and Guba 1985). The argument for the power of the department sample rests on a high degree of evidenced commonalities of setting and of history, largely supportive of a principled enaction. If in analysis of these, I ignored or overlooked salient differences, then validity of findings is clearly limited: I addressed this by repeated revisiting of the data in an effort to expose such prior differences. I could have adopted rather more rigorous and timely scheduling of memos and recursive reflection in order to improve confidence in research diary use, and following evaluation of methodology in the preparatory

study, attempted to do that, though with limited success. Cultural validity requires an understanding of the cultural values of participants, including the use of language: this is both an advantage and a threat for an insider researcher, since apart from power issues threatening access to valid data, commonality of meaning might be assumed, so I attempted sensitivity to such possibilities, as in 'problem solving' above.

3.5.2 Insider Researcher

As an insider (to different degrees in the two schools), I had access to information and knowledge of participants, and also perceptions of some of the influences on understanding and actions, that would not be available to a stranger, with the potential advantages to richness of detail and understanding that affords. It also brings risks – of assumed knowledge that is in fact not warranted, and of bias in response or action due to existing relationships between researcher and participant. The first was addressed by constant referral to a research diary with repeated efforts to stand back and subject that to critical scrutiny. The second was particularly true in Greenways where I had mentored and line managed three of the four participants for several years from the beginning of their career, and line managed the fourth: it is likely that exposed thinking and actions were to some extent coloured by those relationships. In the case of High Wood teachers, while my professional role was as an invited local authority external expert, conceived as a source of both challenge and support, there were, similarly, assumptions inherent around image and professional accountability in that situation. Additionally, all teachers involved were familiar with my views about the nature of the new GCSE as we had historically worked together on a sustained basis. An insider will always be challenged to 'make the familiar strange' in Brock-Utne's (1996) terms and subject it to critical scrutiny – and that strangeness needs to be achieved to some extent by both researcher and participants.

These threats were addressed by overt and repeated reassurances about wanting to know about participants' viewpoints, and consistently attempting passivity and neutrality in interviews. Baker and Johnson (1998, 230) suggest that this may not be achievable, and that rather, questions are 'powerful means of calling on members' cultural repertoires of speaking'. Every effort was made to greet responses neutrally: however, as indicated, some of my views were well known to participants – and indeed Baker and Johnson's argument is that such a shared culture underpins meaning in interviews. I sought to further minimize issues of power by meeting in participants' own spaces, paying deep attention to what was being said in an effort to enter the teacher's lived

experience, responding in that light and reiterating assurances of the value of participant accounts, though power issues could not be eliminated.

3.5.3 Triangulation

As a consequence of this variety of threats to validity, and in order to both check data interpretation and increase the depth of understanding achieved, documentation and classroom observations were used very actively to compare the implications of, and stories told by, the interview data: I endeavoured to timetable for myself frequent revisiting and comparison of the variety of insights so achieved. Appropriation of literature findings from related but different field settings posed a particular threat to validity via confirmation bias, so particular efforts to achieve 'distance' and constant comparison of data were made in these areas. Comparisons fed into subsequent fieldwork, either through interview questions or through the focus selected for observations. The most striking example of the usefulness of this approach was the emergence of a contrast between the articulated policy responses of Dan, a Greenways teacher, and aspects of his classroom practice. A methodological approach such as that adopted by Braun et al. (2011) analyses teacher policy response only to interview level, yet following it through to classroom enaction in this case exposed a further layer of necessary considerations and tensions, explicable as suggested by Leatham (2006), but eventually affording a richer understanding of the teacher characteristics impinging on enaction. However, sometimes this approach lacked timeliness, as with the multiple understandings of 'problem solving', a tension which could only be explored well into the study despite that being a fundamental construct of GCSE 2010: more careful initial probing and/or anticipation might have pre-empted that. In purely policy-enaction research, my methodology would be taken to the final policy level of probing student response, but this study was focused on the policy-practice interface at teacher level although I had serendipitous access to some student reaction at both schools (Appendices 17, 18).

Each aspect of fieldwork is therefore susceptible to threats to its validity: documentation study is vulnerable to partial, and biased, accounting, perhaps for a particular audience; observation is of the present, with historical contributions to the present only implicit; ecological validity may be threatened by the presence of the observer. While I made attempts to minimize these threats, the validity of all aspects of fieldwork benefits from the methodological triangulation adopted.

A number of other triangulation approaches were used to supplement this, in line with Denzin's (1970) recommendations: theoretical, by using a variety of theoretical lenses to probe

the data as suggested in chapter 1; synchronic by comparing and probing data originating from different teachers in one department; and diachronic by comparing and probing responses given by a single participant over time: did these represent different ways of expressing a single 'reality', or were they evidence of genuine development over time? Such issues were, as described, clouded by issues of participant selection in both interviews and observations.

In analysis I used multiple cycles of comparison and searching for alternative codes, categories, and theoretical explanations; I identified the complementary affordances of different theoretical lenses as described later, as well as attempting actively to seek falsification at all stages. At the reporting stage, I attempted to minimize the selective use and interpretation of data, and to clarify the situated nature of the study; and in considering the implications of the study, to spell out the appropriate parameters and limitations to generalisability of the study. Throughout, I used the research diary to challenge and repeatedly revisit interpretations and inferences from fieldwork, always seeking counterexamples to emergent thinking, as well as looking for what had *not* been said or done, and following up significant facets of that. Jaworski (1997) argues that validity lies in the acceptance of the outcomes by an informed other, and promotion of that situation requires detailed situating of the claims, particularly in relation to the threats of an insider researcher. As indicated, 'work in progress' was exposed to peer scrutiny at several stages during its development.

Finally, from a theoretical vantage point, this study attempts to analyse enaction at two levels: that of individual teachers, and that of the whole department. Most data collected, other than documentary, was at individual level, with departmental characteristics inferred from that: a careful and detailed evidencing of the generation of those outcomes has therefore been attempted in chapter 8. Similarly, I have tried to spell out limitations to the foundations of the theory generated, for example where it relies on studies of school students rather than of teachers, in a different phase: the necessarily contingent nature of the conclusions has been addressed in chapter 11.

3.6 Reliability

Long and Johnson (2000) characterise traditional views of reliability as dependent on standardised, neutral and non-biased data collection instruments – and those in qualitative research surely include the researcher: Ball (1990, 157) says 'The basis of rigour in ethnography is deliberate choice and reflexive decision-making'. Qualitative reliability depends also on retention of a sufficiently complete account of context. It is therefore difficult to demonstrate, although a

decision-making audit trail, triangulation of data with attendant limitations, and 'thick' description of context, were attempted, together with frequent reflection on the role of the researcher in data and interpretation (e.g. Appendix 6). Long and Johnson (2000) dismiss alternative framings such as 'dependability' (Lincoln and Guba 1985) as being essentially subject to the same challenges, although I suggest the use of a different word (as with 'plausibility', 'credibility', 'veracity' for 'validity') does serve to focus on the account as one of many possible. I recognise that the use of 'validity', 'reliability' and 'triangulation' suggest positivist approaches to some readers, but on balance chose to retain them as words familiar to participant teachers, interpreted as in Long and Johnson (2000).

3.7 Methodological Challenges

As described in chapter 2, there are particular challenges around the probing of some aspects of teacher knowledge: a variety of tools have been developed, but are largely quite time-consuming and therefore unrealistic for this small-scale study. However, the fact remains that teachers do not always know what they do not know, or the implications of that: the absence of a particular aspect of 'horizon knowledge' (Ball, Thames, and Phelps 2008), for example, is likely to mean that a teacher is not aware of how it could contribute to more obviously central learning objectives. Interviews probed and observations inferred, as described, but since this study sought in particular to expose those aspects of teacher knowledge which impinged on teacher enaction of the new GCSE, a rather more specific tool was developed, as in Appendix 8 and described above.

The literature in chapter 2 is clear that accessing teachers' beliefs in a reliable way may not be possible: they are in part held tacitly, so may be hard to access directly. Belief systems may not always be internally consistent, and will certainly be held in a hierarchy. They may not be inferrable from practice, since beliefs and practice may not be aligned, particularly in times of change. However, initial interviews probed espoused beliefs in a variety of relevant fields (Appendix 7). These did not, though, appear to account fully for emerging differences in enactment. Later stages of the study, though, exposed a number of differential teacher characteristics related indirectly to deeply-held beliefs, and only identified through persistent revisiting of the data, for example self-efficacy in relation to the change.

The research questions refer not only to individual teachers but also to a department unit. Hodkinson and Hodkinson (2005) argue that English subject departments have a distinctive culture as social and learning communities, but their treatment of problematic aspects of this is

limited, as discussed in chapter 8. Some, if not all, of the teacher characteristics discussed in later parts of this thesis are exhibited only in some areas of functioning, and maybe intermittently, by individuals: that is true for example of resilience. So what does it, or indeed, *can* it mean to say that a department of six or eight people is resilient? As such constructs were identified and discussion developed, I tried to ask whether it made sense in some way to attach such labels to a group of disparate people, and discuss this in chapter 8 and elsewhere. Complexity theory has a particular contribution to make here, since the collective emerges naturally. Subsequent conclusions are contingent on this sense-making.

3.8 Ethical issues

Despite use of pseudonyms, my own background is identifiable, so strict anonymity of e.g. the Greenways Head of Department cannot be achieved. Fewer risks to confidentiality arise with respect to High Wood participants. As Pirie (1998) argues, there is a tension between the need to report in detail and the protection of those involved. Details of clear, open and honest informed consent, and facilitation of participant validation of interview responses and response to interpretation, were therefore particularly important; participants were also offered the right to access the final report. In other respects, university ethical guidelines were adhered to. In particular, it was anticipated that participants would gain professionally from the reflection needed to participate in a series of in-depth interviews, in line with Baker and Johnson (1998), Britt, Irwin, and Ritchie (2001), and Peng (2007), despite the demands on time.

There were several stages of the study at which ethical challenges presented themselves. The first significant such occurred when interpreting the apparent tensions between Dan's actions and his espoused beliefs: was this merely a case of Leatham's (2006) 'sensible systems' approach showing belief hierarchies that were not fully accounted for, or did it expose professional tensions more fundamental to the teacher's identity and wellbeing? The challenge of how to deal with this ethically in the longterm was not fully resolved when Dan went on longterm sick leave, subsequently to take early retirement, and although this was apparently not work-related, there remain questions as to whether exposure to such tensions in any way contributed. Certainly, there were contingent responsibilities in reporting those inconsistencies in being very clear that Dan was not a 'bad' teacher when others in the department were 'good', and similarly as the two departments began to diverge in enaction, polarization and value judgments were ever-present threats which were addressed by trying to maintain awareness of misinterpretation.

Observations on two occasions exposed teachers making mathematical errors of a fundamental, rather than careless, sort: in the second case, in a demanding problem-solving

situation – not unexpected, given the sizeable pedagogical demands made by the attempted enaction of the new GCSE. These might not have been exposed by students, but I attempted to address them in low-key, diffident and supportive ways, in an effort to build up capacity without undermining teacher identity, within the ethos of the department concerned. On other occasions, a compromise was struck between minimal disturbance of the lesson as it might have been in my absence (i.e. the promotion of ecological validity), and the clear learning needs of the students. Observations during student independent work regularly exposed student misconceptions or lack of appropriate student knowledge, and I dealt with these at the time, as would befit any active observer. More general opportunities for discussion were noted for subsequent teacher information, so that the opportunity was not lost but rather postponed (although inevitably, changed).

More generally, interviews sometimes exposed unanticipated tensions between my roles as a researcher and as a teacher developer, especially when interviews focused on specific pedagogical challenges focused on 'new' style GCSE questions. After the first occasion and on reflection, these were addressed by concentrating on the needs of the research at the time, but noting the tension and finding an occasion to return attention to the issue outside interviews. Similarly, I had to be conscious of maintaining a prioritization of developmental support in routine interactions at High Wood.

Following Dan's absence, I needed a Greenways replacement. Ideally this would have been a teacher who maintained a good spread of characteristics in the sample, but one such already appeared to be working at capacity, and the other, when approached fairly diffidently, declined to participate. The principle of 'volunteering' with no discernible duress, is an important one, and I was grateful to adopt Gillian into the study, even though that reduced the breadth of 'players' studied and so the strengths of the sample.

Finally, a challenge arose with regard to the timing of the penultimate interviews: High Wood teachers appeared to be under some significant stress at the preferred time, resulting in delays which might well have compromised the reliability of recall, but I decided the principle of non-maleficence overrode that.

3.9 Strengths and limitations of study in methodological terms

Grounds for any claims of generalizability rest largely on the selection of the sample at three levels: the study of a policy widely-embraced; two departments apparently unusually well-placed

for a principled enaction; and a 'telling' (Mitchell 1984) range of teachers within each. However, a more challenged background can sometimes breed e.g. more resilience (Hernandez Martinez and Williams 2013), exposed as a salient characteristic later in the study. The study is over a longer time period than many enaction studies, with the added serendipitous data cited in Appendix 24 bringing its lens to cover a full four years, and it does address the range of layers of policy enaction down to classroom level. Generalisability is discussed further in chapter 11.

As suggested above, my role as an insider researcher for most of the study introduced both strengths and limitations: the last round of interviews did reflect an additional 'distance' consequent on my new, removed professional role. Some later theoretical developments depend on literature about Primary school enactions, or focused on young people rather than teachers, in the absence of more directly applicable evidence, so are very tentative conclusions especially in terms of their implications. The former in particular might be problematic: Tatto et al. (2012) show the different ways in which Primary teachers develop and what different constraints and affordances there are in Primary teacher education, and with largely non-specialist teachers in Primary education one might expect the role of subject-specific knowledge for teaching to be different, perhaps more of a discriminatory factor than in this study.

For any study of this nature there is an 'uncertainty principle': behaviours and thoughts evidenced might not have existed outside my intervention. For example, Baker and Johnson (1998) demonstrate clearly how teachers develop through the process of reflective interviews, and this was evident at several points during the study, as shown both above and later. My presence as a researcher, including bringing a history of relationships and professional interactions, might well have impacted not only on what teachers chose to expose in interviews and observations, but also on their persistence with the enaction, as in Watson and de Geest (2010). The tacit nature of much knowledge and beliefs, as well as later identified salient characteristics, means there are significant challenges to the acquisition of valid data: all of these issues underline the importance of triangulation, and of the revisiting/repeated questioning and reinterpretation described above.

The foci for this study were at two levels - the individual and the department - and I have explained why much of the methodology concentrated on collecting individual data. Because the department as a collective is, as I shall argue in chapter 8, undertheorised as well as under-represented in empirical studies, much of my conclusions at department level are highly contingent, though I claim they both support and enhance the existing evidence base. Nevertheless, in terms of generalizability, I believe I make a good case in chapter 11 for pursuing the proposed theoretical constructs and related actions in larger empirical studies.

CHAPTER 4: GREENWAYS

4.1 Background of the department

The department at Greenways at the start of the study included 9 teachers (some part-time), mostly teaching just mathematics. One was an Assistant Headteacher, but all others would be classified as 'mathematics specialists'. I had joined the school four years previously as Head of Department and had just been moved to the Leadership Team to concentrate on outreach work as an Advanced Skills Teacher and Director of Specialism; I had been replaced by a young enthusiast, Nigel, who at that time had been teaching just two years. The Department also contained three other teachers appointed and initially mentored by me including Carol and Gillian; one longstanding mathematics teacher Dan whom I had line managed; and one other who had several times changed between mathematics and DT teaching.

Five years previously the department had received a critical internal review, as a result of which I was appointed. The Headteacher was ambitious: performance management was very proactive, staff development highly structured, and the school acquired its first 'outstanding' Ofsted rating at the start of the study. As a result of this Greenways successfully applied to become a 'Teaching School' in Summer 2011, two years into the study. It was thus perceived to be on an 'upward' trajectory over this time, and the development of the mathematics department was seen to be part of this, with substantial improvements in headline results at GCSE and A Level for each of the four years after I joined the school. At that point the school acquired a 'Mathematics and Computing Specialism' which justified the role I moved to.

For the school as a whole with an object of broad education (with a definite focus on increasing attainment in high-stakes external examinations), a theoretic understanding as an 'activity system' seemed to me a good fit, with the Headteacher in particular being very proactive in structuring to destabilise existing aspirations. In my years as Head of Department I had begun with strategies similar to his, but had tried over four years to move to a way of working much more aligned with a complexity understanding of a department learning to develop its practice. My own (mathematics education and other) values were of course integral to such decisions, and were well-known to all participants in the study: developments over the following three years will not have been independent of that knowledge. However, when I discovered these two theoretical lenses they very much resonated with nascent understandings I had, and which Kathy (at High Wood) and I had shared when working together.

Historically the Local Authority had been active in offering bought-in support of various kinds, and the Leadership team was keen to take advantage of that, including in the mathematics department. For example, teacher developmental 'trios' were supported by the authority, and in 2010-11 Carol and Dan participated in one such. Local authority approaches to teacher development were, to my eyes, well-structured and top-down, and easily modelled by activity theory, though the Greenways Head was also very happy to support department-level work such as small NCETM-funded action research projects, or participation in national mathematics initiatives such as the CUREE Challenge project (Curee/QCDA 2009), as well as a variety of cross-phase or cross-school activities initiated by the mathematics department: the Greenways department had worked together with High Wood on several of these. The two departments had also worked together in depth to introduce more 'thinking maths', challenge and 'deep learning' into Key Stage 3, though maintaining independent schemes of work, on the grounds that more heads and different contexts would make for more robust and persistent development. Part of this growth was structured and centrally led; other aspects appeared implemented so as to support much more adaptive and emergent learning, so were better understood with a complexity lens. Leadership distributed to departments was therefore well-supported, at least while the department was perceived to be 'successful', and over the few years prior to the study key outcomes at both schools broadly improved, though with small and explicable 'blips'.

Through the study, support continued for development and experimentation within and beyond the department, even though the weighting of mathematics in national accountability measures increased significantly over those years, which can compromise non-standard development (Ofsted 2012). The department was involved in a number of outreach activities with other schools, Primary and Secondary, as a result of the Specialism; GCSE results continued to improve, and participation post-16 flourished. However, decreasing funding meant local authority support became focused on those schools and departments perceived to be most in need, so the department at Greenways was increasingly left to its own resources for motivation and development, within the broad 'learning culture' of the school.

Most department teaching took place in four mathematics rooms close to the department office, though Dan chose to be based in the one outlying mathematics room: Nigel and others made regular efforts to visit and engage Dan in classroom-focused discussion. Other teachers expected to be in and out of one another's classrooms and to share particular classroom successes and challenges through the day. They routinely talked about other possibilities in their teaching, and were in the habit of seeking and using research to support their debate, particularly in department meetings, which always had a 'teaching and learning' slot, often research-informed. All students were invited to evaluate their mathematics teaching and learning each

term, and this fed into planning at all levels, together with (formal and informal) conversations with students. The department thus exhibited 'critical professionalism', in Watson and de Geest's (2010) terms.

They chose to set for mathematics from year 8 onwards, at first loosely and from year 10 in 'deep' but overlapping sets: there was planned continuity of teachers over a key stage, but set placement was fluid and significant numbers of students changed sets every year. All teachers taught the range of year groups and mathematics appropriate to their subject knowledge, so that in the second year of the new GCSE, almost all were teaching two contrasting GCSE groups. Teaching Assistant support was carefully targeted at perceived greatest needs, with creative placement of students where support was tied, and lower sets were smaller: student interviews, which were part of the department culture, showed that the opportunities afforded by setting, and its flexibility, were positively viewed by students, with little evidence of the pressure on top sets and 'sink set', pedestrian mentality of lower sets evidenced elsewhere (e.g. Boaler (1996)). All students participated in a range of mathematics enrichment activities, and lunchtime mathematics clubs and workshops were well-attended, with students additionally feeling confident to ask for support whenever teachers were in the office, corridors or free in classrooms. In department interviews students from a range of year groups and sets cited mathematics as their favourite subject.

Department actions therefore suggest they perceived themselves as comprising a learning community, and students as individuals with dynamic and varied learning needs, and with well-developed critical abilities which could be harnessed to support development of learning.

4.2 The department/policy interface

A modular, 'graduated' GCSE introduced as a short-term catalyst for raising expectations had proved very successful in doing that, structuring to destabilise existing practice and expectations. It was not available for the new GCSE, and in any case the department by early 2010 felt it was leading to too much fragmentation in learning. From January 2010, department minutes evidence discussion about the purposes, affordances and support materials for the new GCSE, and how those related to the department's philosophy, including their desire to 'take more risks'. They engaged with a range of emerging curriculum-related documents, and both within and beyond department meetings had sustained and lively discussions about the nature of 'functional maths' and related pedagogies, how different aspects of the new curriculum were to be interpreted, and

how they might carry through 'link-making' principles from Key Stage 3. This all suggests a more principled approach than that adopted by many centres piloting the 2010 GCSE, who

> 'often (saw)… the pilots as opportunities to get more 'bites at the cherry' rather than rethinking the curriculum and pedagogic experiences of their learners' (Noyes et al. 2011, 17)

The department adopted a development centred on 'rich tasks' as in Piggott (2009). They began to write Schemes of Work where areas of linked curriculum content are broached from several complementary directions that include at least one problem-solving context, reflecting their expressed beliefs about the nature of deep mathematics learning requiring multiple embodiments, and with their reading of Bryant, Nunes, and Watson (2009). Their approach was a social-constructivist one, including signposted opportunities for groupwork and key questions to expose and challenge thinking. In developing this, they privileged emerging Awarding Body materials, including GCSE specifications, over the underlying National Curriculum documents. Noyes et al. (2011) suggest this is typical, and symptomatic of a performativity culture, though discussion within the department suggests rather that they found Awarding Body materials clearer in intent, overlaying their own underlying curriculum philosophy.

They analysed principal changes as the incorporation of more 'functional' mathematics, and the embedding of more unstructured, multi-stage problems drawing on several areas of mathematics. These aligned well with the intentions stated on the QCDA website (no longer available), though were acknowledged to imply pedagogical challenges. The Scheme of Work (extract in Appendix 14) comprised units taking 2-4 weeks, each focused around 'key ideas' within a theme, and written by a small group of teachers in targeted good quality time. Each unit was written at four permeable levels, so that for example all of year 10 would be working on 'Homes and Houses' at any one time. Hodgen and Askew (2007) suggests this approach to development may be particularly supportive of a beliefs-practice consistency. It is, however, very demanding on time, so was completed in stages and to a variety of depths during the first cycle, depending on time available or negotiable. Further, it suffered from a lack of 'buy-in' by Christmas 2010, given the demands it made on pedagogy and the fact that not all teachers were involved in each unit of writing. This was proactively resolved by whole-department work, resulting in little change to documentation but substantial increase in teacher confidence. As time went on it became apparent that specimen assessment materials did not fully represent the new curriculum; the department nevertheless decided the changes they were trying to make were 'in principle' and would include, but not be restricted to, supporting students in being able to address new assessments confidently.

Half-termly formal assessments were used to track student progress, and were the cause of some frustration in that initially they failed to reflect the priorities identified by the department, measuring largely knowledge and technique. Over time, teachers came to appreciate just how hard it is to set really probing questions that also tested a range of curriculum areas in an hour:

> 'It's easier said than done: we've spent hours on it, but it's still not looking how we want it to be. We *can* do it, but we're not there yet: it's very hard to get it accessible but so that they can all show what they can do, with just the four versions and wanting to assess process as well as knowledge and skill.' *Nigel, interview 3*

However, they did eventually come to combine developed written assessments with attempted appraisal of a variety of valued mathematical activity so that the range of espoused learning outcomes was over time reflected in formal assessment of some kind.

Further iterations were found to be necessary for some units, especially where parts of the curriculum had been 'shoe-horned' into place, where different student groups needed significantly different amounts of time to achieve appropriate confidence (for example, with formal algebra content), or where formal assessment exposed previously unidentified need. Over time, then, for some sets the Scheme of Work became an initial guide only, with significant deviations tolerated. This clearly made substantial demands on the subject, curriculum and pedagogical knowledge of individual teachers (Appendix 10), but enabled an application tailored to groups of students and, in some cases, to teacher preferences; on many occasions it appeared to catalyse growth in that knowledge, often developed through informal teacher-teacher reflections. Deviations from plans were documented with varying granularity, so that for some teachers, a second enactment was also very demanding in terms of bespoke detail, whereas for others, the Scheme of Work by then was a substantial support for planning.

Interviews and department talk show a big threat to this attempt at principled change was clearly GCSE outcomes, and as first GCSE examinations approached not only did teachers become aware of shortcomings of the new Scheme of Work in terms of curriculum coverage at an appropriate level, but some, despite careful monitoring of student achievement throughout, became less 'risk-taking' in their enaction: GCSE results in mathematics are high-stakes for students, but also for individual teachers, departments and schools. Nigel drew back from a lead role in developing schemes of work:

> 'I do wonder if we've gone too far too fast, and we're going to see it reflected in results – perhaps we ought to be a little less ambitious' *informal conversation, March 2012*

Both Gillian and Carol, though, argued for persistence, pointing out that not only were student assessments aligned with targeted outcomes, but that some colleagues were less ambitious in

their interpretation of schemes of work than others, so diluting espoused approaches in department documentation would mean very little change experienced by some students.

There was also an awareness that ambitious pedagogy was certainly not demanded by formal assessment mechanisms, and it was Carol who was most persistent, and successful, in both arguing for unadulterated aspiration in pedagogy and proactive in building up colleagues' belief that they could, in her words (Spring 2012, informal talk) 'have their cake and eat it', that is, teach in way they thought were principled without significant threat to GCSE outcomes. These aspects are explored further below. However, in the event results continued to rise, or at least not fall, at all levels and the department expressed a sense of vindication, clearly buoyed by student final grades and the results of a survey of the outgoing year 11 (Appendix 12). At the beginning of the third GCSE cohort, they largely showed a renewed commitment to the principles espoused initially, as reflected in the final interviews and described below, as in Hunter (2010) and Noyes et al. (2011) in that GCSE grades do matter – to students, but also to teachers if they want to continue teaching in a way they value.

It is clear that this department forms a Professional Learning Community (PLC) in Hord's (1997) terms, with a dominant relational (Skemp 1976) foundation to their scheme of work, employing a connectionist view of teaching as described by Askew et al. (1997), and social constructivist theory approaches to learning: I shall explore below the extent to which these reflected beliefs were held at an individual teacher level, and whether they support a construct of 'department beliefs'.

4.3 Summary characteristics of individual teachers

Exposed characteristics of individual teachers are described in depth in Appendix 10. In summary, Nigel, although inexperienced, adopted a confident role as narrator and transactor: as a young and ambitious teacher he led from the front. His subject content knowledge was adequate for most purposes, and his pedagogical knowledge developed rapidly: his classroom was positive, collegial and 'can-do' in ethos, with very constructive relationships. He perceived himself to be 'whizzy' and was keen to establish a distinctive enactment, believing both he and the department could be successful in their ambitions, and was solution-focused in achieving that.

Carol had initially only taught for one year, having previously been a research chemist and accountant. She had been unusually reflective as an NQT and was rapidly building up very deep pedagogical knowledge as well as knowledge of her students. Her classroom was usually calm,

purposeful, secure and challenging, and her students in interviews regularly voiced their confidence in her, and enjoyment and sense of achievement in her lessons. She appeared deeply committed to the proposed enaction, an enthusiast and translator, and steadfastly worked to overcome obstacles as they appeared.

Dan was much more experienced than other Greenways participants, very confident about his subject knowledge and regarded in student interviews as a 'safe' teacher. He played very little part in department discussions. His talk was, nevertheless, supportive of proposals. However, observation of his classroom showed enaction inconsistent with his rhetoric, with challenge de-problematised, 'links' superficial, and 'creativity' for the teacher expert to demonstrate, rather than students engage with: in practice he marginalised himself from colleagues, as discussed in Golding (2011).

As described in chapter 3, he was replaced as a participant by Gillian. She brought a Business background and KS2/3 training three years previously, and was very aware she lacked the breadth of specialist knowledge of some others, though she had a deep pedagogical knowledge of the curriculum to GCSE, and of her students. Highly reflective, she adopted roles of enthusiast and potential entrepreneur, and her classroom similarly oozed enthusiasm, curiosity and a 'can-do' outlook: students habitually enjoyed and were challenged by her lessons.

4.4 Characteristics of the department

Other members of the department are summarized in Appendix 16, in terms of the lenses employed. Nigel, Gillian and Carol between them accounted for most of the active leadership in the department. They complemented one another, though each was solution-focussed ('what we can't find, we write' *Nigel, interview 2),* clearly believing it was both possible and desirable to enact this GCSE in a manner aligned with their fundamental beliefs about learning mathematics: a clearly 'writerly' interpretation of policy affordances in Barthes' (1974) language. At times, each of them functioned as a critic of their current translation of the policy, though not in Ball et al's (2012) terms: I discuss this further in chapter 7.

In terms of listening and interpersonal professional support, Gillian's leadership complemented Nigel's; both she and Carol showed more sophisticated use of professional language, depth of collaboration and awareness of others' needs for confidence and emotional or practical support. They brought more deeply reflective approaches while Nigel concentrated on organizing for implementation and transacting support for senior leadership and the local

authority. Carol's persistence in effectively spearheading creation of a scheme of work appeared sustained by Gillian and Nigel's confidence, but it was largely her steadfastness that maintained equilibrium in the approach to first examinations, acting as an enabling constraint. Critique of curriculum or pedagogical ideas was common in a department apparently committed to deep engagement with mathematical and pedagogical ideas, but it was typically given and received in a spirit of improving outcomes of whatever activity was under discussion.

Is there, then, a meaningful way in which the department could be considered to have group beliefs or knowledge, or to act as 'a policy player'? In chapter 8 I argue so, and discuss just what it might mean to describe a group of people as exhibiting a 'psychological' characteristic or single 'role'. Appendix 16 shows how the rest of the department were at least passively supportive of their approach; they all at least in talk espoused a problem-solving, connectionist orientation (even though they attached a variety of meanings to 'problem solving'), and less ambitious enactions were tolerated: particularities appeared very much to emerge, although the scheme of work, exemplified in Appendix 14, shows wide and deep constraints on espoused enaction. In many ways they appeared to have adopted the new GCSE as 'autonomous change', showing many of the features of 'critical professionalism' identified by Watson and de Geest (2010) and consistent with Spillane's (1999) necessary conditions for deep change.

Within the department at Greenways, Dan was in a position of self-imposed marginalization, and Sylvia and Gerry had limited capacity for e.g. 'translation' work, having substantial other roles within school. These two could be regarded as to some extent institutionally marginalized (Watson and de Geest 2010). However, all three appeared tolerated by the critical mass of positively-disposed teachers in the department, who between them seemed to have considerable capacity to absorb internal perturbances and challenges to their espoused enaction, consistent with a leadership distributed at both school and department levels . The department overall can be conceived of as adopting a role of both enthusiast and narrator in terms of principled development at both school and Local Authority levels, with Nigel leading, and influential in, both school-level and local authority Head of Department sessions discussing emergent approaches to GCSE teaching and learning. Of course, enaction varied across different teachers, but Nigel adopted a positive and constructive approach to this, with the scheme of work acting as an enabling constraint:

> 'I think there's a mix (*of implementation*): as ever there will be – so we still need to work on it: we're stronger if we're more consistent. But I think probably the pressures of teaching mean that people don't use this style as often as they might – I think they probably revert to non-problem solving methods, if you like, more textbook methods, more often than I'd like. Often, just because they haven't had time or capacity to prepare in a much more demanding way – or it's not ready (*prepared in the cabinet*). You can't get away with superficial preparation -

> which is really demanding for experienced teachers, but rewarding too. We'll never do it all the same, but that's not necessary. Students benefit from some variety of approaches and thinking, so long as there's core consistency – and so do we, that's how we develop' *Nigel Interview 5*

Emerging critical roles for both affect and leadership, and of their good capacity for (often shared) reflection building on classroom 'noticing' skills (Mason 2002), are discussed further in chapter 6. They exhibited initial adequate subject knowledge and subject pedagogical knowledge, freely and frequently shared within the department, and this over time appeared to increase in both depth and breadth, supported by increasingly sophisticated language as shown in chapter 6, as they progressed with the sort of teaching they wanted to develop. They largely employed a positive attitude to risk and challenge, as well as a sizeable store of confidence.

Throughout, they were supported by school-level priorities, with directed 'trio' professional development time harnessed for expansion of the scheme of work, and later, a school development priority of 'deep learning' appropriated to negotiate further good quality department time. Overall, they appeared a professional community well-placed to negotiate deep change and, at least on this timescale, moderately successful in achieving that. Except in times of stress, they largely seemed to function as a complex departmental system, with adaptive outcomes emergent in both their construction of the scheme of work and in their classroom enaction of it. Nigel allowed enaction at an individual level, distributing control as above, and showing a confidence in individual teachers' breadth and depth of professional knowledge that I would interpret as sufficient redundancy and diversity of knowledge for adaptive enaction to emerge. Here, I would identify 'neighbour interactions' of ideas with individual reflection on practice, and the scheme of work, with associated suggested resources, with one 'enabling constraint'.

At a department level, their culture of valuing deep communication about mathematics and pedagogy provided neighbour interactions sufficiently well-supported by redundancy of common language, understandings and values, together with diversity of approaches to detail that often manifested itself as constructive critique of either emerging scheme of work or reports of classroom plans or enaction. I have shown a variety of leaders 'seeded' development with 'enabling constraints' as they progressed, and that distribution of leadership appeared critical to their success. At times of stress, the Greenways department appeared rather to resemble an activity system, with overt structuring sometimes by Nigel, or sometimes by Gillian or Carol, to re-stabilise in favour of rules and division of labour supporting their espoused enactment.

I now consider the parallel enaction and 'policy players' at High Wood; further theoretical-lens comparisons of department-level enactions are made in Section 8.2.

CHAPTER 5: HIGH WOOD

5.1: Background of the department

The High Wood Mathematics department consisted of six teachers including an Assistant Headteacher (0.3). Appendix 16 summarises their backgrounds, but compared with the Greenways department, they were highly experienced, the least so being Heather, with seventeen years of teaching behind her, though new to the school in September 2009. Kathy, as Head of Department, had been in post twelve years. Her Second in Department, Norman, was the teacher with the least mathematics in his background, coming from a Business Studies degree, but he had followed some undergraduate mathematics courses and would be classified by the TDLA as a mathematics specialist: like Greenways, this was a department unusually well-endowed with specialist subject knowledge. Previous reciprocal observations had shown them also with deep pedagogical knowledge.

High Wood mathematics teaching took place almost exclusively in a corridor of five mathematics rooms and a department office. The department had previously taught GCSE in a 'modular' structure: typically, about a quarter of students retook at least one module to boost their grades. Support for progress was made through daily lunchtime 'drop-in' sessions usually very well-attended, and supported by at least two mathematics teachers. The five-form intake was split into sets at Christmas of year 7, with movement between sets commonplace as students went up the school. In years 10 and 11, 'blocking' of sets (a pair and a triple) meant that there was significant overlap in attainment between sets 3 and 4, by the time students sat final examinations. Attainment at GCSE was typically significantly above that expected from intake data, although in the summer prior to their involvement in the study, results had dipped to be in line with national value-added expectations, which occasioned my intervention. Post-16 provision was shared with the nearest other secondary school, some seven miles away. They had a well-qualified and experienced Teaching Assistant based fulltime in the department, and she frequently produced high quality resources, took initiative in interventions as the need arose, and actively supported students throughout the day, including at lunchtimes.

In terms of professional learning, the department initially engaged frequently in fairly deep classroom-based discussion. Department meetings always featured a 'teaching and learning' slot which Kathy described *(Interview 1/2)* as 'never long enough given other pressures on time'. In recent years, High Wood mathematics teachers had worked with the Greenways department to

develop good implementation and embedding of Key Stage 3 innovative problem-solving materials (Bowland 2010), on the CUREE Challenge project (Curee/QCDA 2009), and on trialling some cross-phase materials developed by Greenways with their Primary feeder schools. Kathy *(Interview 1/2)* cited these experiences as 'highly influential in moving us on, really challenging - it's so easy to get complacent'. My initial perceptions of the department were of one functioning as reasonably adaptive, with Kathy seeding to allow individual level emergence of practice within a loose 'enabling constraint' of a scheme of work. Historical joint work between the two departments had suggested High Wood had a generous diversity and redundancy of professional knowledge of all kinds, and sufficient 'tools' and neighbour interactions to support fairly expansive possibilities – as they had appeared to do at Key Stage 3.

The Headteacher largely left an apparently successful department to pursue its own priorities. Kathy fed into plans for use of the mandatory whole-school professional development days, but compared with Greenways, these, and attendance at external courses, appeared less tightly driven by school (and department, and individual) development plans – a school with apparently more complex than activity-theoretic system characteristics. Following the Summer 2011 dip in anticipated GCSE results, the senior management team conducted in October 2011 a small-scale 'department review' which identified as areas for development use of groupwork, assessment for learning, use of ICT, checking for prior learning, and activity and engagement. The Headteacher subsequently negotiated my AST support in evaluating the department's tracking of students, their interventions and their teaching, and I was redirected to work in High Wood one day a fortnight. This could be construed as him taking a proactive role in restabilising towards school goals, using identified 'rules' to do so.

Although I was familiar with all teachers in the department as colleagues in development projects, and with Kathy as a former fellow Head of Department, my role during the course of the study was therefore more that of a 'critical friend', and this might have affected the authenticity of some interview data in particular, as discussed in chapter 3. The intervention did mean, though, that I spent more time in the department than I otherwise would have done, and that I had access to intervention, meetings and other data. There were inevitable associated tensions between my two roles: these were largely addressed by overt labelling of 'researcher slots' to myself and to participants, outside allocated AST time. I made every effort to privilege the developmental needs of the department at all other times: sometimes these would also become apparent during fieldwork, and were then largely dealt with by noting them for future action.

In many ways the issues identified by the 'review', and the dip in results, appeared on investigation to be exaggerated: scrutiny of the data with Kathy and Norman exposed their deep

understanding of raw data, careful tracking of individuals, appropriate interventions in response to threats to progress, and very understandable idiosyncrasies in final outcomes. Observations typically showed adequate or good lessons in the areas identified by the 'review', although teachers in the department showed little appetite for risk-taking to the extent regularly seen in Greenways lessons, or indeed previously at High Wood. However, one clear result of the review was that they claimed loss of trust by senior management:

> 'He's always trusted me - and us - to be doing what's best for the kids, and to know what that is. It's most uncomfortable, having lost that' *(Kathy, interview 1/2),* and
>
> 'I'm very aware of them valuing activity - and that's something I share - yet perversely, I feel I need to play safe, and get the result come what may, or we'll be even less respected as a department' *Norman, interview 1/2.*

5.2: The department/policy interface

The department appeared in meetings and informal talk keen to embrace the principles of the new GCSE. In summer 2011 they, like Greenways, had completed a Key Stage 3 (11-14) rewrite to accommodate new curriculum demands and incorporate significant aspects of the above projects, as well as teaching of the first year of the new GCSE (changes were chronologically misaligned by a year). Norman *(Interview 1/2)* described the joint demands as

> 'crazy: it's as if someone's sitting there in an office trying to make your life difficult. There's no way you can find the quality time needed to rethink year 9 and rethink year 10 properly, at the same time.'

Discussion with Kathy *(Interview 1)* suggested this was a major factor in the department deciding to make limited change to their GCSE programme:

> 'We decided we could keep most of the content the same, then add in the problem solving and the functional maths later, so we could continue to use the same resources and build on them. We know what's working for our students: with the year 9 rewrite as well we simply don't have the capacity to have a complete rethink, so they'll do better if we build on what's already working well.'

During Autumn 2011 they made significant progress in adding to existing Schemes of Work, but interviews showed that they felt constrained in what they could attempt, in part because of the risk to results:

> 'I'd really like to be more adventurous, but I daren't risk their results, especially after last year' *Heather, interview 1/2;*

> ‘Steady, is what’s needed: we can’t afford to risk results, and we’re making good progress in opening up what we’re expecting of them’ *(Kathy, interview 1/2).*

However, In December 2011 it was announced that all GCSE modular structures would be replaced by linear (terminal assessment only) structures from Summer 2014, so that High Wood were forced to rewrite Schemes of Work for first teaching from September 2012, after just one cycle of the new GCSE had been completed and well before completion of their enriched Scheme of Work for that. It was clear from interviews in Spring 2012, as well as from informal interactions, that High Wood teachers felt overwhelmed by these new demands:

> ‘we’re working flat out with students at the minute, there’s nothing spare to dream up new Schemes of Work, yet it’s like a black cloud hanging over you, and it’s a real disincentive to going further with our existing Scheme of Work because we’re just going to have to start again’ *Norman, interview 3.*

Kathy was less outspoken, but still clearly challenged:

> ‘I’m not quite sure how we’re going to do it: at the minute we’ve got to prioritise the students in front of us, the year 10 and the year 11s – they don’t go away just because someone’s decided we need yet another change, and the results this year are going to be critical, after last year’ *interview 3.*

In the event, I worked with them in late summer 2012 to begin a basic linear Scheme of Work, but with Kathy choosing to prioritise a wide base of teacher support over detailed progress, they began first enactment with little different in approach from pre-2010 documents. Final interviews showed them unanimous in their espoused intention to build in problem-solving and more functional teaching and learning. Despite ‘in principle’ commitment to these changes, as shown in the next section, external assessments continued throughout to make limited demands on these newly-emphasised part of the curriculum, and that clearly framed High Wood’s priorities:

> ‘We’re still waiting to see all that rhetoric turned into questions: I’m quite sure that in principle we should be basing everything around problem solving and being more student-centred, letting that drive the whole, but that is so so hard to do, and at the minute they (the department) just want to get on and teach these students and make sure they get the results’ *Kathy, interview 5.*

Again, we see the framing of ideas (and (lack of) action) by high-stakes assessments.

Overall, then, the department felt somewhat oppressed by multiple successive and misaligned policy changes, supportive of the basis of most of these in theory, but challenged to operationalize them within the timescales given and with limited incentive from (school and national) external drivers, to do so. This response is explored further in chapter 6.

Because of my development work with the High Wood department, I had access to specific information about beliefs and priorities from all teachers, not just study participants, in particular from a 'foundations-setting' meeting (Appendix 9). Additionally, much of my development work with this department was focused development of teaching at GCSE and writing of structural support for that, so I was privy to a range of related beliefs, attitudes and knowledge in both formal and informal situations, as well as to student interview data. Use of such evidence was agreed by the Headteacher and teachers concerned, and participant validation was employed, as described in chapter 3.

As well as Kathy as Head of Department, I approached Norman (incidentally second in department) and Heather as participants, since they had quite different backgrounds and teaching approaches from Kathy and from one another, so forming a 'telling' (Mitchell 1984) sample. All three in responding referred to participation in the research supporting 'learning from' or 'reflecting on' experience.

5.3 Summary characteristics of individual teachers

(detailed in Appendix 11)

Kathy was historically a narrator/translator of pedagogical initiatives, but in Autumn 2011 was coping with both challenges to the department's perceived 'success' as above, and considerable personal issues which persisted through the rest of the study. She subsequently became more averse to risk-taking, and her classroom often lacked the habitual sparkle and challenge I had previously seen: her knowledge – of mathematics, pedagogy and students – remained intact, but she drew on it less for in-depth informal discussion, both in class and with colleagues, and additionally began to withdraw from much of the leadership role she had historically taken.

Norman, although keen not to label himself a mathematician, had very adequate subject and pedagogical knowledge for teaching GCSE; KS4 classes were typically very secure, supportive yet challenging, and much more didactic than his younger classes. He moved from participating apparently enthusiastically in department pedagogical discussion to overt frustration and impatience with the lack of leadership and external constrictions, resulting eventually in him completing the 'good enough' linear scheme of work little changed in approach from their historic GCSE documents. He became a translator/critic of the new GCSE, turning over time into what I term (chapter 7) a 'survivor'.

Heather joined the department in 2009, and clearly appreciated the autonomy she was given to experiment and discuss. She was very keen to embrace the principles of the new GCSE (an 'enthusiast') and had a number of specific ideas for doing so, but with a young family, limited extra time to offer. Her subject and pedagogical knowledge appeared very adequate to support a move to enaction which would then be more consistent with what she was doing at KS3, but tensions between Kathy and Norman about leadership of change seemed rapidly to sap her confidence to offer, and pursue, ideas, and in common with the rest of the department, she seemed to retreat into her own classroom over 2011-12.

5.4: Characteristics of the department

The department's efforts appeared challenged by a perceived loss of trust from senior management, further structural changes nationally, and a loss of leadership capacity arising from Kathy's personal issues, although they had initially appeared well-placed in terms of knowledge, skills and beliefs to make a principled enactment. Adam and James, both very experienced, were initially generous with both time and ideas, but as time went on, were both very critical of further imposed changes, appeared to 'retreat' on a department level, and spent less time in the shared office, also offering less in meetings, although student interviews evidenced both making some classroom efforts towards espoused change.

The combination of these responses meant that the department was sharing less, and corporate classroom-based reflection was marginalised in favour of organizational interactions; in Spillane's (1999) terms the 'zone of enactment' was impoverished.

High Wood therefore adopted a largely 'readerly' rather than 'writerly' enaction, in Barthes' (1974) terms, more passive and less risk-taking than Greenways' from the outset. As policy players, roles appeared to change over the course of the study, with initial sufficiency of narration/translation/enthusiasm/constructive criticism insufficiently robust or internally consistent to withstand the challenges to them, and 'survivor' roles consequently being adopted, with some members of the department choosing effective self-marginalisation. I discuss such roles further in chapter 7. They were not Ball et al's (2011b) inexperienced 'receivers', with insufficient resource to choose a more proactive role, and each of them at different times provided a much more constructive criticism of their planned enaction than that suggested by Ball et al's (2012) 'critics'. At the same time, reflective and 'noticing' characteristics evidenced initially were not maintained in the same depth: as a department the quality and quantity of classroom-focused interaction dropped (so that shared language had limited opportunity to develop

further), and in Kathy's case this was also true within her classroom: as Flores and Day (2006) show, teacher enacted capacities are not always maintained uniformly over time or circumstance.

The data shows a dissipation of the characteristics necessary for a complexity-like emergence of outcomes aligned with principled outcome goals, apparently arising from lack of leadership to seed appropriate 'attractors'; limited directly supporting resources and early GCSE papers which failed to provide sufficient 'enabling constraint' added to this. Further, repeated structural changes, and senior leadership actions, appeared to sap perceptions of decentralised control: what emerged was a learning to make minimal change in practice. Similarly, as the department in some ways began to operate in a more activity-theoretic way, lack of leadership to structure for principled change, accompanied by a perception of both poorly aligned 'rules' (GCSE papers) and limited availability of appropriate tools as shown in Appendix 20, meant the department restabilised with different, less ambitious, goals.

From situations of apparently similar potential, then, these two departments diverged significantly over the first two years of their enactment of the new GCSE, and I have identified some specific influences that might account for this at least in part. However, repeated revisiting of fieldwork data also suggested differential characteristics beyond the initial focus, some of which appeared to be interrelated and which the literature suggests might have impinged on enaction: I now turn my attention to several such.

CHAPTER 6: EMERGENT DIFFERENTIAL CHARACTERISTICS

In this chapter I compare the data emerging from the two departments and identify differential characteristics. Where those differ from the original focus of knowledge and beliefs, I relate them to the literature. I show they include both the cognitive (a reflective palette) and the affective: a 'virtuous network of positive affect', where following Hannula (2012, 138) I consider affect (often poorly, or locally, defined) to be the other than purely cognitive elements of human thought – emotions, beliefs, attitudes, motivation, values, moods, norms, feelings and goals. Much work on e.g. motivation, though, includes cognitive aspects, and core texts on affect, e.g. McLeod (1992), acknowledge a significant role for social considerations. In the same way as there appears to be a reciprocal relationship between mathematics achievement and affect, I postulate from the results of my study that there is a reciprocal relationship between teacher effectiveness and positive affect, which I define. In chapter 8 I explore further differential social characteristics, considering in particular the roles of distributed leadership and the nature of the professional community developed.

I have described department enaction diverging significantly, and (relatively stable and similar) results from first cohorts confirmed each department in the different pathways they were following. Profiles of knowledge and espoused beliefs initially appeared supportive though High Wood demonstrated a greater store of the range of subject-related knowledge in talk. These did not therefore explain differential enactments observed: I had expected greater pedagogic knowledge surfacing at High Wood, given their experience and historical differences exposed in joint work, but could not identify it, and as time went on, Greenways, but not High Wood, clearly grew in both the range of subject pedagogical knowledge as described in Ball, Thames, and Phelps (2008), and in the depth of range of classroom manifestations of knowledge as described in Rowland, Huckstep, and Thwaites (2005).

Beliefs both historically and initially espoused, appeared very similar, and as time went on it became apparent the *hierarchy* of beliefs in both departments was headed by the necessity to produce good GCSE results. However, Greenways overall believed that was compatible, and achievable, with development of a principled enactment despite the limited validity of specimen assessments whereas High Wood privileged maintenance of results over the challenges of attempting both. Borko and Koellner (2008) suggest mathematical knowledge is deepened through planning and discussing mathematics lessons, and also through interaction with colleagues in parallel with implementing new teaching practices – both more consistently evident

at Greenways even from the start, though High Wood might have felt that they had less need. It is clear from the scheme of work extracts (Appendices 19, 20) that during development Greenways engaged with the curriculum in greater depth, linked with a greater change to practice, as in e.g. Cohen and Hill's (2000) study. However, it should be noted that such studies are largely based on teacher self-report, whose limitations are clearly demonstrated e.g. in Spillane (2004).

As the GCSE progressed – and stresses showed in both departments – other apparently influential differential characteristics emerged from repeated visits to the data, and supported new coding structures as in Appendix 9. These included capacities for a reflection-linked collection of attributes (termed here a 'reflective palette'), a group of positive affect characteristics whose presence appeared to be mutually reinforcing, and the nature of the department's group functioning. Apart from the last, these varied at individual level, but there also emerged, to a greater or lesser extent, a dominant 'department-level characteristic' in each. I shall consider the evidence for them in turn, relating that to the literature, and discuss why each might impact on enaction. In both departments, these generally appeared to 'emerge' iteratively as facets of response to unfolding circumstances.

6.1 A reflective palette

For some teachers, an inclination and capacity for deep reflection appeared to support progress towards a demanding and principled enactment:

> 'I've become much more aware of the subtleties of their algebraic understanding – or not! - in part I think because this sort of work exposes it so much more – they're not just following a procedure, they're having to be so much proactive in selecting not only tools but models and approaches….I'm doing so much more listening to their thinking... so I learn much more not only about their understanding but their skills for learning – their metacognition, and their resilience for learning, and all those supporting characteristics. So yes, it's very exciting professionally: in this game you don't stand still do you – you either move forward or you wither.' *Gillian, Greenways, interview 4.*

Appendix 16 tabulates exposed capacities by teacher, including for reflection: at Greenways, a differential 'reflective palette' of reflection, noticing/attention, listening, and developing language for expressing the results of these, appeared mutually supportive, and is discussed below. In complexity terms I consider reflective attributes to contribute to 'neighbour interactions' of ideas, whether at an individual or group level; in activity-theoretic terms they act as tools that mediate solutions.

6.1.1 Reflective practice

'Reflection' has a variety of meanings and depths in the literature, but I use it here to mean the conscious critical engagement of an individual with a cognitive item in order to analyse, make links with other knowledge or experience, and possibly reconstruct. The ensuing response is entailed in my definition, and implies an ability to analyse and address professional problems, and to construct professional knowledge before, during or after their enaction - reflection for, in and on action, respectively. The seminal work usually quoted is Schon (1983), although it could be argued that Schon's use is largely one of metacognition. Both Schon (op cit) and Mason and Spence (1999) identify the centrality of focused reflection for teacher professional development, though since reflection might not result in changed action it is hard to observe even indirectly. Further, legislation for deep reflection is elusive: Hodgen and Johnson (2004), for example, found that reflective engagement was unusual even when working in an intensely supportive 'zone of enactment' (Spillane 1999), though they note that having a leadership as well as teaching role helped teachers to achieve the necessary distance from the object(s) of reflection. Lerman (2001) points out that the mechanism for the development of deep reflection is not apparent, but argues that it is necessarily language-dependent, and at Greenways data showed a progression in rigour and creation of language to describe their actions, as described below.

In a relatively inexperienced department progression over time in the exposed depth of their reflection is not surprising, provided they value it, but the challenges of the chosen enactment appear to have been a catalyst for fairly deep, teaching-and-learning-focused reflection. Additionally, the department were in the habit of sharing successes, failures, thoughts and ideas throughout the day, as well as monitoring, and valuing, their own understandings:

> 'I suppose that's how we learn as teachers, not just how the students learn. It's like the Kagan structures – they give you a context which makes that learning step easy, they enhance your ZPD. Yes, that's an interesting link…why didn't I make that before? Your interviews are so so good for me' *Carol, Greenways, interview 3.*

This readiness to engage in dialogue about teaching and learning was not confined to study participants: Greenways' James began the study with two years' experience and formal and informal meetings showed a limited confidence to share his thoughts with 'the experts' as he called most of the department, but a year in, he wrote

> 'I used a similar approach with year 10 circle theorem proof that we (you) use for the A Level AP and GP revision sessions. I had prepared the proof which I sliced up and they worked out what order the steps needed to be. It was very clear to me that the deep learning was not from the sorting which can be done in quite a superficial way but from the "can you explain what it means in your own words"…

> From discussions with Carol, I think that we need to expose them to reasonably formal proof before A Level so that they are not uneasy with it….because of the precision of the language and notation expected.' *James, Greenways, unsolicited personal email.*

Here, it is not just the content or communication that is significant, though it demonstrates clearly his reflection-on-action in Schon's (1983) terms: he reflected not only on the students' learning and how his actions related to that, but also on his own learning. It is striking that no later interactions with any of the High Wood teachers showed autonomous teaching and learning reflection at this sort of depth, though all teachers had historically participated in joint comparatively deep reflection with Greenways. It is not clear whether this is because that capacity was dormant, or out-privileged by other, perhaps performativity, considerations.

6.1.2 Development of shared language for group reflection

The interviews quoted above appropriate quite technical and specific language with which to talk about teachers' thinking: a social perspective would suggest that the environment at Greenways supporting this might have been *creating* that thinking rather than merely *reflecting* it (Lave and Wenger 1991) and certainly Carol's comment suggests she perceived the interview to be at least catalytic of new articulations. Nigel's 'rich but skills-based KS3, but rich-with-skills-in KS4' *(Interview 4)* is an example of this. However, language development was not confined to interviews: Greenways analysis of performance data from the second term of enaction showed algebra an area needing development, and teachers combined that knowledge with in-class 'noticing' to talk about 'developing a greater fluency in accessing algebra as a tool' and 'developing a natural algebraic thinking' as desirable outcomes, initially in a department meeting, but then in subsequent informal encounters, and identified opportunities for these to happen. This language development is similar to that identified by Watson and de Geest (2014) as their departments 'shifted' from talking about tasks to talking about learning. In contrast, teachers at High Wood typically showed little additional social construction of language for thinking about teaching and learning after they joined the study, and the language they did use did not fully reflect the depth and richness of enaction initially espoused: predominant talk became administrative or organisational, and participants answered comparatively superficially when probed about such matters - it is not clear why.

However, in critical ways, Greenways teachers assumed common professional understandings which were not entirely shared among themselves, let alone with policymakers. A critical example is the use of 'problem solving', as discussed in chapter 3 – though the last round of interviews did show some move towards a more challenging and shared interpretation of that, and an

acknowledgement that while progress had been made, students still experienced limited opportunities for genuine deep problem solving. Other variations appeared in department meetings: early on, the department discussed ways of supporting the development of genuinely collaborative student work, and subtle, but quite important, differences in understanding of the teacher's role emerged. The critical issue, though, is that these differences were exposed in a highly interactive and reflective department, and there was a will to find at least a consistent set of understandings: if there is no opportunity made for principled discussion of teaching and learning, assumptions and misunderstandings remain and teachers don't 'grow' in Gillian's terms above.

6.1.3 The place of noticing and attention

'Noticing' and 'attention' are closely related, and theorised by Mason (2002) and Ainley and Luntley (2007) respectively. I adapt their definitions slightly to better relate to common teacher usage, using 'noticing' to mean 'developing sensitivities to and identifying noteworthy aspects of a classroom situation, and bringing a range of contextual and broader knowledge and connections to them in order to interpret them (implicit is the need for knowledge of which are the noteworthy aspects); 'paying attention to' is a conscious act of structuring one's mind and actions so as to enable potential noticing. Reflection depends on *noticing* the thoughts/actions/situations which are the object of reflection, on the motivation to engage in that reflection, and on having the knowledge tools to do so effectively. Previous combined work had suggested that initially, High Wood teachers had a greater store of tools, as well as capacity for noticing (perhaps arising in part from their greater experience), though the study showed them to have less motivation to use either; I adopt Davis' (1997) hierarchy of effectiveness in this area, as summarised in Appendix 16.

Appendix 16 shows depth of noticing skills correlated well with depth of reflection, as well as of pedagogic knowledge exhibited, and perhaps one might expect those to develop together in a virtuous circle: one can only reflect on what one has noticed, but having paid it attention, one is sensitized to related actions or issues. The objects of noticing varied, apparently linked with beliefs and priorities: for example, Carol particularly noticed gendered behaviours, Norman noticed individual levels of organization, Gillian the wider implications and responsibilities of teaching. Teachers varied in their perceptions of the affordances of new ways of working to support valued 'noticing' in the classroom: above, we see Gillian perceiving opportunities opened up as she was freed from micro-management, whereas Norman, in interview 4, claimed that the

unpredictability of more unstructured situations made it harder for him to notice students' thinking.

All participants were happy to talk about the challenges of noticing enough in the classroom to support the learning of students to the extent they would choose, but the depth of their communications, and their ambitions, varied: Norman appeared happy to accept he will only ever see the tip of the iceberg, but espoused a theory of learning where students largely conform to a 'National Curriculum' single ladder of attainment, so that he's looking for a limited range of indicators of learning or misconceptions at any one time; whereas all Greenways teachers except for Dan, (who claimed the demands of such teaching were unrealistic), claimed new possibilities for achievement – but also greater demands on knowing individual students and their learning (and by implication, on noticing indicators of those) in their new enaction.

Van Es and Sherin (2002), building on Mason (1998), show that experienced and effective teachers have a toolbox of active but tacit 'attentional' skills. Ainley and Luntley (2007) describe them as transferable skills for generating contextual knowledge, enabling experts to exhibit greater creativity and handling of novelty, and to embrace complexity: I suggest this is via reflection consequent on noticing. Dreyfus and Dreyfus (1986) claim that as expertise develops, attention can move from the pre-conceptual to the conceptual. Conceptual noticing seems a prerequisite for deep reflection, although they seem to conflate the capacity for conceptual noticing with its (external) articulation, as does Lerman (2001). Luntley (2009) synthesizes these positions to argue that teacher capacity for learning many aspects of professional practice is therefore a function of their capacity for attention: I suggest that is necessary but not sufficient. Gattegno (1987) goes further, suggesting 'awareness is all that is educable', where I interpret 'awareness' as capacity to notice. I would suggest that awareness *is* educable, but so too is reflectivity, that is, how one reconstructs and harnesses for use what one is aware of.

6.1.4 Listening

One evident facet of noticing, was that of 'listening', in a particular sense of sensitivity to what might underlie a question or a comment: both Carol and Gillian were observed 'digging deep' into what might appear small aspects of student comments or responses, with very illuminating results. Davis (1997), in one of the few longitudinal studies in this area, evidences a progression through what he terms 'evaluative' listening through the 'interpretive' to a 'hermeneutic' mode. She goes on to suggest this needs interested colleagues to disrupt what is assumed; time away from the classroom to think; and a shift from conceptualisation of teaching as discrete items for

mastery, to locations for exploration: these increasingly characterized Greenways rather than High Wood.

A capacity for noticing appeared to contribute to the embedding of Greenways' enaction by affirming teachers in their experiments: valued outcomes were emergent, and reflection allowed them to attribute those to specific aspects of teaching and learning. Noticing and reflecting, then, both generating and supported by reflective language, appeared symbiotic characteristics underlying principled enaction. Neither are they isolated as positive factors in enaction: Korthagen and Vasalos (2009) describe how, in studies of teachers who persist in reflective practice, this brings a host of benefits, including strong feelings of personal security and of self-efficacy in relation to professional actions; better relationships with both colleagues and students than their less reflective colleagues enjoyed; and a higher degree of job satisfaction, together with less likelihood of burnout. The virtuous circle engendered by Greenways' reflective palette therefore adds to findings in the literature. Why did this elude High Wood? There appeared to emerge a range of inhibiting affective characteristics which are discussed below.

6.2 A virtuous network of positive affect

As the study progressed, Greenways' more sophisticated pedagogical approaches and tools appeared sustained by access to a range of positive affective traits emerging from the data, including resilience, motivation primarily through mastery rather than performance goals, positive emotion, and confidence in relation to their attempted changes. Within a complex system these largely appeared to act as 'attractors', serving to maintain conditions necessary for expansive change; with an activity-theoretic lens their role again appeared to be one of maintenance – of the tensions necessary to support transformation. Indicative sensitisation to such traits is demonstrated in Appendix 5.

Variations between individuals and over time appeared to be compensated for by a social effect, as if these traits were distributed: a 'group affect', and that is explored further in chapter 8. Hannula (2012), unusually, embraces psychological, social and physiological aspects of affect in his proposed metatheory, but he does not fully explain what he means by e.g. socially-held beliefs; group affect occurs naturally, however, within a complexity framework. Below, I indicate of the ways in which such characteristics manifested themselves.

6.2.1 Resilience to contextual factors

Both departments were at times challenged to maintain the development trajectory they espoused. In Greenways' case this was particularly noticeable at Christmas 2010; in Summer 2011 when results from the previous cohort were exceptionally good; and again in the approach to first external assessments in Summer 2012, when the performativity agenda actively threatened adherence to principles. Nigel was usually proactive in addressing any threats, but on the last two occasions listed, he seemed particularly sensitive to accountability measures, and informal and formal conversations show it was Carol, with no official responsibility, who took leadership and persisted in quietly reminding the department of their stated beliefs, in each case then supported by Gillian. They were able to tolerate the self-isolation of Dan, and subsequently, his long-term absence, and after two years were affirmed in enaction by good GCSE results from the first cohort.

Resilience is this capacity to bounce back, to recover strengths and positive attitudes in the face of challenge or adversity (Henderson and Milstein 2002). Gu and Day (2007) show that is relative, dynamic and developmental, and supported by positive emotions, later (Gu and Day 2013) extending their definition to include persistence in the everyday challenges of teaching. Drawing on Fredrickson (2004), they argue that such positive emotions also broaden the scope of attention and cognition, enabling flexible and creative thinking: they cite evidence that participating in an effective community of practice can enhance that effect, and also that resilience is necessary to support a deep sense of vocation for teaching, and good self-efficacy, motivation or commitment – though sufficient pre-existing self-efficacy and motivation are also necessary for the establishment of resilience relative to a task (Henderson and Milstein 2002). Gu and Day (2007) show resilience can be undermined by tensions with teachers' moral purposes, as in for example excessive performativity demands, so is unstable and determined by interaction between environment and internal assets. Their work, within a framework of policy change, found that teachers' resilience was moderated by the stage in their career (in their terms Carol and even Nigel were early in their career to have developed strong resilience, and two High Wood teachers probably rather late), and the balance between their professional, situated and personal contexts, so that if these were in reasonable balance small fluctuations in intensity of demand could be tolerated, but if not, then fluctuations could trigger instabilities. Resilience in this context could then perhaps be conceptualised as the degree of stability of equilibrium in pursuit of professional goals.

In terms of threats to the stability of High Wood's initially espoused enaction, additional policy changes and adversity in Kathy's personal life fed into a situated context where teachers

already felt under pressure from management to demonstrate their effectiveness and two teachers were drawing to the end of their careers. As in Gu and Day's (2007) work, such issues appeared to feed into a negative spiral of minimal compliance. It is worth noting too, that even early on High Wood did not appear to have the distributed resilience clear at Greenways, so that with Kathy under particular pressure in the personal domain, alternative leadership did not emerge.

Greenways appeared a department increasingly tolerant of both risk and challenge, and talk exposed both: on a number of occasions someone would say 'that's a bit risky, isn't it?' or 'nothing like a bit of challenge', and colleagues would grin or make a joke in response: they seemed to be taking a pride in going out on a limb, whereas the talk at High Wood became not uniformly, but increasingly 'downtrodden'.

Within the departments, reflective talk in Greenways frequently led to the questioning of approaches or materials adopted, but this was typically constructively received, sometimes resulting in addressing the issue and sometimes in acknowledgement that compromises were being made in the interests of limited time and energy. At High Wood, in contrast, I several times heard constructive criticism poorly received. As discussed in chapter 3, there is of course an uncertainty effect: my presence might despite my efforts have caused tension, and I do not know what would have transpired had I not been there.

The new curriculum makes big demands on teachers: Kathy, highly experienced and historically both successful and innovative, said:

> 'That lesson you saw where I tried some of the really contextual functional skills stuff with them, in groups because I genuinely felt that was the best ways for them to be learning where they can support each other – and they do need lots of support for that - but the demands are just so great, I felt exhausted: they all have different approaches and get to different answers and you don't know how – I shan't do that again.' *Interview 3*

The relative inexperience of the Greenways department also means that policy fatigue might have been less likely: the High Wood talk about future developments was dominated by 'we've seen it all before, and it will come full circle eventually' or similar, as with Gu and Day's (2007) most experienced case study teacher. In contrast, Greenways teachers, other than Dan, talked about proposed further changes, as 'a bit of a challenge, but we'll adapt' or similar. They evidenced a flexible, principled approach which suggested new 'policy whims' (in Gillian's words) should be subjugated to core beliefs about teaching and learning. Their resilience appeared boosted by their immersion in an effective community of practice and by an absence of overwhelming stress elsewhere, but would also appear to have been supported by a determination to make the

initiative work (despite some reservations about the drivers), and a confidence that they were well-placed to do so. Resilience, then, while being clearly differential, appears closely related to a number of the other identified differential traits.

6.2.2 Resilience in response to curriculum challenge

A key intention of the new curriculum is that students should learn material with conceptual understanding, and how to reason mathematically with it, so that they can confidently tackle multi-stage problems. Bryant, Nunes and Watson (2009) show that teaching for unstructured problem-solving is highly challenging. Extension of Curee/QCDA (2009) suggests (Appendix 17) *challenging* teachers to develop in policy-consistent ways means framing policy so as to elicit from teachers their best efforts and to supporting them to develop in transferable and/or discipline-specific ways which are progressively more complex, critical, creative and context-specific. Although the CUREE project related to student challenge, I explored use of the outcomes as they might apply to teachers, in an effort to investigate its generalizability, and compared the responses of the two departments.

Greenways clearly felt they could cope with quite significant challenges, and were solution-focused in their approach: 'we expect the students to learn to deal with challenge, and enjoy it, so it's only right we do ourselves – anyway, it stops us going stale' (*Nigel, Greenways, interview1/2*). As indicated above, the literature suggests these attitudes link with other identified differential traits. Most work discussing teacher response to risk and challenge does so only tangentially, and response seems closely linked with resilience.

Greenways largely worked on the new curriculum in ways which for students the CUREE project had shown to be constructive: they interpreted it as both an opportunity and a deep challenge to develop their teaching, and were largely motivated to try to do so; they habitually worked in collaborative professional problem-solving ways, sharing both successes and perceived failures as opportunities for learning and addressing emerging problems proactively. For example, ebbing confidence in the demands of the new approach towards the end of the first term of enactment resulted in the commitment of a precious day to whole-department evaluation and reframing: in fact, little of essence was changed, but confidence (discussed below) in relation to the new Scheme of Work was restored. Similarly, algebraic weaknesses exposed during the second year were addressed both in the short-term, for those students, and also by revisiting and reframing the approach to algebra in Key Stage 3, in an effort to pre-empt future such difficulties. Teachers were, further, confident to interpret the demands of the new curriculum in ways which

were context-specific and closely allied to their beliefs about their work, and many of these characteristics co-developed during the course of the study, in a 'virtuous circle'.

In contrast, the department at High Wood chose not to use the vocabulary that had been developed during involvement with the project, let alone embrace that. With a shrinking culture of shared professional collaboration and professional problem-solving, and with an apparently smaller harnessing of capacity or language for reflection, as well as a more intrusive perception of accountability requirements, the CUREE work cited suggests they were less well fitted to embrace this challenge as a positive opportunity for development, so it is not surprising that they sometimes appeared overwhelmed and even threatened by it at times. Individual negative or neutral responses to challenge appeared to contribute to a dominant 'department' response, whereas above, Greenways appeared to have relatively stable coping mechanisms underpinned by positive affect, and tolerated threats to coping with challenge through distributed leadership.

6.2.3 Motivation

Core to Spillane's (1999) necessary conditions for deep change is motivation. I shall initially, with Spillane and with Lai (2011), take *motivation* to mean the internal psychological processes which spur individuals to perform goal directed actions, acknowledging that these internal processes are impacted by external stimuli. As such, motivation cannot be observed directly, but manifests itself in a will to perform those actions: studies typically use time on task, observed affect, or self-report, as proxies, each of which has limitations. Further, the literature sometimes shows conflation of internal process and external stimuli, but I shall try to maintain that distinction. Much of the work is with students, for whom superior motivation leads to a number of behaviours: preference for challenging goals and risk taking, intrinsic interest in learning, positive attitude to learning (Ames 1992), persisting in difficult tasks, high levels of task involvement, high levels of effort and persistence (Meece, Anderman, and Anderman 2006). Thus, *if* generalizable to teachers, motivation links a number of the differential characteristics observed at Greenways. Lai (2011) cites evidence that greater motivation in school and college students is supported by teachers giving students more autonomy or control over their own learning by allowing them to make choices, and using collaborative or cooperative learning approaches.

Although such evidence does not automatically transfer to the study situation, it is worth noting that Greenways *perceived* themselves to have a choice about the degree to which their enactment of the new GCSE was a principled one, and many choices about the detail of that; and

had also chosen (and valued) a highly collaborative approach to the initiative. In both respects they acted very similarly to Watson and de Geest's (2010) departments successfully undergoing autonomous change: it would appear that embracing available choice within imposed change, is empowering. Such intrinsic motivation leads to greater persistence with a task than extrinsic motivation (Capel and Gervis 2009) and additionally, it appears that tasks perceived to have only a moderate probability of success are generally found more enjoyable (Middleton and Spanias 1999): for school students at least, success in a challenging task is all the sweeter, though failure can be demotivating. If such results are generalizable to teachers in this situation, it would appear then that Greenways placed themselves in a good position for a 'virtuous circle' of enactment.

Hannula (2006), defining motivation as a potential only indirectly observable through affect, emotions or cognition, does not regard it as affect, though appears to have changed his stance in Hannula (2007); I would agree that it is only indirectly observable, but argue that with my definition above it is affect. The concept of departmental motivation is therefore problematic: it could be understood as a commonly held characteristic of individual teachers, but my preference is to attribute motivation to a group metaphorically as a result of goal-directed actions undertaken by the group with persistence and solution-focus, in other words if as a group they show 'symptoms' of what we would call motivation in an individual. I shall adopt a similar approach with other characteristics sometimes defined psychologically, and shall in chapter 8 argue that accommodates a complexity approach.

6.2.4 Mastery goals

As these motivational traits, independently identified from fieldwork in a grounded way, were probed, it emerged that there were links with the literature on goal theory, which appears to cover a variety of constructs, of which Ames' (1992) *mastery* and *performance* goals have been particularly influential. An individual with mastery goals is learning-oriented, conceptualising learning success in terms of achieving understanding and self-referenced improvement, in this case with a principled enactment, whereas someone with performance goals would privilege the demonstration of competence and superior performance to peers (perhaps through performativity measures) as successful outcomes. Conceptualising a department as a unit, for which there appeared some justification as described above, Greenways in this instance would appear to have a clear mastery orientation, whereas High Wood's would be characterised as rather mixed. Note that this moves the discussion into a clear 'learning' paradigm aligned with the

talk emergent at Greenways, where phrases such as ‘we have to learn to do this’, ‘I don’t know yet how it’ll work, I’ll have to try it and see’ and ‘talk about a steep learning curve!’ were heard not infrequently in casual conversation, in contrast to High Wood, where little such talk was evident. At Greenways, it appeared that developing and enacting a principled scheme of work for the new GCSE was the prime focus, but there was overt, and developing, embrace of the professional learning this necessarily entailed.

For students, mastery orientations in respect of a particular task are generally found to elicit superior motivational responses (Meece, Anderman, and Anderman 2006), since goal achievement is perceived to co-vary with effort, and is therefore linked with a high degree of self-efficacy: reflected in Greenways’ enaction in this study. The same paper shows student goal orientation is heavily impacted by their perceptions of the goal orientation of their learning environment. Here, the critical word seems to be ‘perceptions’: Greenways perceived they had effective autonomy in choosing mode of enaction, and felt supported in taking a risk with a more principled approach, whereas High Wood, although in a situation where management support for their choice was overtly espoused, believed in fact that performance in terms of student examination outcomes was a non-negotiable priority. Ames (1992) and others discuss the evidence that deep learning and persistence through challenges is associated with mastery goals whereas surface learning is associated with performance goals, and Middleton and Spanias (1999) describe positive impacts on achievement of mastery orientations: thus, *if* their work with school students extends to teachers, a mastery orientation, co-varying with the range of affective traits observed at Greenways, is much more likely to lead to success in a challenging task.

For Key Stage 4 mathematics students, the systematic review by Kyriacou and Goulding (2006) suggests *motivation* is promoted by a focus on mastery and understanding; by a variety of actions which contribute to their identity as a mathematician, including the use of tasks perceived to be relevant, development of self-regulation, formative feedback, and the promotion of belief in the efficacy of effort; and by the use of appropriate challenge together with sufficient success. I suggest parallel conditions for the promotion of teacher motivation in Appendix 19, and used this study in part to explore such a generalization. It will be seen that whereas Greenways experienced all of the suggested conditions to a significant extent, for High Wood their espoused belief in the importance of student mastery based on deep conceptual understanding appeared trumped by the perceived need for maximum student attainment, and their talk contained little reference to their own learning, except superficially when prompted; they also perceived the level of challenge implicit in a principled enactment of the new GCSE to be unrealistic, i.e. they were not confident of success. Historically, though, they have engaged in some depth with autonomous

and challenging change, with clear motivation and the requisite skills: some of these appeared not to be available in this context.

The contrast is clear: at Greenways perceived success in terms of their goals built up both capacity to continue further, and motivation to do so; at High Wood there was evidence of policy initiative fatigue and a perception of limited success in terms of espoused ideals:

> 'There's no point in continuity, or planning more than a couple of years ahead. No point in putting in too much effort into making the changes thorough and good…It might have the potential to be better, and we did think it's a better model, but we haven't had the chance to make it work yet, and now they're asking about a replacement, so there's no point…. You can't afford to do what you really might think is best if you don't absolutely have to because that takes too much time and energy and if you do that then it'll all be kicked into the long grass and you'll be badly affected by change fatigue and then nothing works.' *Norman, interview 5*

The nature of one's goals seems intimately related to one's beliefs and particularly, one's belief hierarchy, and here, core purpose as a mathematics teacher: motivation for deep change needs both resilience and supportive belief priorities if it is to be translated into effect, and as we see here, exposed priorities are time- and context-dependent.

6.2.5 Self-efficacy and self-concept

A construct of confidence in relation to a planned teaching action in a limited field, which is the situation described in the study, is closely related to that of positive *self-efficacy*; and when applied retrospectively, particularly in relation to bigger fields of functioning, it is sometimes used as one indicator. In interview data, it was represented be for example

> 'We've got really able, enthusiastic teachers committed to making it work – and though it's really demanding, it is. And we're confident we can make it better.' *Nigel, interview 5, good self-efficacy in relation to the department;*

> 'You can't do it, not with all the changes, you can't do what you want to be able to do, what you think is right. ..The reality is we'll look at our old scheme of work and we'll change things if we have to…but it comes off quality marking, quality communication time. You can't do it well.' *Heather, interview 4, poor self-efficacy*.

Bandura is the principal theorist of self-efficacy, defining it as 'a judgment of one's capability to accomplish a certain level of performance', and differentiates it from outcome expectation, which is 'a judgment of the likely consequence such behaviour will produce' (Bandura 1986). Moreover, Bandura writes of self-efficacy:

> 'This core belief is the foundation of human motivation, performance accomplishments, and emotional well-being. Unless people believe they can produce desired effects by their actions, they have little incentive to undertake activities or to persevere in the face of difficulties' (Bandura 2001, 2).

Much of the literature on self-efficacy and its related construct, self-concept, is centred on empirical research that investigates individual student learning in schools: this study is relatively unusual in considering them in relation to teachers. Bong and Skaalvik (2003) summarised the extant literature and describe the key differences between the two constructs: (Teacher) *self-concept* relates to individuals' retrospective perceptions about themselves in relation to the field, whereas *self-efficacy* relates to confidence of success with a particular goal - here interpreted as confidence that a principled enaction of the new GCSE could be achieved. That was repeatedly exhibited:

> 'I think I've been liberated to teach in the way that I'd choose to work…to teach in a more extended and synthesized way. Of course, there's a way to go, but we're good at pulling together, and I'm confident we can …expand, and flex, better in our teaching.' *Nigel, interview 3*

> 'I know now that I can be flexible without any longterm loss, so I don't … tense if I have to add a bit longer than I'd planned here because the students need it, or cut short a bit there because I've privileged something we really value…. So yes, I'm feeling good about both what we've achieved so far and what we can still achieve with it' *Gillian, interview 5.*

Some studies conflate self-efficacy with self-concept, e.g. Tschannen-Moran and Hoy (2001, 783) define teacher self-efficacy as a teacher's 'judgment of his or her capabilities to bring about desired outcomes of student engagement and learning, even among those students who may be difficult or unmotivated', which is quite generic – researchers have therefore sometimes found it difficult to operationalize the distinction.

Empirical research has linked both constructs to desirable outcomes summarised in Bong and Skaalvik (2003) as persistence, adoption of task and achievement goals, intrinsic motivation, low anxiety levels, and achievement: Beswick, Watson, and Brown (2005) link confidence at a variety of levels with teacher effectiveness, for example. Ferla, Valcke, and Cai (2009) demonstrate that for their studied teenage students in relation to mathematics, they are though two conceptually and empirically distinct constructs, with academic self-concept strongly influencing self-efficacy beliefs. The former appears a better mediator and predictor of affective-motivational variables and the latter a better mediator and predictor of academic achievement.

This literature taken together suggests that resilience, motivation and mastery goals interact with teachers' self-efficacy in a virtuous network. When reflective behaviours, the strength of the professional community, and this range of affective traits were probed in interviews and informal

talk, it became clear that participant teachers in both departments conceptualized them as interdependent, consistent with my own perception of their operationalization. Since they appear to be central to successful deep change here, I argue they should be identifiable within any useful construct of teacher occupational capacity, at least in times of change, and I attempt this in chapter 9. The interactions within this network of positive affect are summarised in Figure 8, below.

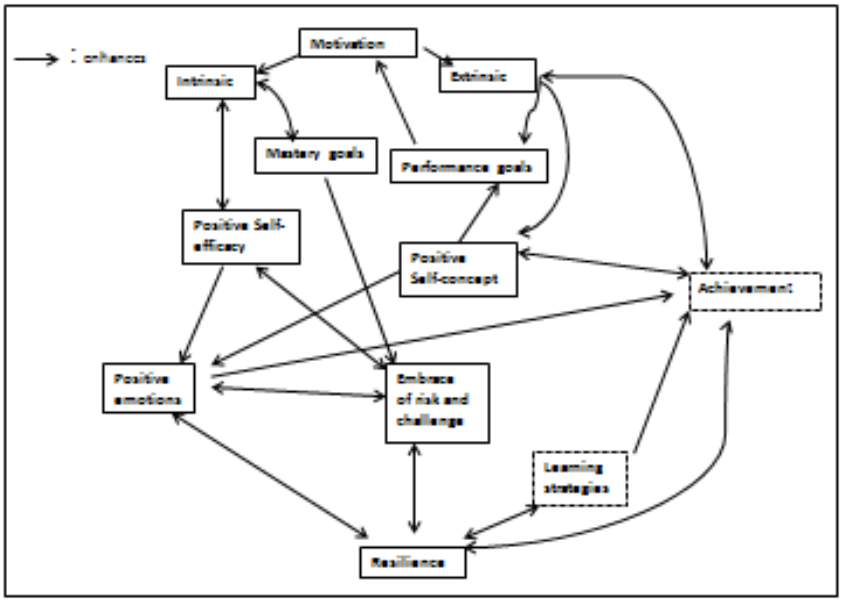


Figure 8: Virtuous positive affect network summary

6.2.6 Affect as socially and contextually held characteristic

It is relatively easy to demonstrate such characteristics at individual level, and I have shown that each department of individual teachers developed some commonality of such: I have begun in 6.2.3 to address the issue of what it might mean for a group to be described as having psychologically-defined characteristics, and explore that further in chapter 8. Complexity theorists argue for just such a development (as exemplified in e.g. Davis and Simmt 2003): a complex organism would be characterized by the emergence of coherent collective attributes arising from the activities of individuals. To what extent was this true of the study departments?

Over time, it was clear that every teacher at High Wood (not just participant teachers) moved in a direction of 'creative compliance' (Ball 1993) with the new GCSE, accompanied by a decreasing self-efficacy in relation to it: a negative web of apparent helplessness in relation to a more principled enaction. It seems unlikely these moves were entirely independent, so it makes sense to describe them as to some extent 'socially held'. They certainly appeared to be 'socially developed', since they were accompanied by the dilution in strength of their previously active learning community, a degree of individual physical and emotional retreat from shared space, and fractured and relatively low profile leadership. In contrast, Greenways' distributed store of positive individual affect appeared to support deep change on a collective level that was apparently not entirely represented in any of the individual agents – typical of a complex system undergoing learning. For example, resilience in the face of the challenges of limited time and demanding professional change appeared to be maintained throughout, even though most individual teachers experienced 'wobbles' in commitment to the envisaged enaction. This is not to say that teachers at Greenways developed as affective clones of one another: on the contrary, their diversity in any one field sometimes appeared to serve as a catalyst for the mutually more robust development of that:

> 'Fundamentally, we all believe it's the right way to go: some of us are more confident we'll get there of course, and sometimes we have wobbles, especially if it's a hard area to teach in this way – fortunately that doesn't usually happen to us all at the same time! But then we talk about it and you can see people shifting, and getting confidence from not only other people's ideas, but their concerns, and the more we invest in it, the more we risk if you like, the more we're convinced it's worth doing – a kind of virtuous circle. And we get strength from each other and each other's doubts as well as successes, almost as if it's OK to find this hard.' *Nigel, Interview 4, talking about department meeting discussion.*

Note the profile of 'we', and of high quality classroom-focused talk, in Nigel's response, as in Gillian's in section 6.2.5: this department could be seen to be strengthening its corporate identity through such challenges. There is a clear acknowledgement of the difficulty of the task they had taken on, but talk was almost always 'solution-focussed'. Dan's described perception of a lack of available materials, for example, was isolated while most of the department committed to sourcing, evaluating and developing appropriate teaching and learning tools. At High Wood, though, Heather was clear about the availability of resources: 'you're spoilt for choice, if you look – though they sometimes need development or tweaking, to make them work for your class' (*Interview 2*); Norman and other teachers in the department were initially seen, and historically were known, to be reasonably creative about the resources they used to support teaching, yet over time the dominant theme became one of 'insufficient time to find or develop the resources we need' or similar.

It is clear from chapters 4 and 5, too, that both departments came to adopt a high degree of agency with respect to the policy, although in very different ways. On a superficial acquaintance it appears to be highly 'readerly' (Barthes, 1970) and 'imperative', embedded as it is in the machinery of high-stakes examinations, yet in practice it afforded a range of 'writerliness', with Greenways teachers interpreting it as offering opportunities for sense-making and creativity apparently driven by core beliefs about the purposes of their role aligned with the policy, and High Wood moving from that to a position of writing-out much of the process element of the associated curriculum in their minimal-compliance translation of the possibilities. High Wood's enaction was valid in terms of the machinery associated with the curriculum, given emergent assessments, but not valid in terms of the espoused intentions of the core policy.

This is not to say that High Wood as a department did not engage with 'principled' thinking: in contrast with Ball et al's (2012) departments, first interviews showed all teachers engaging, in various degrees, with ideas of the core purposes of mathematics teaching, although later interviews at High Wood expose these sometimes being 'trumped' by practical pressures. Chapter 5 shows that given accumulating stress, they reverted over time to a 'results' talk typical of performance motivation. Gu and Day (2007) show this is a typical outcome of excessive stress, with diminished resilience undermining positive emotions and intrinsic drivers.

In contrast, interviews and informal talk showed Greenways largely able to maintain a focus on intrinsic, mastery motivation: this was what was right to do in terms of mathematics learning, and subsequent policy changes would be accommodated within this approach (e.g. *Nigel as above, with similar sentiments expressed by Gillian in Interview 5*), which appeared to be supported by other teachers in the department. The Affective Network shown in Figure 8, and developed further in chapter 8, demonstrates how these interdependent affective characteristics can combine to produce either a virtuous or a deflating cycle. Once this is perceived to be a collective response, it is meaningful to ask questions about how a virtuous spin might be promoted: this is addressed in chapter 10.

It would appear then, that in this case such characteristics may meaningfully be described as socially held. Are they also contextual in nature - that is, would these teachers show the same characteristics in different professional situations, or working with others? Berliner (2004) shows how context-dependent teachers' individual expertise and self-efficacy are; as a group we see a confident, solution focused department at Greenways tolerating a marginalized Dan in a similar way to Watson and de Geest's (2010) 'bullish' departments, yet at High Wood apparently capable, experienced and well-intentioned teachers gradually succumbing to an approach focused on a 'good enough' (for purposes of assessment) one, with initial intentions still just that. Given they

initially had knowledge and skills at least equivalent to those exhibited at Greenways, and had previously very successfully enacted considerable quite deep change at Key Stage 3, it would seem that a combination of apparently relatively small impediments undermined their affective resources, sending them into a debilitating cycle. As complex systems, 'attractor' reflective palettes dissipated, undermining neighbour interactions, and waning positive affect meant characteristics for ambitious change were no longer supported; with an activity-theoretic lens there were insufficient reflective and affective tools maintained to support destabilisation for expansive possibilities.

Data analysis and reflection on my part suggested such differences also appeared to constrain the range of roles which teachers could adopt, as indicated in Appendix 6. This is discussed in chapter 7, where I also expand the role typology proposed by Ball et al. (2011a) and link it with those characteristics.

CHAPTER 7: DEVELOPMENT OF ROLE TYPOLOGY

Despite these departments being apparently well-placed for a principled enaction, I have shown that over time a number of the teachers in fact adopted a minimal compliance role in relation to it, effectively embedding a set of actions which limited the changes in teaching they had previously identified as desirable. Such a role lies beyond Ball et al's (2011a) typology, which I revisit and expand. I further develop the use of that typology by showing links exposed in the data between the roles adopted and some of the teacher characteristics evident at the time, suggesting ways in which such characteristics appeared to limit the policy roles available to teachers, and so beginning to open up its use for prediction as well as description. Such a typology lies within an enaction theory, yet it has implications in particular for leadership possibilities; for activity systems through division of labour as well as 'rules', and with a complexity lens, for the availability of both attractors and the necessary conditions for expansive adaptation.

7.1 How do teachers' policy roles vary?

Heads of Department, both of whom enjoyed considerable delegated autonomy within their school, played significant roles in developing enactions - but other teachers also often adopted distinctive, and sometimes apparently critical, leadership roles that seemed to have implications for enaction well beyond their own classroom.

Ball et al's (2011a) typology does not suggest that a given teacher adopts any given role exclusively or across the range of their professional functioning. However, as in their study, chapters 4 and 5 show that most participants adopted a predominant role or sometimes, pair of roles, in relation to their enaction of this policy at any one time: for example, Kathy initially showed elements of both an enthusiast and a transactor, depending on the context. Roles sometimes changed over time, and teacher communication about the policy was usually, but not always, aligned with the current role: the obvious exception was Dan.

The typology therefore initially seemed reasonably operationalisable, although I suggest Ball et al's (2011a) description of 'critic' could usefully be subdivided into *policy-constructive* and *policy-subversive* or at least *policy-resistant* criticism: in both departments evaluation of both the policy as represented in various policy texts, and their own emerging interpretation/enaction,

were subject to constructive criticism similar to their historical treatment of Key Stage 3 innovations. Department meetings and informal conversations showed this served in their eyes to improve the emerging enaction in its early months. It was maintained over the course of the study at Greenways, but at High Wood such active engagement dissipated. Norman's criticism had always had elements of policy-resistance, though he also used more policy-constructive criticism on occasion.

7.2 Dan: An individual (and tolerated) 'survivor'

In practice, Dan appeared to adopt a role outside Ball et al's (2011a) typology: I term him a 'survivor'. This role has something in common with that of their 'receiver' although accompanied by a subversive agency: the survivor is not trying to 'receive' and then enact the policy, but rather to adopt a minimal adaptation in order to survive without external censure. Dan did not overtly resist or undermine the policy; he did however exert sufficient agency on an individual level to choose to engage only superficially with policy-related materials, at both planning and classroom levels.

Dan's interviews suggest that initiative-overload, and repeated experiences of seeing policy changes themselves replaced after relatively short periods of time, might have contributed to his response. He appeared to adapt his talk so as to conform to in-department expectations, and also his practice, at least superficially, but was observed using structures designed for 'deep' learning of mathematical linkages in a procedural and minimally compliant way, physically pairing students to match multiple embodiments of linear relationships between two variables, but apparently indifferent to whether this resulted in collaboration, accuracy or understanding, with the result that some students appeared not to expect to make any sense of the task, apparently content to guess matchings – but then nor did Dan expect them to understand it:

> 'I didn't want to cloud the issue….Just getting them to the idea of – generally - how they calculate it, is the important factor - I did feel I was drifting too much into that murky waters bit – it would have confused them – they're a group that like to be led. *'Dan, interview 2, reflecting on observation 1*

Dan appeared to have the capacity to comply with principled expectations to a greater extent than he habitually did: he could for example adjust his classroom enaction to produce lessons considered 'good' by Ofsted criteria, using 'valued' behaviours when observed by senior staff, but in interview he evidenced beliefs not fully aligned with those:

> ‘All this thinking stuff, you have to be very careful with it: if they are allowed to develop their own ideas…. misconceptions can creep in. That’s a difficult one. Again, it’s a fine line: I’m going to ask you to think for yourself. And now that you’ve thought for yourself, I’m going to tell you that you’ve been thinking wrong.’ *Dan, Interview 2*

Observation showed him well-described as exhibiting ‘creative non-implementation’ (Ball 1994, 20).

7.3 High Wood: A departmental ‘survivor’

At High Wood more passive policy roles were generally adopted over time by most teachers, and by Summer 2012 a high profile for ‘survivors’ emerged as well as a policy-resistant critic. Roles adopted were less stable than at Greenways, with changes most obviously apparently catalysed by hiatus in either assessment structure or Kathy’s personal situation, and there were increasing overtones of change fatigue in both formal and informal department interactions. As a department they were highly experienced, and reactions might have stemmed from greater exposure to repeated innovations and change than generally experienced at Greenways. It is interesting to note that Dan too was an experienced teacher whose interviews showed disillusion with repeated imposed change.

Particularly influential at High Wood was Norman, as Second in Department in a situation where the Head of Department was for some time unable or unwilling to fully meet the responsibilities she had historically undertaken. His role in relation to the policy developed through the study, from a critic/translator to predominantly a survivor/minimal translator. As a critic his talk was sometimes but not always constructive:

> ‘Oh yes, it’s a good move: obviously they do need to be able to solve problems … so it’s good if we’re expected to teach them that – though often these changes don’t live up to their hype, and we could really do with more decent resources…. like the Bowland ones, only for this, that you can pick up and tweak a bit for your students’ *(Autumn 2011)*

> *(You were talking about putting it into themes to help the students make connections and think outside the box a bit, have you managed that?)* ‘Well no not really, I just thought we’ve got to have something that will work. And at the moment, I think it’s also a question of we’ve just got to suck it and see. That’s in a way so different from what we have been doing, ..So no not really, we haven’t had the chance really to add in those applying ideas, there are some applied questions in the books but they’re very limited. It really has been a question of question of let’s build the wall. Where are the holes? Where’s the mortar a bit dodgy? So until they build the basics really securely,.. So actually building in problem solving is down the line, it’s an optional extra’ *(October 2012)*

This was typical of his rhetoric in observed department interactions and he appeared to be increasingly influential in the department as a vacuum appeared where Kathy's leadership had been.

On her part, Kathy's role morphed from that of a transactor and enthusiast at the start of the new GCSE, a role apparently supported by an enthusiastic department, to that of a survivor by Spring 2012. Here, the role was overtly one of minimal compliance, since there was little remaining attempt at principled enactment. By that time every other teacher in the department also showed aspects of a predominantly survivor approach – at Greenways too 'wobbles' needed proactive addressing - and this continued for the rest of the study, with the result that the department as a whole appeared to function as a survivor, and interviews showed this was driven not by ideals but by pragmatism. Their perception was that there was neither time nor energy to develop a more principled enactment, at least at that time. There was therefore a clear contrast between the profile of roles adopted by the two departments. Roles appeared to spill over into the classroom, with students at Greenways often commenting (Appendix 12) on active, fun, can-do lessons, whereas those at High Wood were much more equivocal in their responses (Appendix 13), recognizing maths qualifications as valuable to their future choices but lukewarm in their comments about lessons – each consistent with the prevailing ethos observed in lessons.

What does it mean for a department to adopt a 'role' in relation to a policy? I have argued, here and in chapter 6, that each department over time acquired effective 'department-level' characteristics which served both to embed tendencies and approaches to the GCSE and to rationalise them, so that each appeared largely to converge in the way teachers talked about the options open to them, their enaction and interaction within the department, and the affective traits associated with that – in short, in the role they adopted in relation to the policy, with Greenways adopting that of a translator cum enthusiast, and High Wood that of a survivor.

In that policy player 'roles' for individuals are inferred from their actions, including communications, so I conceptualise the department 'role' as one inferred from department level structures, documents, and prevailing actions, usually supported by dominant talk. At Greenways, teachers other than Dan appeared to maintain autonomy in conversation within this, confident to voice disagreement or question proposals, similar to Watson and de Geest's (2014) departments where active critique of developments and enactions appeared part of a robust teacher development. At High Wood, though, emerging 'survivor' characteristics resulted in the adoption of Norman's much more 'minimal compliance' model, as shown in chapter 5.

7.4 Policy roles, affect and leadership: development of the typology

Synthesising evidence for the different aspects of teacher work in relation to this policy over time, it became apparent through scrutiny of evidence and repeated reflection on it, that the roles adopted drew on different aspects of teacher capacity, and involved different aspects of leadership: this is reflected in the diary extract in Appendix 5. Of course, adoption of a positive and active policy player role here draws on a range of knowledge and skills if it is to result in a valid enactment, but in this study those appeared not to be distinguishing features. In summary, and including my subdivision of the 'critic' role and also 'survivors', the study suggests critical role-related features might be characterised as follows:

Table 5: Expansion and development of policy player role typology

building on Ball, Maguire and Braun (2012)

Policy player role	Typical Affect drawn on	Leadership role
Narrator	High levels of (often intrinsic) motivation, self-efficacy, resilience, enabling emotions and beliefs: a positive affective palette	Proactive interpretation, selection and meaning-making
Entrepreneur		Proactive advocacy, creativity and integration
Transactor		Leadership of accounting, reporting, monitoring and facilitation
Enthusiast		Proactive investment, creativity and (perhaps career) satisfaction
Translator	Varied levels of motivation, self-efficacy, resilience	Leadership of production of necessary support texts, etc.
Critic: *policy-subversive, policy-resistant or policy constructive*	Motivation and self-efficacy directed for or against policy; might be 'enabling' or 'disabling' beliefs and emotions	Proactive critique of current enaction: might be directed to develop, to block or to undermine

Receiver	Little positive affect: disabling or neutral beliefs and emotions.	Passive dependency
Survivor: Minimal change - superficial compliance but little or no active public resistance	Poor motivation and resilience, self-efficacy in relation to policy limited at least in relation to 'reasonable' investment but maybe more widely.	Not overt, but lack of positive commitment to policy can affect vulnerable others

I hypothesise from the data that the range of potential derived from the department community, and the positive affect available, interacted at any time to predispose a teacher to adopt a particular role or roles, depending also on those undertaken by others in the department. Taken individually and collectively, those roles then both mediated, and framed the possibilities for, enaction. Further, over time, such characteristics can be undermined or supported by a range of external factors leading to positive, negative or neutral policy roles. However, the strength of the professional learning community (Hord, 1997), discussed in chapter 8, combined with redundancy and diversity (Davis and Simmt, 2003) of positive player roles, can lead to resilience and stability in development of principled enaction, and here, to consequential growth of occupational capacity as greater knowledge and positive affect emerge through adaptation. Over time, groups of teachers who work closely together may come to adopt a de facto dominant response to it (although roles within that might change), within which variations of enaction are tolerated.

How do teachers come to take up these roles? Ball, Maguire, and Braun (2012) show that some active policy roles support career progression, and it is certainly true that the roles Nigel adopted were perceived within Greenways to enhance both his individual, and department, status (informal conversations). Further, mathematics departments in English schools are in a position of power, able to negotiate access to a variety of resources and support, because of the high status of their most valued 'output' – GCSE results – as shown in Perryman, Ball, and Maguire (2011), and reflected in the position of both departments here. Greenways as a department was supported in a role of policy entrepreneur – provided headline results did not suffer – and that

appeared to boost their confidence to engage actively with the policy. As student engagement and formal assessments began to emerge, they were affirmed in the (individual and departmental) roles they had embarked on. Similarly, High Wood was devolved considerable autonomy in enaction subject to maintenance of acceptable results, and first headline attainment figures were similar to those expected, so confirming the department in their minimal change enactment. For them, participation post-16 dropped, but was within normal year-to-year variation and so presented no significant challenge to practice: their pathway suggests that in a busy and pressured professional life teachers will only adopt apparently optional change if they perceive that it is both achievable and worth the necessary effort.

7.5 Why does it matter if teachers turn 'survivor'?

Ofqual (2008, 2012) show that in relation to demanding change aligned with that envisaged in GCSE 2010, many mathematics teachers are to a greater or lesser extent, 'survivors'. Ball et al. (2011a) stop at the stage of description of teacher roles, yet the power of the typology surely lies in its potential to not only describe but predict, and if so, perhaps catalyse development of ways to support growth of those types of role which are most productive in relation to a given policy, assuming compliance with policy intentions is desirable – as I have argued is widely perceived to be so in this case. I have suggested ways in which available capacities might indirectly frame the possibilities for enaction via the roles adopted. For this policy, they matter because of the implications for the classroom, and also for repercussions on commitment and retention within the profession, as described in chapter 6. Teacher beliefs about 'good practice' are relatively stable over time (McLeod 1992) - more so than the priorities exhibited by politicians (who of course will no longer be in office next parliamentary term if their policies are not producing immediate visible, so usually easily-measurable, effect). Such policy considerations are discussed further in chapter 10.

In this case, then, principled enaction is a matter of equity: this is a desirable policy in a state education system, so all young people should have access to it. The policy was designed to improve student attitude to mathematics, their depth and range of transferable mathematical capacities, and their post-16 participation. Achievement of the first two at least is evidenced from the student responses at Greenways (Appendix 12), and from teacher assessment of the processes not privileged by the GCSE papers taken; and post-16 participation there was already relatively high (typically 60-65 choosing to continue to AS Mathematics out of a comprehensive cohort of 170-180). Of course, there is a danger of over-interpreting their enaction since any

innovation commands effort and commitment from teachers, and is likely to result in a significant effect size (Hattie 2009) . However, informal contacts show these outcomes indicators to have persisted to Summer 2014, although since teachers are still feeling very positive about what they are achieving and how, that also impacts on students. At High Wood, informal contacts in Summer 2014 show a department in somewhat greater equilibrium than two years previously, with some progress made towards introducing aspects of a more principled approach, yet without the 'buzz' and very positive self-efficacy evident at Greenways. Perceived outcomes in student terms are solid:

> 'Fine, they're absolutely fine: GCSEs on target, enough of them choosing to go on. For most of them, maths isn't the highlight of their life, but they're doing OK' *Kathy, Summer 2014*

Robust evidence as to the depth of valued student outcomes achieved is, though, harder to come by. For teachers, the professional growth witnessed during the study is still in evidence:

> 'Do you know, I think we've grown so much while we've been doing this: …I never stop learning about this job, but the discussions we've had, and the disagreements we continue to have, they all feed into a really challenging and rewarding place to be, even if it is also exhausting.' *Gillian, Summer 2014*

The Greenways enaction evidenced a significant growth in a range of skills and knowledge for more informed, nuanced and challenging teaching, and with it, growth in job satisfaction. In contrast, High Wood experiences show that such capacity can very easily be dissipated by apparently small changes in policy context - the potential can appear no longer available. Teacher capacity, then, is a fragile and complex construct, and in chapter 9 I develop a theorization of that encompassing the evidence of this study. First, though, what can be said about the possibility of understanding a 'department level' capacity? Chapter 8 develops discussion of the influences on and characteristics of department-level functioning in relation to this policy.

CHAPTER 8: THE DEPARTMENT - GREATER THAN THE SUM OF ITS PARTS?

My research questions posited the existence of a department-level characterisation that would impact on enaction of the new GCSE, and in chapters 6 and 7 I described related evidence. Here I discuss the meaning and implications of that, relating those to the literature on teacher learning and departmental functioning. In particular, I consider the role of scheme of work development, the impact of the quality of change-related talk in the department, and the role of distributed leadership within the department at this time of demanding expectations of teachers. I shall show that Wenger's (1998) 'community of practice' theorization proved a limited model for my data, so I returned to the literature looking for alternative theorisations, eventually adopting the construct of 'professional learning community' (PLC) as described by Hord (1997), and incorporating a particular emphasis on distributed leadership. I shall demonstrate that aligns with a complexity theoretic approach to understanding the characteristics necessary to support a principled enaction; and that it subsumes at department level the construct of 'expansive learning environment' developed in the Activity Theory literature. The roles of department-level characteristics in a department-level complex or activity-theoretic system, then parallel those at an individual level.

8.1 Why a department-level focus?

'The department' can be considered either with the focus on the collection of individuals, or, where meaningful, as a single collective. Here, it was certainly true that both departments drew on individual teachers' expertise, but at Greenways it went further as the study progressed, with appropriation for group consideration of individual teachers' deep reflections, and discussion of broader moral and civic implications of enaction:

> 'You have to think of the implications of what you're doing. For instance, this unit, when we've been working with the real cost of running a car, apart from the fact that they're shocked and keep thinking the figures are inflated, we've had some really good discussions in class about the ethics of HP, and also the environmental costs of different sorts of transport and how far you can still justify use for your own convenience. And I know N's class actually challenged him on his use of a car to school, without car-sharing, which is great.' *Carol, Greenways, interview 2*

Further, as the study progressed, all Greenways teachers (to variable extents) exhibited an increased capacity not only in relation to the range of planned pedagogical changes, but also

over other areas which were not the direct focus of their planned change. For example, observations show teachers became more aware of individual learning needs and preferences:

> 'Trying to work in this way has made me think so much harder about individual student needs – I take much more care about how I group students...– but then, I know them so much better because I'm released to think about what's actually going on, they're taking much more responsibility for the actual learning, so I can often listen, and think. It's great! *(laughs)..*except for the days when it goes horribly pear-shaped.' *Carol, Greenways, interview 3*

…and this was reflected in Interview 3 as Greenways participants talked about how individual students would react to given more demanding new-style GCSE questions: what they'd struggle with, which ones would cope with the literacy demands, and so on. Such examples at least in part appear from observations and interviews to arise from the greater both scope and demand in Greenway's enactment. For example, teacher knowledge of (electronic) tools and promotion of intellectual curiosity were both observed in enhanced form some two years into enaction, when Cathy's year 10 modelling investigation which required fitting algebraic equations to graphs was extended by students *choosing* to fit parabolas to rugby footage and subsequently to explain the mathematics behind the model – this latter a task normally considered to be the clear province of Advanced level mathematics. Because of the focused collaborative nature of department functioning in relation to this GCSE, that task, and the related teacher thinking, were both shared and extended across the department, feeding into the next year's enaction. This clearly demonstrates the centrality of the department in developing capacity, although as argued in chapter 6, distributed leadership also played a significant role.

For the two departments in my study, initial indications were that each functioned as a reasonably effective unit with largely shared beliefs, purposes and priorities, significant parts of which of which were culturally distinct from those of other departments in the school, thus justifying a focus on departmental level 'community', in Gellert's (2008) terms. He suggests a largely collective nature of professional orientations, and although this study evidences individual and idiosyncratic knowledge, skills and beliefs, I have also argued in chapters 6 and 7 that these interacted to produce some characteristics apparently both developed and effectively 'held' at department level. This is not to argue uniformity of approach: emerging schemes of work, for example, were appropriated differentially by individuals although approaches to their development initially appeared driven by whole-department consensus. A range of initial evidence showed individual teachers at High Wood exhibited greater expertise across a range of domains, yet reflecting Edmondson, Bohmer, and Pisano (2001) it was the Greenways department which learnt, and eventually performed, more expertly in relation to achieving the espoused goal of principled enaction of the GCSE.

8.1.1 What do I mean by a department level characteristic?

As in 6.2.4, building on the literature I mean predominant characteristics are those exhibited by an individual described in that way: for example, we describe an individual as being 'motivated', meaning they have a goal-orientated psychological drive that results in prioritization and persistence in working towards that goal. If that prioritisation and persistence predominate within a group, I call the group 'motivated'. We do in fact require behaviours: we describe an individual as 'believing all students can learn' not only if that is their espoused belief, but if they exhibit actions consistent with that, seeking out and responding to the learning needs of the whole range of students. This is, I would argue, an approach which accommodates a complexivist lens as complexity-understood learning is of adaptation, that is, the behaviour consequent on psychological learning; complex understanding of intelligence is of the generation of diversity of possibilities, together with a harnessed mechanism for evaluation of those possibilities (Davis and Sumara, 2008), and so on: a characteristic is inferred from related actions. Further, in this study it appeared that if most individual teachers in the group individually exhibited that characteristic, then talk, decisions and actions at department level generally aligned with that, at least over time. Hodgen (2011) suggests the effect could then be greater than that of the sum of individuals', as one would expect with a complexity lens. Such group characteristics can be evidenced in observation of department actions, talk or documentation, which underlines the centrality of the methodological decisions made.

8.1.2: School level effects and beyond

Chapters 4 and 5 show both schools in this study could be broadly described as supporting an 'expansive learning environment' (as in Appendix 4), with teachers actively supported in developing autonomy and collaboration within negotiated planned professional development. Further, Meyer and Koehler (1990) show how management support for an inquiry-based ethos, and recognition both of short-term failure as an acceptable phase and effort as a mediator of ability, support the positive self-efficacy chapter 6 suggests necessary for deep change. Informal communications show both departments had recognised this during earlier development of Key Stage 3 teaching, although at High Wood that confidence later dissipated. Chapter 6 shows significant differences external to the schools seemed to be firstly, the timing of the High Wood 'blip' in GCSE outcomes, which in activity-theoretic terms produced tensions between 'rules' and 'object' as in Figure 2; and secondly, changes in GCSE structures that affected them more than Greenways, and resulted in a greater degree of necessary change to be negotiated.

8.2 Department-level change: a comparison

Chapter 6 suggests the Greenways department built up a reflective, supportive professional learning community where distributed leadership nurtured a positive affect manifested in a virtuous circle of resilience, motivation and a 'can-do' approach to a principled enactment. These approaches appeared to support an ownership and drive to the new GCSE that carried them through a variety of threats to its development. Such change-related positive self-efficacy was not reflected in High Wood's minimal change enaction. Ofsted (2012) suggest this was the norm nationally, risking the policy suffering a *'lethal mutation'* (Brown and Campione 1996).

Both High Wood teachers and Dan, being highly experienced, are likely to have built up substantial stores of routines, which allow economic distribution of attention and effort. Gellert (2008) argues the necessity for sustainable practice, of routines as socially formed and acknowledged modes of action, intrinsically linked with tacit forms of collective knowledge, and suggests significant change threatens them via loss of competence/security.

At High Wood, Norman adopted early 'critic' and then 'survivor' roles. His relatively high profile default position of 'we know the actions necessary to maintain current performance' appeared to surface in the near-vacuum of leadership and gained ground in department thinking. His approach at times appeared subversive, yet from his point of view a lack of leadership was highly frustrating and also threatened even minimal achievement in the department. However, the sustained nature of his resistance allowed the department as a whole to fragment into a collection of individual teachers whose predominant role in relation to this policy tended to that of a 'survivor', apparently draining both teachers and students of self-efficacy and energy.

Although these two departments enjoyed unusually good stores of a range of professional knowledge it is also clear from both observations and interviews that trying to implement a deep problem-solving curriculum is demanding on a range of teacher knowledge and skills, and particularly subject-specific knowledge and pedagogy, as shown in chapter 4. Principled enaction required not simply editing a previous scheme of work, perhaps reordering and adding minor details and extra references and resources, but rather fundamental re-prioritising and re-thinking in the classroom, being open to – indeed, sometimes seeking – challenging new professional understandings. Post-lesson reflections and informal talk in Greenways, as well as formal observations and interviews, exposed teachers feeling highly challenged by the range and depth of demands made of them in new classroom situations – although also stimulated by the professional and student thinking emerging.

It is therefore not surprising that the change made such great demands on other (supporting) aspects of professional capacity such as reflection, positive affect and, I shall argue, the strength of the professional community. Chapter 4 shows their professional knowledge resources were seen to expand, with a consequent 'virtuous circle' of increasing capacity for principled classroom behaviours. It is important to realise that even among the participant teachers and with a shared developing scheme of work, there was not a single enaction at Greenways: the affective model proposed would seem to derive benefit from a retention of 'writerliness' potential at both individual and department level. There are implications for leadership: Nigel was clearly aware of, and tolerated, a range of enactions of the scheme of work (4.4), yet distributed leadership, with associated perceptions of responsibilities, meant that issues of consistency and mutual understandings were repeatedly addressed in department formal and informal meetings. For High Wood, though, the combination of other demands was eventually 'trumped' by a less demanding 'creative compliance' with the new curriculum.

Chapter 4 shows Greenways seemed well-characterised as a complex body showing emergence and adaptation, and building on both internal diversity and redundancy (in terms of common espoused beliefs aligned with their interpretation of the new GCSE, and common languages of mathematics and pedagogy), with a variety of de facto leaders providing 'attractors' at different times, and providing further diversity. Both internal assessments and early specimen GCSE papers provided enabling constraints. Some inconsistencies in shared meanings (e.g. 'problem solving') were exposed and hammered out, and there was a willingness to compromise on some things while persisting with others, for example in deciding that teacher, rather than written test, assessment of process lent validity at an acceptable cost to reliability: self-organisation emerged through adaptation, with deeper reflection and related vocabulary providing dynamic and expansive interactions.

On occasion, Nigel in particular assumed a directive, more activity-theoretical approach both initially, negotiating and setting up structures for destabilisation of historic practice, and later, for dealing with threats to sufficient consistency of enaction, or to time for development. This was particularly necessary as there was limited tension between previous enaction and centrally-provided resources and specimen GCSE papers. At Christmas 2010, given tensions between the object and some lack of confidence in relation to whether that could be achieved, he acted to restabilise the activity in terms of motivation, rules and division of labour in a highly 'top-down' manner. However, when, later, his own wavering confidence threatened the degree of aspiration of enaction, others (usually led by Carol) challenged the way in which he wanted to change the object (and the rules), apparently drawing on distributed resilience and motivation. Over the

hiatus period the department appeared to work primarily as an activity system, before settling back into functioning rather better modelled by complexity.

At High Wood, an accumulation of stresses over time appeared to sap internal diversity and redundancy for such a demanding change; pedagogically-focused interactions were severely reduced, and the effectiveness of decentralised control became compromised by lack of leadership acting as an 'attractor'. As a community of practice what emerged was a learning to enact new demands in a minimally compliant way. This was not expansive change – necessary conditions appeared unavailable - but rather they learnt to select from within their historic repertoire.

An activity-theoretic lens exposes the threats to espoused outcomes posed by social tensions (in community and rules) and fragmented purposes and motives, as well as lack of leadership to structure for continued destabilisation of previous activity, so that, although the department initially perceived the necessary tools, in terms of e.g. resources, to be available at least by adaptation, interactions between teachers as well as individual depth of reflection (internal interactions) and perceptions of availability of tools became diluted. Such goal-related tensions led to re-examination of motivations and eventually re-framing of goal, norms and division of labour, though the change seemed to emerge in an adaptive way. In Wenger's (1998) terms their practice, community, meaning and identity co-varied with the emergence of a less challenging goal.

8.3 Teacher learning: theoretical lenses

For Greenways, these changes involved considerable development of professional knowledge and practice, although teacher learning was not the primary focus of work. Different theoretical models offer complementary insights. With classrooms and department as complementary interacting activity systems (Engeström 2001), the emerging scheme of work acts as a 'boundary object' – the object of teacher learning activity and a tool or 'instrument' for classroom activity. Similarly, assessments were tools for classroom activity (object: student learning) as well as for evaluating and consequently developing the scheme of work. With this lens, learning occurs when there is tension or contradiction within the system, such as when the scheme of work (output) does not meet assessment requirements (rule), test results do not reflect desired student learning, or when the scheme of work is overloaded so not deliverable on the planned timescale, resulting again in the first situation. With this lens, lack of the first would have allowed High Wood

to continue without learning. Further, the two departments behaved quite differently as activity systems, especially in their recognition and appropriation of tools (see Appendix 20). There is further analysis could be made using this lens, as in e.g. Watson and de Geest (2014), but my focus was as a sensitizer to illuminate possible differential characteristics – here, notably, use of available tools.

Similarly, if these departments are conceived with a complexity lens, this serves to focus attention on firstly, leadership as providing 'attractors' for desired behaviours; and secondly, the importance of redundancy, diversity and richness of neighbour encounters within the department if expansive change is to be supported. This study shows these are neither static, nor monotonically increasing, characteristics: at Greenways all appeared to increase over time as change-related capacity increased, whereas at High Wood previously-exhibited leadership, extensive and deep subject and subject pedagogical capacity, and deep classroom-focused talk appeared to become unavailable to the department.

8.3.1 The role of talk in developments

Attempting a profound change is a risky and demanding business: no wonder the need for a range of robust positive affect which this study evidences. This study showed some teachers clearly developing their understanding in interview situations, as in e.g. chapter 4 – but also in department meetings as they debated approaches to schemes of work, and in informal talk: in all of these they clearly drew on reflection in and on practice. Any collective orientations allow for redundancy, in complexity theoretic terms – but engaging with availability of diversity of orientations allows for new thinking, provided it is supported by reflection. Chapter 4 shows Greenways participants, other than Dan, were able to maintain and even develop deep reflection, and by continuing to actively seek external expertise also maintained respect for a diversity of possibilities, admitting vocabulary and ideas beyond those prevailing.

High Wood initially exhibited a range of well-established collective orientations historically susceptible to development, but the diversity and reflection exposed were not maintained, allowing existing approaches to Key Stage 4 practice to re-emerge – as in Gellert's (2008) study. In complexity terms, this relates to insufficient diversity and redundancy for the establishment of demanding change, although availability appeared changed over time; with an activity theory lens it suggests a lack of contradiction or tension to destabilize the system and promote development, as teachers retreated from that. Watson and de Geest (2014) describe their departments successfully enacting change as being proactive in sharing and constructive criticism of one

another's ideas ('rich neighbour interactions'), as happened at Greenways, yet this capacity, clearly exhibited historically at High Wood (informal observations), appeared to dissipate as perceived pressures mounted. In both departments the emergence of Cobb, Zhao and Dean's (2009) changing departmental norms of general participation and institutional reasoning could be argued, and for Greenways, of mathematical and pedagogical reasoning also.

Articulation allows refinement and testing of developing teacher thinking – and that requires a social element. If the professional situation is such that engaging in shared thinking about classroom-focused issues is the norm, valued in the group, then as shown, such conversation can actually be productive of newly-articulated thoughts.

8.3.2 The impact of leadership

The impact of school level leadership on teacher professional learning is clearly articulated in Robinson et al's (2008) (generic) synthesis, though many of the positive actions identified here are at department level: I have argued above that for English secondary schools the more appropriate focus is often departments, provided they are delegated reasonable autonomy. Robinson et al's principal identified factor is leadership promotion of and participation in teacher learning and development (effect size 0.84); among other roles for leaders they identify creation of educationally powerful connections, engaging in constructive problem talk, and selecting, developing and using smart tools. Chapter 6 shows these were differentially enacted by (distributed) leadership at Greenways. Similarly, characteristics identified by Watson and de Geest (2010, 2014) as being influential in their mathematics departments' autonomous change (for example deprivatisation of practice, and active critique of one another's ideas and perceptions) were more apparent there, actively sustained and broadened by distributed leadership.

Both departments initially appeared led primarily by the Head of Department, and engaged in the range of activities and approaches identified by Vescio, Ross, and Adams (2006) as typical of a PLC. Note, though, that professional circumstances at that stage meant that demands on a breadth and depth of leadership, as well as on pedagogy, reflection and positive affect, were not as great as they were later to become.

De Lima (2008) reviews the literature on distributed leadership within subject departments, showing that leadership, understood as activities which are designed to influence colleagues within a network, is both systemic and relational, and suggesting it is attributional, so that teachers typically must both allow and recognize leadership. He suggests the main medium through which professional leadership is exercised in schools is social interaction with colleagues,

and evaluates development of both peer relationships and a capacity for learning among teachers. In High Wood's situation leadership roles became focused on 'survival' rather than development strategies, and de Lima (2008) cites evidence that leadership targeted at teaching and learning is indeed thought to be uncommon. In terms of his 'centrality' of leadership, the two study departments behaved quite differently: at High Wood, Kathy was initially very central to developments, with the rest of the department not passive, but accepting of her leadership and working to support her decisions, in a typically hierarchical department (Hodkinson and Hodkinson 2003). Such hierarchy meant that when she encountered pressures diluting her leadership, the deficit seemed naturally, if reluctantly and fairly passively, filled by Norman as second in department, and he became central to subsequent developments.

At Greenways, in contrast, Nigel exercised a high degree of centrality of leadership in some respects, e.g. in relationships with senior management (in Ball et al's (2011b) terms, a transactor and key narrator), but the core leadership work of interpreting the GCSE for classroom enaction was driven and shared by several teachers, so that at times when Nigel's commitment to a principled enaction faltered (though not only then), others took responsibility for not only arguing for continued focus on that, but for driving change. There were occasions when the accountability pressures on Nigel meant he effectively withdrew from non-management informal interactions within the department, but high-quality and developmental classroom-focused talk was maintained by others' leadership. There was not always agreement – indeed, one distinguishing feature of Greenways' practice was their active engagement with a variety of interpretations and possible responses, as a whole department or as sub-groups of that, and active constructive criticism of both enaction to date and suggested ways forward.

Distributed leadership was also seen to influence transactions with senior management: Nigel was throughout the figurehead in these, yet other teachers in the department persisted in arguing for sustained high quality time for groups of teachers to work together to develop schemes of work, arguing that change would be more sustained, as well as higher quality, if more of the department had investment in its form and development. They also argued for minimizing the effort devoted to compliance with other changes they perceived to be less central to core purposes, for example, school-level demand for greater detail in tracking of poor behaviour, arguing that they were concentrating on addressing root causes (department meeting minutes). In activity-theoretic terms, externally-imposed rule change is unlikely to be sustainable unless there is a strong support platform via internal rules and division of labour; further, rules relate in part to the provision of sufficient time for non-superficial learning (Stoll, Fink, and Earl 2003, 240).

In contrast, informal observations show that although teachers at High Wood, including Kathy, argued on an individual level for the need for greater high quality time if they were to achieve a more principled enaction, interactions in the department by the second year of enaction were usually about procedural rather than development matters. Kathy herself admitted to priorities driven by survival rather than development:

> 'I can see we're not working together as well as we used to be, but I can't see what to do about it. There's just not time to talk about things, …let alone to enjoy working on teaching together. We're so focused on having to track these students every week so that they don't drop below expectations, it's just as well we can get away without changing things too much.' *Kathy, interview 4*

de Lima (2008) argues that weak or empty leadership of teaching and learning is by no means uncommon in school departments. Hodkinson and Hodkinson (2003) show that departments can function apparently very successfully with centralised leadership in times of stability, but I would argue that with leadership under stress for my departments because of the high-stakes nature of mathematics GCSE (Perryman, Ball, and Maguire 2011), distribution of leadership allows for greater resilience.

Different leadership structures appeared to have implications not only for the enaction of the GCSE, but for development of the wider professional capacity of teachers. It is unclear whether distributed leadership per se is necessary for successful change, but in Greenways' case that enabled a sustained focus. As in de Lima (2008) above, distributed leadership appeared to work at Greenways because those concerned wanted it to work – it requires the willingness of the whole department, whether to delegate, take on, or accept alternative leadership - but it served to offer redundancy as well as diversity within leadership, in complexity terms. At High Wood, Norman could have adopted an active leadership role – historically Kathy has handed that to him – but he chose not to:

> 'I'm just going to do what I need to do…and other things aren't there. It's just not happening, and she's Head of Department. But I can't do everything. I just watch out that my sets are getting what they need.' *Interview 5*

- resulting in the tension of Kathy having power but not exercising full responsibility. Heather did exercise some operational leadership, as did Norman, but not at a strategic level.

8.3.3 The role of documents

Spillane (1999) identifies good quality supporting documents as necessary to deep teacher change: these include central curriculum-related documentation, emerging assessment materials,

and those produced elsewhere either designed, or perceived, to be aligned with the espoused change. As is common (Noyes et al. 2011), both these departments privileged Awarding Body interpretations of the curriculum over reading and use of the 'official' curriculum, at least in Greenways' case for clarity of message. They had available the same range of support materials, yet over time appropriated and perceived them differently. High Wood's early attempts to find and develop available materials to support a principled approach were not sustained as other pressures emerged, and once they analysed emerging specimen assessment materials, they began to regard preparation for those as a substitute first goal, with their talk increasingly resembling Dan's 'there aren't enough materials there'. It is possible that had early assessment materials reflected curriculum aims more closely (i.e., had they been more valid), and/or had there been available a wider range of curriculum-linked support materials, they would have persisted in attempting a more principled approach.

In contrast, Greenways' response to the same availability of support materials was to adopt, adapt, or write their own, as they perceived appropriate to their curriculum goals, and this approach supported increasing confidence, as well as knowledge and skills in curriculum development, adding to Hodgen and Askew (2007) and sustained by a breadth of leadership privileging that. For most of the first cycle, their use of emerging assessment materials was largely to check that their approach was subsuming those requirements, although in the few months leading up to final assessment, they used specimen materials rather more actively (department minutes and observations). The two departments therefore both perceived and appropriated available documents in very different ways, apparently closely linked with the state of their affect and leadership. Notice the challenge for curriculum policy design: what proved a level of support positively fruitful for Greenways, was insufficient to support High Wood's initial aspirations - there is no 'one size fits all' solution.

8.4 Theoretical models for the professional environment

I introduced in chapter 2 my initial frameworks for analysis of the professional environment of the two departments: here I show how well those modelled study evidence.

8.4.1 Communities of practice

Both departments appeared initially to function as cohesive and well-defined communities with largely shared goals and working tools. Individuals contributed to teacher learning from previous experiences (e.g. Gillian contributing to design of a Finance unit from her Business

background), and relative newcomers influenced an existing culture (e.g. Heather drove colleagues' effective embrace of ICT for enriching learning). However, as time progressed, teachers at High Wood showed progressive self-marginalisation resulting in a breakdown of many of the more constructive aspects of their previous approaches to teaching development, and by the end of the study constituted a rather poorly-cemented community at least in relation to the GCSE: informal observations showed they seemed sustained by common histories and 'routines' (Gellert 2008) rather than active goals.

It also appeared that learning as 'increasing peripheral participation', as in Lave and Wenger's (1991) construct, was not a good fit to the study departments: they did include peripheral participants such as Dan, but his functioning was not well-described as that. Further, much of the more principled learning that did occur at High Wood was influenced by Heather, the most recent newcomer and arguably the most peripheral member of the community. Increasingly the High Wood department functioned as a (weak) community learning to adopt minimal compliance.

8.4.2 Expansive learning environments

Chapters 4 and 5 show that while both Greenways and High Wood initially showed characteristics of fairly expansive teacher learning environments as described in Appendix 4, over time High Wood's approaches became more restrictive, though school-level structures and support remained largely stable. Opportunities did not change, but attitudes towards them did, and the construct does not accommodate such differences. In Appendix 21 I exemplify Davis and Simmt's (2003) necessary conditions for expansive learning for mathematics teachers: they include diversity and redundancy of teacher resources such as time, talk and various kinds of knowledge, as well as of shared goals and values. The balance matters: too much diversity means there is insufficient common ground on which to build; too much redundancy means that 'horizon possibilities' are not recognised and embraced. Here, Greenways managed to maintain a productive balance whereas High Wood's extensive experience appeared to endow plentiful redundancy, while a critical level of pressures sapped resilience with which to maintain available diversity.

8.4.3 Professional Learning Communities

At the start of the study, informal evidence and department documentation showed both departments had worked as PLCs in developing Key Stage 3 practice, and their stated focus was

on working similarly with the new GCSE, with structure provided by the need to develop schemes of work to support that development. Initial data showed both departments looking beyond raw results to ideas such as 'quality of confident engagement with maths' *(Carol, interview 1*) as indicators of student learning, and at Greenways this was both maintained and developed: chapter 4 shows how for them, maintenance of GCSE grade outcomes was a necessary but by no means sufficient measure of success, as they looked also for improved attitudes and self-efficacy towards mathematics, and for at least sustained progression to AS mathematics.

Appendix 4 shows that the two constructs of expansive learning environment and PLC have much in common. The focus of an expansive learning environment is on the learning of teachers, and includes boundary-crossing beyond the department; for a PLC the core purpose of the community is to improve student learning, by developing teacher practice collaboratively, reflectively and in a structured and informed way. A PLC subsumes both Spillane's (1999) necessary conditions for department change, provided sufficient materials are available, and Watson and de Geest's (2010) notion of 'critical professionalism'. Additionally, it appeared to accommodate a number of emergent distinguishing characteristics, so is the model on which I focused: sharing, reflecting and risk-taking are key to learning supporting paradigm shifts in practice within a PLC (Vescio, Ross, and Adams 2006); additionally, they identify the power of a collaborative culture focused on (delegated) classroom practice. Louis (2006) shows teachers in PLCs report greater job satisfaction, a stronger sense of efficacy, and a greater confidence in meeting new demands, as Greenways did. The critical role of outside expertise to challenge and inform (perhaps through research findings) and especially a physical presence to maintain focus, is widely supported in Vescio, Ross and Adams' (2008) review. Here, a primary role of the PLC *structure* appeared to be maintenance of direction focus on principled enaction.

I found no claim that leadership in an effective PLC needs to be distributed. However, Supovitz (2002) demonstrates that giving teachers the authority to make their own development-related decisions within professional collaborative groups, can be central to improving student learning, and that finding is endorsed by Bolam et al (2005), though both those relate to responsibility devolved from a school-level PLC to smaller groups such as departments. Spillane (2004) further demonstrates how focusing on leadership practices rather than leaders exposes the power of distributed leadership, where leadership is understood as the influencing of colleagues and their allowing of that. However, de Lima's (2008) study of Portuguese departments suggests that even given the central delegation of leadership authority, the 'low actor centrality and high network density' necessary for effective distributed leadership and strong community, and seen at Greenways, are unusual, and yet chapter 4 shows how this seemed central to their continuity of focus. Much more common is the situation at High Wood, with, in de Lima's (2008)

terms, variable actor centrality for Kathy, and emerging low network density. He argues that in this situation, deep development of department practice focused on student learning is highly unlikely, though he offers no evidence to support that.

A PLC therefore seems the best available, but an insufficient model: in this study distribution of leadership also seemed critical.

8.5 Implications

Taken together, such considerations suggest the Affective Network of Figure 8 should be developed to show impact of social structures at each of department and school levels:

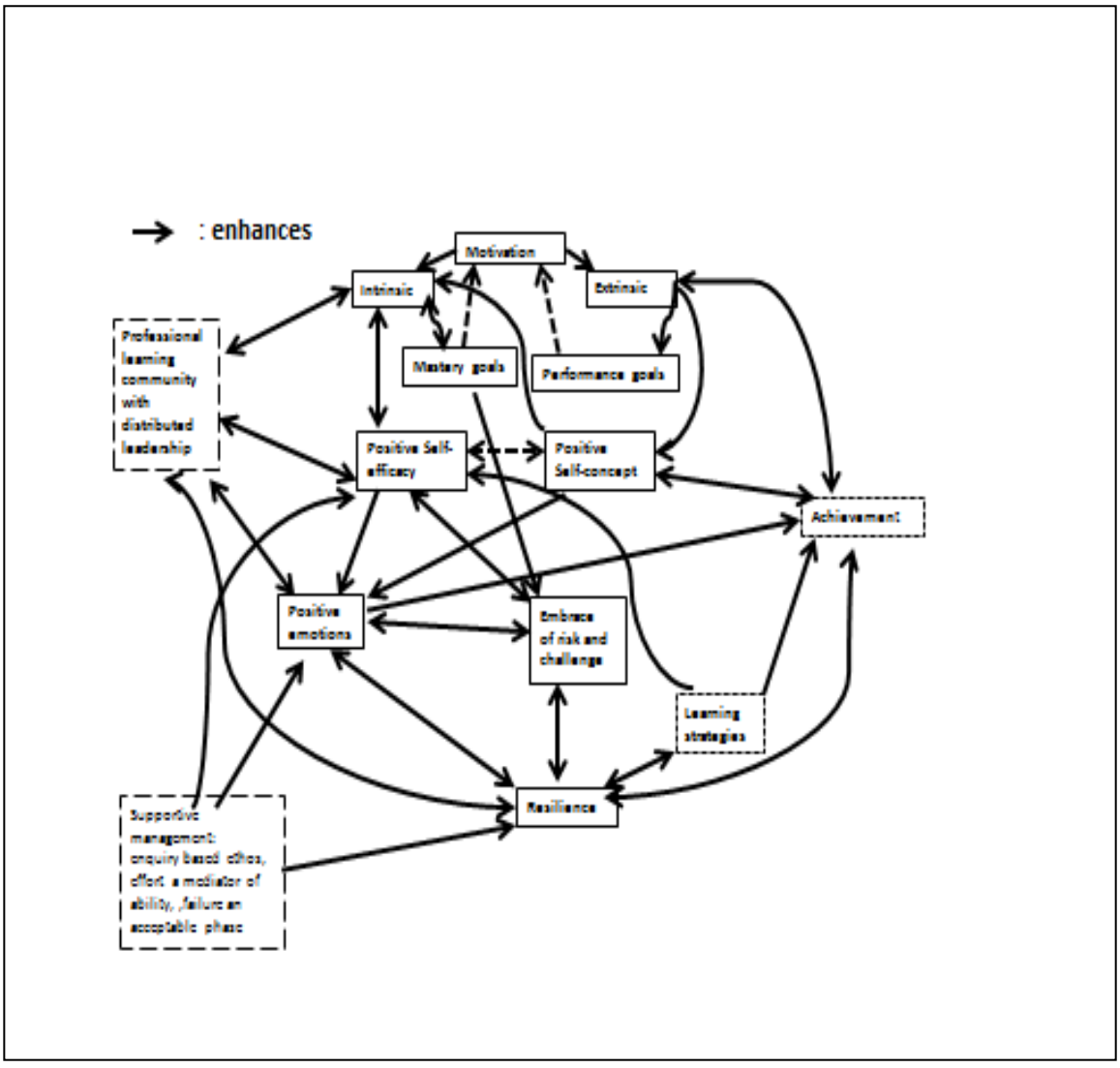


Figure 9: Virtuous positive affect network – context

Justifications for each of these relationships are in-text, but sometimes reflect suggestive evidence only, e.g. from a small-scale study, cross-curricular rather than just for mathematics, or for school students rather than teachers: nevertheless, they show that the observed positive affect apparently so productive at Greenways adds to similar evidence in the field.

CH 9: TEACHER OCCUPATIONAL CAPACITY

What contribution do these considerations make to our understanding of mathematics teacher capacity for deep change? I sought a theoretical construct which accommodates the identified differential characteristics, at both individual and collective levels. The argument is grounded in a profound sense, since the need to consider such constructs beyond knowledge and beliefs was not anticipated at the start of the study. I argue the study exposed as necessary but insufficient a professional learning community with a well-developed reflective palette and positive affective network, as well as a belief hierarchy that is goal-supportive: I suggest these should be subsumed into any useful construct of teacher capacity, at least in times of change, and that they largely lie beyond current well-developed frameworks. I justify the adoption and extension of Winch's (2010) construct to a social and more widely affective one, applicable to a group as well as to individuals, and accommodating these aspects.

9.1 Rationale

The aspirations of the 2010 GCSE represent a significant shift in the direction of enriched and demanding mathematics learning. I argue that developing to engage successfully with teaching for such demands is an integral part of mathematics teacher 'occupational capacity' in this country at this time (and that similar demands are espoused through much of the developed world).

9.2 Occupational Capacity for Mathematics Teachers

With my definitions, mathematics teacher *expertise* is manifested directly or indirectly in the classroom and related activities; *occupational capacity* is not only wider but of a bigger scale and scope. Since it is domain-specific and to be reflected in practice, it could be specified in a number of ways, differing in ideal format according to both purpose and the capacity profile of the operator. A clear understanding of teacher occupational capacity and the means by which aspects of it can be enhanced, is needed both for teacher initial and continuing development and for teacher education policy, and those ends, rather than its use for evaluation of a teacher's practice, are the focus of this discussion.

Teachers in this study identified that the range of demands on their teaching capacity altered as they changed teaching groups even within GCSE in one school:

> 'You have to be prepared in a depth you could get away with before, and that looks quite different for different groups of students…to be on top of the demands you're going to make, and to use the resources in a meaningful and engaging way. You have to anticipate…where they might get stuck and be ready to provide a way through it, or at least some signposts or some readiness-to-pick-up, and do that in a completely different way from with more confident learners.' *Gillian, Interview 5*

Occupational capacity profiles could therefore be developed at a variety of scales and scopes: generic cross-occupation, for e.g. teachers of young people 5-18, or perhaps for teachers of mathematics to 11-16 year olds. I suggest that for the purposes of teacher development, the scope needs to be big enough to offer a high-level typology, as well as small enough to support development of broad facets of characteristics that might be necessary to e.g. teachers of mathematics in a particular time and culture, allowing for exemplification and probing within particular contexts.

I would argue that teacher education should be for occupational capacity rather than expertise, in my terms, but that is part of a wider debate. For example, Winch (2012) argues for the reinstatement of the philosophy of education in the (initial and ongoing) education of any teacher, suggesting it would empower them to engage productively with contested views, conceptual debates and the evaluation of empirical research especially in relation to conceptual issues, though such activity can be marginalized in times of frequent and wide-reaching change:

> 'The rate things are changing, you only have time to change what's absolutely necessary to fit – there's no time to think about what you should be doing, even if all these changes reflected what's most important… All this theoretical stuff you get when you train, it's not a lot of use: what matters is the skills you develop in practice.' *Norman, High Wood, interview 1*

This is in contrast to attitudes observed when the same teachers were involved in curriculum development work some two years previously, when they had engaged in comparatively deep discussion about the wider purposes of mathematics education, the implications for classroom practice, and the warrants for that thinking. They might contest, as in much current central rhetoric, that direct development of expertise is what is needed in challenging times. I argue though that this study shows the relevant focus is 'capacity', since substantial change appears to draw on wider, relatively undeveloped or hitherto only superficially applied teacher characteristics. Chi (2011) cites evidence to show that experts (here, those who have a comparatively good grasp of the relevant knowledge) employ deliberate practice with a mastery orientation, and exhibit an 'adaptive expertise' dependent on deep reflection and metacognition, focusing on process rather than object – and implicitly, therefore, they need to be effective

learners in a deep and wide sense. I would argue that this study exposes wider resources necessary for the development of this particular expertise, including both affective and social and structural support of a particular kind, at least in the study context.

9.2.1 Models for Mathematics Teacher Occupational Capacity

I have found no framework which fully incorporates the differential aspects identified in this study. The English Teacher Standards (DfE 2012) used sensitively expose e.g. differential depths of teacher planning and assessment, but they in no way accommodate those characteristics identified in terms of reflective palette, positive affective network, or development of a professional learning community with distributed leadership. They are also presented in a way which can be satisfied in the short-term, without regard to longer term practice or some wider outcomes. Within the limits of their scope, and although intended for use in relation to individual (preservice and inservice) teachers, they do extend to accommodate characteristics of departments, either as descriptors common to the group of teachers or as department leadership and management descriptors. They are largely not linked directly to student outcomes: the implicit assumption is that if teachers fulfil the Standards then good student outcomes will follow.

While the Standards can expose increased demand on teachers trying to make a principled enaction of the new GCSE -

> 'the new SoW makes greater demands on all these standards: I don't think it's just that it's new, it's more demanding teaching and more demanding learning: that's why it's more effective' *Carol, Greenways, interview 5, echoed and then expanded by Gillian* -

many of the exhibited differences exposed are about range and/or depth and/or active embrace, so these Standards do expose aspects of expertise discriminated in this context, but only a subset of them. They are largely couched in terms of what are thought to be 'symptoms' of effective teaching, rather than analysing the ingredients necessary for that. There is some valuing of reflection and of collaboration, both in fairly restricted senses, but all other Standards are focused on classroom expertise.

Other constructs are discussed in chapter 2, though none directly models a 'department level capacity'. Krainer (2003) distinguishes between teams, networks and communities, like Gellert (2003) distancing himself from Lave and Wenger's (1991) 'communities of practice'; and in his terms also this study initially dealt with two communities of mathematics teachers. It could be argued that latterly, the High Wood department functioned more as a network than as a

community. There are therefore a range of theoretical approaches arising from empirical studies and each addressing some of the issues raised by this study.

9.2.2 Winch's construct of occupational capacity

Although teachers varied considerably at an individual level, the overall range, depth and balance of such capacities in the two departments, including all aspects of their assessed knowledge resources, were initially broadly similar, although markedly different from those of other departments with whom I was working: in terms of the above frameworks these departments justified their identification as a 'telling' sample in Mitchell's (1984) terms. This was also true in relation to Winch's construct, and that too fails to accommodate all the discriminating characteristics identified in this study. However, the structure proved amenable to development, and Appendix 23 shows how it then accommodates eg The Knowledge Quartet (Rowland, Huckstep and Thwaites 2005, and similarly for other teacher knowledge frameworks.

In Winch's terms a 'reflective palette' as identified could, as above, be considered a transversal set of abilities, and some normative beliefs (about the purposes of mathematics education, for example) could be regarded as 'normative civic and moral dispositions', but this study suggests the construct needs a wider affective component. Within that, I have demonstrated a need here for both a 'positive affective network' as in chapters 6 and 8, and both collaborative and learning dispositions. The latter includes valuing of external expertise and of learning. 'Leadership' could be interpreted as a 'project management' skill, but the embrace of distributed leadership, whether of oneself or others, is affective and related to a collaborative disposition.

The model for occupational capacity then becomes, minimally,

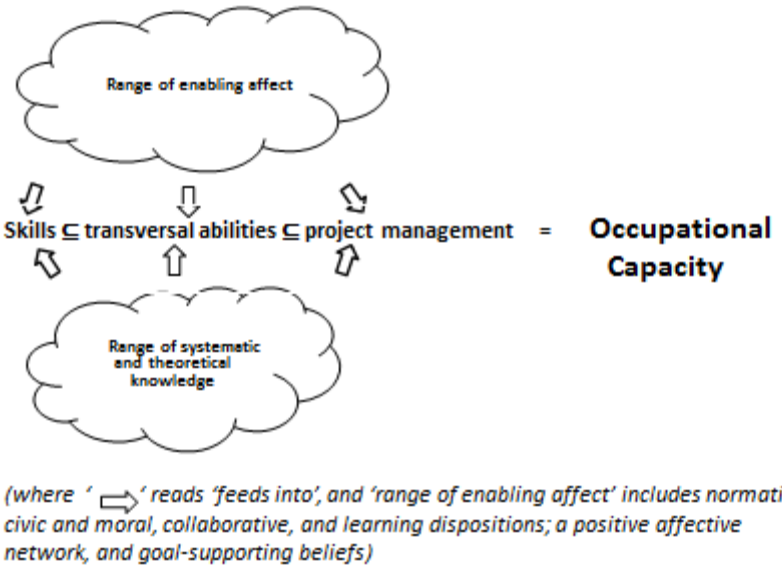


Figure 10: Winch occupational capacity developed for the study situation

so a range of 'know-how' drawing deeply on both systematic and theoretical knowledge and on a range of affect. The profile of necessary constituents within each of those areas (my introduction), at any level of functioning, varies with situation and context: for example, in a time of (imposed or autonomous) change, this study suggests that not only are the range of aspects of teacher learning necessary, but that those are furthered by the simultaneous presence of characteristics which support a professional learning community, preferably with distributed leadership. The diagram centralises classroom-related actions, since these are what impinge directly on students. It also shows only a subset of the relationships between variables, since for example successful project management can, with reflection, both enhance self-efficacy and expand knowledge of 'what works', and so on.

How does this model relate to the work of Kunter et al. (2013)? Self-regulatory skills are transversal, and motivation now included, as is the capacity to 'collaborate' with the range of stakeholders, as well as colleagues, so valued in their COACTIV model. Similarly, the 'orientations' of Schoenfeld (2013), as well as his resources and goals, are now accommodated. Further, where the above teacher function frameworks go beyond observed practice, those additional aspects can also be accommodated within my extended model. Teacher development practice and policy have in recent years moved towards focusing on 'know-how' at the expense of systematic and theoretical knowledge, and have often almost ignored the role of enabling affect: this model suggests there is probably a better balance to be had, and this issue is addressed in chapters 10 and 11.

9.3 A construct of departmental occupational capacity

I introduce a construct of 'department occupational capacity' to describe a group of teachers' collective potential to affect individual teacher expertise, and therefore at a second remove, student learning. I have shown how much recent work conceptualises teaching as social and situated, and in English secondary schools that the department is the key working community, although framed by school-level affordances. I argue in chapter 8 that the department capacity can be larger than the sum of individual teacher capacities: this would be consistent with a complexity construct of capacity. Here, both departments drew heavily on individual teachers' expertise – Heather's at High Wood has been demonstrated and at Greenways

> 'This unit, the homes and houses one, it's looking nothing like it was last time round – we've all had a hand in putting in hints for making it work better, or pitfalls to avoid, or more curriculum links – well almost all of us have, and it's nothing like systematic enough yet, but that ownership is building up I think.' *Nigel, interview 4*

Such developments appeared supported by the student learning-focused, deep and sustained discussion characterising structured teacher learning at Greenways. Teachers at High Wood have historically been observed to participate in discussion, and teaching, at an equivalent depth, for example when working with Greenways to develop lessons using the Bowland (2010) materials, but none such was observed during the study, even when interview probing offered opportunities.

In chapter 8 I suggested that where an individual is e.g. described as having good self-efficacy in relation to a goal, that is inferred by their actions and interactions, rather than directly, and that it therefore makes sense to attribute self-efficacy to a collection of people who behave or communicate in that way. Similar arguments can be made about the range of characteristics in the extended occupational capacity model, although one would expect affect (values, beliefs, emotions, dispositions) relating to the social to be particularly important. As knowledge can be construed as being 'socially held' and situated, so too can affect. It then makes sense to talk about a department as having e.g. a 'strong occupational capacity' in relation to a given goal, where 'occupational capacity' comprises a profile of practical and propositional/case/strategic knowledge, and affective traits and dispositions whose necessary relative weightings vary over time depending on the changing demands of the occupation. The extended model now encompasses the social and affective, the collective as well as individuals.

However, as with individuals, the model is not yet complete: it is set up to focus on what feeds into classroom practice, yet there are relationships in other directions and between other variables also: for example, classroom experiences contribute to development of the range of

professional knowledge and also to emotions, confidence, self-efficacy in the department… For both individuals and departments, different aspects of this occupational capacity construct play different roles in complex or activity-theoretic understandings of enaction, as I have suggested in chapters 6 and 8. The mutual dependencies and often blurred boundaries between such aspects inherent within occupational capacity and exemplified in part in Figure 10, align rather more with the holistic notions of complexity rather than the more atomistic analysis of an activity framework.

In chapter 10 I consider the implications for policy-practice consistency of the analysis and theoretical developments made.

CHAPTER 10: CONSISTENCY BETWEEN POLICY AND ENACTION

It should be stressed that Greenways is an outlier in its principled enaction, and that the norm has been for mathematics departments to exhibit only 'creative' (and superficial) compliance with the policy (Ofsted 2012). In this chapter I discuss why that might matter; what the exposed impediments to policy-enaction alignment appeared to be; and how those might be addressed.

Theoretical lenses served to sensitise me in particular to, in the case of activity theory, teachers' perceptions of available tools and the 'rules' accompanying the policy at different levels; and with a complexity lens, to the 'enabling constraints' in the policy context, as well as to the diversity and redundancy of the breadth of teacher characteristics available, and the opportunities for interactions of ideas.

10.1 Why does it matter?

There are a number of reasons why creative non-implementation might matter. Fundamentally, there is the issue of 'better' mathematics education for young people in schools. This policy was not devised in the face of mathematics education community opposition: on the contrary, it enjoyed widespread support. It is aligned with much current literature that reflects approaches to those elements of mathematics education most deeply valued in twentieth-century 'developed' nations, and in particular, mathematical thinking and problem solving based on deep conceptual understanding across the range of (largely agreed) mathematics content.

It is widely argued that such goals should be privileged in a knowledge economy where young people will experience enormous change in demands and expectations over the course of their working lives (ACME 2011a, b). Ministerial rhetoric (Gove 2013) suggests such abilities are highly valued also in the wider community, though a politician's focus is necessarily not to achieve embedded success, but rather to persuade in a relatively short timespan that policies introduced are likely to achieve their goals: as a consequence, easily measurable gains that appear aligned with goals, are politically more valuable than slow and steady embedded gains over the course of a generation's mathematics learning. Mourshead, Chijioke, and Barber (2010) argue that longer system-level policy timescales are needed for embedded challenging progress of the sort

envisaged. However, here was a widely-supported policy aligned with evidence of 'best practice': if even well-placed teachers cannot turn that policy into a valid reality at the classroom level then there would seem to be little chance of achieving that with policies enjoying less widespread support (and some would argue that would be a good thing).

Secondly, there is the matter of equity. If a policy is aligned with our best understanding of what is 'good educational practice' then it is inequitable that students should be reliant on what would appear from this study to be unusually (Ofsted 2012) capable teachers in an unusually fertile professional situation. If this policy represents our best understanding of what young people should be learning in their middle teen years, then, informed by studies such as this, efforts should be made to adapt policy context and affordances so as to support access by a much wider range of students.

10.2 What are the impediments to policy-practice consistency?

This study suggests a number of impediments to the achievement of large-scale alignment of classroom practice with policy, at least on the (comparatively) short time scale of about three years. This timescale is significant in two ways: on the one hand it is extensive, representing the full Key Stage 4 experience of one cohort of students and the first half of another: they have just one such opportunity. On the other hand, in terms of teacher development and deep adaptation of practice it is short (Berliner 2004), yet will have been in place only five years in total before the next significant GCSE change, with associated demands, is implemented. Young-Loveridge (2010) argues very cogently for the unreasonableness of expecting widespread deep and embedded teacher change over a 'limited' timescale – in her case, ten years, and following on from two years' intensive input.

I have argued that 'challenge' is not necessarily a show-stopper, and in Greenways' case actually seemed to serve to develop their occupational capacity, but notice how both Heads of Department talk about the *longitudinal* nature of development: implications are discussed below.

As in Ball, Maguire, and Braun (2012, 21) I consider the impediments to consistency under the headings of situated contexts, material contexts, external contexts, and professional cultures. The study has little to tell us about the impact of schools' locale, history or intake (their *'situated context'*), other than to reinforce the argument that these two departments are 'telling' - that is, they 'punch above their weight' in terms of implications, since both enjoy a successful history,

local esteem, largely cooperative students and supportive local context - situations this study confirms are conducive to experiment and change.

10.2.1 Material contexts

In terms of staffing, budget, buildings, technology and infrastructure, neither school is particularly well-endowed since rural education has comparatively low per capita funding in England: however, of itself this did not surface as an issue for teachers when they were talking about the achievability of their vision. There were repeated comments about the availability of high quality resources appropriate for the new curriculum, with both Dan and all High Wood participants arguing there were insufficient, but their perception was of lack of availability, not lack of affordability, and for Greenways we have seen how that led to the development of their own materials, which, as in Hodgen and Askew (2007), appeared to act as a catalyst for both greater commitment to, and deeper understanding of, the perceived distinctive features of the new course: limited materials in that case apparently positively contributed to deep development. Certainly the most recent Ofsted inspections for the two schools, and a recent Ofsted Subject Inspection at Greenways, suggested that while material resources, including department-level capitation and staffing levels, are not over-generous, neither are they in these cases a significant limitation on the quality of learning that teachers can facilitate in the classroom.

10.2.2 External context

The two departments enjoyed the same *external context* in many respects, although for High Wood that changed early on in their enaction. However, the high-stakes nature of GCSE had a high profile in talk in both departments. Participant teachers were very aware of these ramifications for the young people in their classes, and cognizant of the major responsibility they exercised

> 'It's really important for them – there's no getting away from it and I wouldn't want to, this GCSE has significant effects on the choices they have in life, and so it should – and that's an awesome responsibility.' *Nigel, Interview 1*

This was typical of a general view that such responsibility was sobering but appropriate (Winch's 'normative civic and moral beliefs'), and it produced tensions in thinking about principled enactions of the new curriculum, especially as emerging specimen assessment materials appeared to maintain previous interpretations of the curriculum rather than align with the stated intentions

of the new GCSE. Assessment interpretations determine how students (and teachers, at a variety of scales) are judged, with often far-reaching implications, so pursuing a path not clearly aligned with these would be a significant step.

GCSE mathematics is a high-stakes assessment for individual students, and many stakeholders would argue, as Nigel does above, that this is right and proper in a twenty-first century society. However, it is also high-stakes for individual teachers, for departments, for schools and for local authorities, and this can lead to adoption of the assessments perceived to be most accessible, even if they do not always support most valued wider learning outcomes. 'Raise Online' data (Ofsted) documents mathematics GCSE performance in absolute terms as well as relative to prior attainment, to other schools reckoned to be in similar contexts, and to other subject areas, by overall cohorts and by subgroups; and (individual, department and school) teacher performance is evaluated in large part relative to this. This results in 'layers' of pressure which can be both productive and destructive.

> 'The forensic analysis to which our results are subjected, it can be helpful – we should never shy away from asking questions about whether we're absolutely doing the best for our students – but we've also seen it misused, largely from ignorance I think; managers don't always understand the error bars, or the intrinsic variability between cohorts, and it's a fine line before it can slip into feeling like bullying, because everyone's under pressure. We've been lucky, because we've usually been able to go away and explain what's going on, and that's been respected.' *Gillian, interview 4*

As suggested, this might be short term scrutiny and result in a 'clean bill of health', as in the case of High Wood's 'blip' in results, in which close examination was triggered by the local authority: it can still result in significant consequences:

> 'It doesn't matter what he *(the Headteacher)* says: it still feels like we've not been trusted to do our best for the kids, and that's hard when we're working our socks off: it undermines our confidence, but also the goodwill to put so much in, I think' *Kathy, interview 2.*

Such pressure can also be costly in terms of commitment to innovation:

> 'It's not that we no longer believe it's the right thing to do in principle, we just can't afford to go too far in risking another set of poor results. We know what works for our students, and we can't afford to jeopardise that.' *Kathy, interview 4*

It is not that she has changed her belief about what is important in the classroom, just that, as shown in chapter 5, she has a managerial belief trumping her pedagogical belief. A policy context which allows assessments of curriculum inconsistent with curriculum intentions, that is, of limited validity, clearly does not best support principled enaction.

Lack of clarity (including exemplification) in curriculum policy documents could be argued to have restricted alignment: for example, although both the curriculum and GCSE specifications refer to 'problem solving' as a key construct, it became very apparent at Greenways that even with common backgrounds, teachers initially imbued the term 'problem solving' with widely differing meanings, as described in chapter 3. Such ambiguity allowed an inconsistent system of enactions at a variety of levels: importantly, the aspirations of the National Curriculum (QCA 2007) were ambiguously reflected in the guiding Criteria for assessment (Ofqual 2009), thus allowing a 'least challenge' *(Carol, interview 3)* interpretation. It should be noted in passing that there is every incentive for Awarding Organisations to adopt an 'attractive' (more accessible to students) interpretation in a high-volume area whose entries typically subsidise those of small-entry subjects.

A further concern is ***central policy hyperactivity***. This study only addressed the first full cycle of the new GCSE, and it may well be that given time, both departments would move to a semblance of congruency with intentions. However, even if this were finally achievable at scale, the lack of early principled enaction is costly: each cohort of young people has only one experience of Key Stage 4 mathematics. Further, the context remains fluid: a new National Curriculum, leading to new GCSE criteria, will be taught from September 2014, with first GCSE teaching September 2015. There was simply not time to embed the study change before teachers had to begin addressing new ones, and this is a recurrent situation. There are different ways to react to this challenge, as is clear when Nigel and Norman talk about further changes:

> 'for us to fundamentally change our whole approach, the way people work and approach their teaching when what we've got is coming into line with what we fundamentally believe is right for the students mathematically – I'd be very reluctant to do that... I think we've got it right in terms of what we're trying to do, so we'd try to absorb new demands into that.' *Nigel, interview 5*

> 'There's absolutely no point in trying to make deep-seated change if we don't have to: it will be here today, gone tomorrow, just like everything else. What we need to do is make sure the students can answer the questions they're asked *(in the GCSE*), whatever that looks like this week.' *Norman, interview 5*

From a policy-maker's point of view, of course, neither of these positions is ideal. Both departments were initially well-disposed towards this policy, yet the indications above are that neither would be keen to invest significant efforts into a successor policy in the near future – and further, that there are often ways in which to circumvent the intentions of a policy. This might not matter to a politician, if easily-measurable short-term indications are that the policy is on-track, but in terms of principled development of high quality education it is a serious issue.

10.2.3 Professional culture

Teachers operate within a succession of layers of policy-related constraints, including a professional culture specific to the school and the department. At a whole-school level, as well as individual teacher level, there is a ***hierarchy of policy*** within the plethora of (sometimes inconsistent) policies to which schools are subject. 'Raising aspirations' is an unexceptionable 'master' rhetoric overlaying various accountability policies, and inevitably this not only supports the privileging of attention to some students' development over others –

> 'Whether they get a C or a D makes an enormous difference to them, which can be a real pressure... - but also to us: it's very tempting to try to drag them over hurdles so they get there, and also to put the most effective teachers with those groups – the Head's always asking me about that. There are pros and cons, though we're lucky our teachers are happy to be rotated, which seems fair, but I do sometimes wonder....' *Nigel, interview 5*

Such pressures inevitably run counter to the 'Every Child Matters' policy (DCFS 2004), but also privilege short-term outcomes (GCSE results, and in particular, the proportion of those at the critical 'grade C+' level) over longer term considerations, which might include development of a positive self-efficacy in relation to mathematics, as well as continued participation in formal mathematics education. Performativity agendas also support the privileging of accessibility over validity in the development of assessments. While both departments in the study were comparatively well-placed to resist those pressures, they simultaneously were very aware, as in chapter 4, that an unexpected dip in results could force a reassessment of priorities.

In view of an intense competition between schools (despite central espousal of the benefits of collaboration), the heavy dependency of Inspection outcomes on such data, and potential consequences of that, it is remarkable that the Greenways department were given such unstinting support in taking the risks inherent in attempting a principled enaction, and interviews showed teachers well aware of this:

> 'I took it to the Headteacher and he said go for it – I couldn't have done it without that, obviously, precisely because it was such a risk.' *Nigel, interview 5*

More immediately though, teachers work in a departmental culture which the study shows was highly influential in developing attitudes and approaches to the enaction, and I have shown that one which amounts to a 'professional learning community' can support deep change. Teacher values and beliefs, commitments and experiences, as well as underlying knowledge, all affect not only what is possible at any one time but what is perceived to be possible. The combination of these factors means that not only can the national 'master rhetoric' of raised aspirations and increased accountability result in unintended negative consequences for broadly

valued outcomes, but that the impact can vary enormously between even apparently well-placed groups of teachers.

The High Wood department did not have to confront the constraints of their decisions in terms of potential learning, since they were able to maintain headline GCSE results. More broadly, enrolment to AS Mathematics, nationally a key indicator ACME (2011a), dropped slightly, though both Kathy and Norman pointed out that it was still within the normal year-to-year variation experienced at the school: again the challenge of establishing medium- and longterm effects of policy in a rapidly-changing landscape is clear.

10.2.4 Teacher occupational capacity

Beyond the professional culture, though contributing to an enhanced conception of it as argued in chapter 8, is teachers' occupational capacity, considered in this study both at an individual level and as a department-level construct in some ways greater than the sum of the parts, as in chapter 9. 'Occupational capacity' as developed frames the range of choices felt to be accessible to an individual or group of teachers: the implications of that can be seen for example in the differential way in which teachers in the two departments appropriated the 'tools' available for enaction (Appendix 20). These clearly feed into a department professional culture, and some tools are susceptible to enhancement, either directly, or via the strength of the learning community or positive management support, as discussed in chapter 6. A principled enactment of this policy exposes teachers to unpredictable demands on their subject knowledge and range of pedagogical skills, as shown: ACME (2011b) lists the vast range of needs of learners in relation to such a curriculum.

In terms of the core theoretical lenses employed, departments' (individual or group) functioning as complex systems was originally well-supported by their store of professional knowledge: there appeared ample both diversity and redundancy to support expansive change, though Greenways teachers increased theirs further, and the necessity of deep subject-related knowledge was clearly exposed. Both departments initially enjoyed rich (and sometimes constructively critical, and so diverse) neighbour interactions and decentralised control, but 'enabling constraints' of valid specimen papers and policy stability were limited; for High Wood also further active seeding of such constraints by effective leadership virtually disappeared.

In activity-theoretic terms, Section 8.2 again suggests that (perceived) limited availability of goal-consistent tools at High Wood undermined moves towards equilibrium in an initially leader-

destabilised system, and that successive policy changes and stresses on leadership similarly contributed tensions in rules and division of labour, allowing a change in purpose. In contrast, threats to motivation for outcome at Greenways appeared counteracted by distributed leaders acting to re-structure for stability.

Possible actions to address such threats are discussed below.

10.3 How can the gap be bridged?

There would appear to be a number of actions which could be taken to improve alignment of enaction with this policy's intent, and they vary in scale, as well as in ease of implementation. What is needed for one set of teachers might be counterproductive for others, e.g. in degree of autonomy afforded; however, there do seem to be some clear messages.

10.3.1 Policy documentation

Supporting Matland (1995), *clarity of policy intentions* could have been improved: exemplification of key constructs such as 'problem solving' in a variety of curriculum areas would clearly have enhanced shared understandings, including for Awarding Bodies, who can otherwise hide behind 'least challenge' interpretations that results in their specifications being more attractive to schools, as discussed above.

I have demonstrated that availability of sufficient supporting (and exemplifying) material is necessary for teacher change (though this study shows that 'sufficiency' is rather more subjective than might be thought), and that there appears to be positive benefit in a group of teachers deciding they need to develop their own materials. There would seem to be no 'one size fits all' ideal level of provision, though even Greenways often started with bespoke materials and then adapted them; further, the time and energy needed to develop a comprehensive scheme of work to support consistency and appropriateness of teaching, should not be underestimated. This study suggests documentation at all levels needs sufficient clarity to support appropriate enactions, while allowing a degree of 'writerliness' that allows adaptation to local situations and development of 'ownership' but precludes 'lethal mutation' (Brown and Campione 1996).

10.3.2 Curriculum Policy

Rapid successive change of curriculum-related structures can be counterproductive, and stability could be better balanced with innovation, if even relatively capable teachers are not to struggle with the scale and frequency of change expected. The study demonstrates that high stakes performativity measures are not always well aligned with longterm valued goals; and in particular, that external assessments could be significantly more aligned with deep intended outcomes, that is, more valid.

Accountability measures, particularly in high stakes areas, can have unintended consequences when there are competing, not always consistent, valued policies whose outcomes might be less easily measurable. The Department for Education recently (October 2013) made some moves to address some of these issues, though no doubt these too will have unintended consequences.

10.3.3 Teacher occupational capacity

I have argued that these two departments began the study with an unusually good store of professional capacity, and that the changes entailed in a principled enaction made enormous demands on those. What, then, of the majority of mathematics departments (Ofsted 2012) who have a smaller intrinsic professional resource? The alternatives would appear to be to adopt less demanding policies, or to support the development of teacher capacity to engage productively with the intended demands. In terms of aspiration, the latter would appear to be preferable; additionally, I cite in chapter 2 evidence that challenging expectations can, as in this study, catalyse the development of professional skills and knowledge – but have suggested with reference to the Curee/QCDA (2009) work that this needs to be both framed in terms of a 'reasonable' policy and to have realistic, appropriately supported, aspirations. Coherent approaches to teacher development are still under discussion in this country, in e.g. ACME (2013), but how could my expanded notion of the occupational capacity of mathematics teachers be applied?

The study suggests leadership at all levels, but especially department level, should support professional reflection and positive affect, supporting Watson and de Geest's (2010) 'critical professionalism' and Spillane's (1999) necessary conditions for change; it should build up distributed leadership and a genuine professional learning community to support perturbations in context, whatever the source, and it should be alert to and challenge the adoption of 'survival' approaches at the expense of principled decisions. A *mastery* mindset should be developed by

supporting distributed autonomy and the embrace of challenge at an appropriate level, encouraging efforts for principled enactions and tolerating associated failures (Edwards 2007, Newman 2004), but what is effective in a given context depends on both senior and department-level leaders knowing teachers individually and responding to build up appropriate skills, knowledge and affect, so makes enormous demands on leadership.

All this can be supported by the valuing (by the range of players) of such efforts and outcomes in sustained approaches to teacher and leadership development, and assessment of (that is, proxy valuing of) those by accountability bodies such as Ofsted. In particular, those involved in teacher initial and continuing education at any level and through any structures should take steps to build up positive affect and appreciation of the affordances of professional learning communities, as well as knowledge and skills, including, importantly, the range of reflective skills. This suggests that the development of teachers is a task which is highly demanding in terms of both skills and specialist knowledge; it needs to be sensitive to context and to subject-specific challenges, to be both challenging and affirming. There is no 'golden bullet': if we want classroom practices aligned with our understanding (and the evidence) of what best supports valued learning, we have a substantial, sustained and sensitive job to do in terms of teacher development. This will take investment of time, money, effort and expertise, as well as policy coherence and consistency, amounting together to 'enabling constraints' in complexity terms, and achievement lies well beyond current political timescales, as well as being outside party-political boundaries.

With a complexity lens on principled GCSE enaction, then, I have suggested that even where the considerable demands on redundancy and diversity of related teacher characteristics, and deep interactions of ideas, were available, these were threatened by limitations of 'enabling constraints' in the wider policy context. Similarly, to the extent that teachers and departments behaved as activity systems, perceptions of lack of availability of appropriate tools, reasonable management of division of labour, and rules aligned with the espoused enaction, at times threatened change. In High Wood's case, these threats were exacerbated by limited leadership to seed 'attractors' for such constraints, or to structure for sustained tensions with previous practice, respectively.

CHAPTER 11: REFLECTIONS AND CONCLUSIONS

11.1 Bringing the analysis together

I have analysed how two mathematics departments responded to challenging, but widely valued, policy change, and interpreted that in terms of the enaction process, adding to understanding of policy enaction at classroom level. I have, further, developed for predictive purposes the enaction theoretic tool of 'policy player roles'. The study has underlined the breadth and layers of issues inherent in the policy/practice interface in mathematics education, and in so doing has exposed the need for a broader understanding of the characteristics contributing to a teacher 'occupational capacity' to engage with such change. I have developed a proposal for such a construct, developing Winch's (2010) model to incorporate the individual and collective, the social and affective. The study builds on Llinares and Krainer (2006), which evidences the centrality of social dimension, organisational context and teacher reflection for understanding teacher learning, and it does so in a very grounded way, since none of those was an original focus.

Each of activity theoretic and complexity models of enaction not only offered sensitisers to differences between the two departments, but also explanations as to why the identified differential characteristics should impact on enaction. Overall, complexity models seemed to better model enaction, whether with expansive or more restrictive possibilities, in that enaction largely appeared to emerge in adaptive, holistic and sometimes apparently unpredictable ways. However, at different critical points in this longitudinal study, each of the departments behaved in more centralised, atomistic and structured ways more typical of activity systems.

11.1.1 An expanded typology of policy players

In trying to understand how differential enaction pathways came to be adopted, I have argued that individual teacher characteristics served to delimit the roles which teachers can adopt in relation to policy enaction. In doing so, I have been able to further characterize Ball et al's (2012) policy actor typology (although I prefer 'player', for the reasons explained), and show that it requires at least the addition of a 'survivor' type, as well as differentiation of 'critic' roles. The former in particular is important because Ofsted (2008), (2012) suggest such teachers are widespread and, significantly, that this group of teachers has an impact on the implementation of

valued outcomes. I have additionally shown how the (expanded) typology might be used not only to describe but to predict: in this analysis, a particularly helpful lens was that of Davis and Simmt (2003), suggesting that demanding change is supported by both redundancy (e.g. commonality of both goals, and language and tools with which to address those), and diversity (e.g. availability of distributed leadership and varied backgrounds). These insights suggest that it is necessary to consider the *profile* of available policy roles within a department to understand its functioning in relation to that policy.

11.1.2 An occupational capacity construct for mathematics teachers

If the situation described in, and inferred from, this study is to be addressed, that might be achieved through policy and teacher development. The former is addressed in Section 11.1.3; the latter requires the addressing of at least identified differential characteristics, as part of a broader understanding of what it takes to become an effective mathematics teacher. I have argued that such understanding is ideally available at two levels: first, via a high level occupational capacity model encompassing the range of characteristics necessary for sustained and extensive effectiveness, that would be used to ensure the necessary balance and scope of teacher development and policy; and secondly, a range of lower level models of what is needed to build up each of the relevant facets of this occupational capacity. These latter would vary over time, context and culture.

11.1.3 How could validity of policy enactment be improved?

In chapter 10 I suggested several ways in which the study suggests policy could better support the espoused changes. First, it exposes the importance of building up a range of positive goal-related affect as an integral part of teacher development, including self-efficacy relative to the changes, resilience, intrinsic motivation, embrace of risk and challenge, and dispositions for, and valuing of, both professional learning, including the use of external expertise, and collaboration. It underlines the importance of structured and informed leadership at department level, and the centrality of continuous deeply reflective habits within an informed, challenging and supportive learning-focused community, to support teacher learning.

All these have implications for practice in teacher development, at department, school and wider levels, including Higher Education; but also for the valuing of them in policy. For example, policy valuing of perhaps well-designed department leadership or subject-specific mentoring

courses could build up not only those individuals, but also enable them to facilitate distributed capacity within their departments. Although it was not a focus of this study, fieldwork also exposed the challenging demands a principled enaction makes on subject-specific expertise, whose nurture needs a mixture of expert-developed and classroom-developed experiences, supported by focused reflection with informed others (Kunter et al. 2013), and that has implications for the nature and structures of teacher development.

More generally, the study adds to the evidence base for our understanding of the importance of consistency within and across policies, and clarity and stability in education policy, particularly where the policy relates to high-stakes assessments, when scope for interpretation to mitigate unintended consequences is likely to be severely limited. It confirms the critical role of validity in assessment: we need to take steps to better measure what we value, rather than tacitly valuing what we can easily measure. These are not new findings: in recent months they have been echoed by for example The Royal Society (2014). There are of course some political disincentives to their implementation, not least of which are the political timescale, and the imperative of individual politicians being seen to make a short-term apparent impact on education: Mourshead, Chijioke, and Barber (2010) suggest such constraints have a high cost throughout education policy. Although there is clearly an argument for an education system to be responsive to changing political will, perhaps a rethink of the range and scope of party political influence in education is needed.

11.1.4 Caveats and limitations

There is a danger of 'exposing' what one sets out to look for, and although in this case the outcomes are profoundly 'grounded' in that they lie outside the original focus of teacher knowledge and beliefs, if partly related to the latter, it is still true that once putative differential characteristics were surfaced, it required conscious effort to look for where these might *not* be supported, and for this I am very grateful to the critical input of both research and teaching colleagues. Similarly, I have tried to approach new literature with a view to actively seeking contra-indicators to study findings. There remains a non-unique interpretation of the data, and a different researcher would both have acquired different data through differential iterations, and have made different interpretations. Nevertheless, the study participants say they recognize a recent version of this account as valid (email communications, June 2014), and I argue, in line with Jaworski (1997) that validity lies ultimately in the degree to which an informed reader is convinced by what is written – though this should apply to a range of readers as well as participants.

Some colleagues have asked how High Wood teachers feel about the way their development in this study is portrayed. It should be stressed that in terms of centrally-valued performance measures High Wood students continue to perform well in national terms, and that Ofsted (2012) suggests that at Key Stage 4 their practice is less examination-driven than that in many departments in England, while at Key Stage 3 it remains more conception- and process- driven than is usual: this study merely offers some possible reasons why they did not progress further towards the enaction to which they originally aspired. Moreover, as above, both Kathy and Norman gave affirmative feedback on the draft thesis in Summer 2014.

There is an internal uncertainty effect: I have shown e.g. in chapter 4 that my role in catalyzing thinking about the espoused change was recognized by participants, and outcomes would undoubtedly have been different had I not been conducting the research. I was not an invisible and neutral observer, but participated in study-related changes in both departments via different roles, as well as through my role as researcher, bringing with me values, beliefs and a range of subjectivities. Although as described in chapter 3 I endeavoured to both adopt an 'outsider' lens as a researcher and also separate my role as researcher from my professional roles in the two schools, that was simply not possible all the time, and on occasion there were definite advantages to having 'insider' knowledge. There remains no way of knowing how enaction would have differed had I not been present in the two departments. Nevertheless, my presence is likely to have been an additional motivation: it is hard to see why enaction would have been less principled in my absence, and if my presence increased Greenways' commitment that does not invalidate the findings, but rather serves to suggest a (not always available) source of positive goal-related affect.

Study interpretations and theorization of teacher occupational capacity partly rest on the use of research conducted in related but different contexts, and sometimes on small-scale work, for example with school students rather than teachers, where closer matching to the study situation was not available. This had the advantage of raising issues and suggesting lines of investigation, and I endeavoured to maintain scepticism as to direct transferability. It means parts of the evidence edifice on which the study is built have less deep foundations than others, but opened up possibilities in a way which would otherwise not have been possible, for example in considering teachers' response to challenge. Other researchers might have decided not to pursue such areas.

What does the thesis offer in terms of generalizability? I have argued that the power of this study rests on the 'telling' nature of the sample, which was also unexpectedly fruitful in exposing the challenges in making a principled enaction of the GCSE: for other departments there will be

different factors in play. Further, the situation is very different with a contested policy, raising questions of ethics as well as capacity. One facet of claimed generalisability is that the study findings are consistent with, though in some respects extending, a range of other empirical and theoretical work, including Winch's (2010) construct of teacher occupational capacity and Ball, Maguire and Braun's (2012) policy role typology. It adds to the empirical base for enaction work. However, small-scale research will always be vulnerable to charges of over-generalisation, and ultimately, as with validity, any such claims depend on the extent to which my arguments resonate with, convince, and are useful to those in related research, policy and teacher education communities.

In terms of a contribution to our understanding of teacher expertise or occupational capacity, I do not claim that the model offered is complete: for example there are other relationships between the component variables. Additionally, there may well be factors not exposed in this study, or that I simply did not engage with, through either ignorance or oversight – but I do offer what colleagues recognize as *a* high-level part-model for teacher development policy and structure, even if for translating into development practice, its different aspects need exemplification using other frameworks, such as knowledge typologies: different purposes benefit from different types of model. At the least, my development of Winch's (2010) model raises questions about the roles of development of goal-related affect (beliefs, emotions, dispositions and values), and understanding and nurturing of structured and learning-focused collaboration: how can initial and ongoing teacher development harness the greater potential these aspects appear (in my study and elsewhere) to make available, and how can policy support that?

The model of occupational capacity developed is grounded in a study of teachers of GCSE mathematics; however, I suggest the structure is worth investigating not only for teachers, but as a generic occupational construct, as Winch's (2010) model intends.

11.2 My own learning

This study served to catalyse a higher level of personal reflective engagement in the range of fields of my current professional functioning: as a pre- and in-service teacher developer, as an education policy-engaged professional, and as a researcher. When I embarked on the study I was unaware of much of the literature discussed above: the need to engage with it was grounded in analysis of and reflection on emergent data.

My understanding of the affordances and constraints of small-scale qualitative research has developed considerably, with a deeper understanding of the subjectivity of interpretation and outcomes. I am now in a position to give future work the benefit of initial theorization of the (explicit and implied) terms of the research questions and a deeper analysis of the ideas and variables underlying my research questions. I understand the implications of prompt analysis of emergent data to support productivity of successive iterations of observations and interviews, and allow emergent new foci to be pursued at an early stage, and in future work I might pilot use of video recording of lessons in order to make a grounded evaluation of the costs and benefits of that. Where evidence from highly comparable situations was not available my use of distal results was often productive, and perhaps there is more to be learned by plundering e.g. the student learning literature when we want to know about teacher learning: not to translate results unthinkingly, but to use them to frame possibilities and lines of enquiry. Similarly, I am aware that my use of multiple theoretical lenses primarily as 'sensitizers' to what might be underlying data, is non-standard: however, I have shown these opened up new understandings for me.

On balance, I would claim the study benefited from my role as a part-insider, despite the threats discussed: apart from the sustained access available, the added incentives for departments to 'succeed' in their efforts because they were open to a familiar scrutineer must surely mean that the difficulties evidenced are if anything under-stated. In many ways I was a 'boundary-crosser', with associated tensions and interactions between roles, goals and communications as teacher, teacher-developer and researcher especially, and this too provided advantage as my reflection on data often crossed the boundaries. I endeavoured to make ethical choices as discussed, and certainly expanded my own diversity of thinking, especially that related to the complexity, and especially, uncertainty of both teacher and student learning, as individuals and as groups.

As a policy-engaged professional, the study offers me further evidence to support well-known issues, and also new sensitivities, lenses and proposals that require flagging-up, dissemination and further investigation. Some findings bear directly on my work in teacher development, for example the exposed need for development of a range of positive goal-related affect, including the centrality of building up valuing of structured collaboration, and those are already being applied. In terms of new understandings, findings highlight the breadth of reflective palette needed, but primarily the sheer complexity of the professional change needed not only for a principled enactment of GCSE 2010, but of the still more ambitious curriculum reforms proposed for enaction from September 2014. Although this study suggests that aspiring to what we understand to be 'the best' can sometimes undermine development of 'the good', it also suggests ways in which we can support the likelihood of changes in the direction espoused.

11.3 Unresolved research questions

The outcomes of this study are of two kinds: some add to an already extant evidence base relating to the challenges of large-scale and deep change in mathematics teaching, and I have suggested some ways in which, with political will and sufficient resources, those could begin to be addressed, while recognizing that prioritization is involved in deciding to do so. The study underlines that at present, even with teachers who are well-placed to engage with reform, the enaction of policy at classroom level can be far removed from intentions, leading to systemic loss of validity. Regarding the whole policy-related system from government agent to classroom as complex, there are insufficient 'enabling constraints'; the degree of decentralisation of control needed varies for different (varied scale) players; and many teachers do not yet have available the capacity to offer the internal diversity and redundancy necessary to support expansive change.

Other findings offer evidence for new insights in our understanding of teacher occupational capacity and how that can frame the available possibilities for policy/practice interface in this area: both aspects need further research. I have used data from fieldwork to support further theorization of (possibly generalizable) constructs of mathematics teacher occupational capacity at both an individual and a department level, suggesting ways in which these might relate to one another, as well as how they might delineate the policy player roles, and hence the policy enactions, available to teachers. The proposed implications for teacher development policy and practice have potential for testing and if appropriate, scaling. In particular, it is likely there are other aspects of affect which are pertinent for departments in different situations, as well as other necessary teacher characteristics already evident in the literature but which I have not yet incorporated into the model. The whole capacity model needs further testing and development, in particular in relation to other relationships between the variables, and a better grasp of how, and to what extent, we can realistically develop valuable teacher characteristics, whether knowledge of some kind or affect. In principle the model could usefully be developed not only for Primary teachers of mathematics, but for other teachers and perhaps beyond teaching: what is the same, and what needs to differ, for individuals and for communities within occupations?

Appendix 24 shows serendipitous evidence from Summer 2014: an ongoing state of flux is clear, underlining rather than resolving the findings, and implications of, the original study. I reiterate that mathematics education aligned with the intentions of the study policy is widely

valued, and I have exposed some aspects of what teachers appear to need to enact that: work is urgently needed to develop further classroom-level evidence, and to address the building-up of related teacher capacity.

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APPENDICES

Appendix 1: Memo - Commensurability of theoretical lenses for this study

In Section 1.6.3 I justify my adoption of a variety of theoretical lenses and discuss the issues this raises, even though later chapters demonstrate their role in sensitising me to facets of the emerging data. Here I compare different lenses on aspects of the enaction, demonstrating that at least earlier versions of Activity Theory offer quite different – and often complementary – understandings from those resulting from Davis and Simmt's (2003) complexivist lens. In Section 1.6.3 I also suggest that with Engestrom's later development of third-generation activity theory, exemplified in e.g. Engestrom (2005), the contrasts are less marked. My conclusion is that complexivist and alter activity theoretic lenses are often complementary, enabling easy comparison; and that other theoretic lenses employed, notably PLC, occupational capacity and enaction theory, are locally integrable into either, in Prediger's (2009) terms.

	Activity lens (Engestrom, 1997, 1999)	***Complexity lens (Davis and Simmt, 2003)***
Purpose/outcome	Deterministic teacher learning, e.g. through production of a new scheme of work. Inherently social and contextual analysis.	Emergent, unpredictable teacher learning. Collective behaviour is central. Includes both the contextualised and the non-contextualised.
Mechanism for change	Top-down: tensions between present teaching (as represented in SoW) and espoused enaction, mediated by tools. *Expansive transformation* takes place when rules and conventions are challenged.	Bottom-up: self-organising, adaptive, emergent and unpredictable, arising through interactions. *Expansive transformations* need internal diversity and redundancy, rich interactions, and decentralised control
Unit of analysis	Individual teacher within the social setting, or department: inherently contextualised. Perhaps atomistic.	Individual teacher nested in department (each a complex system). Holistic.
Key variables	The activity (provides meaning and purpose), the subject, object, outcome, tools, social setting, division of labour	Interactions and behaviour of agents, diversity and redundancy of attributes, enabling constraints, decentralisation of control
Constrained by	Rules and conventions	Similar rules, here seen as potentially enabling constraints
Role of leadership	To destabilise the structure in the desired direction	To seed 'attractors' which are enabling constraints
Role of history	Markovian (history is subsumed in analysis of the present)	Non-Markovian: the system has memory
Teacher learning	Results from tensions between an individual or group's present capacity and what is needed for the outcome, provided tools are available to support that development: to be expansive,	Is unpredictable in detail, but expansive learning emerges (at individual or distributed level) in a self-organising way through interactions of agents, supported by

	some part of the system must challenge the norms or object. Socially and contextually understood.	interactions, diversity and redundancy in the system. Socially and contextually understood.
Occupational capacity including knowledge etc.	Tools which also affect goals and motivations (the purpose of the activity)	If sufficiently wide and deep, provides the necessary diversity and redundancy; beliefs can act as 'attractors'- enabling constraints. Collaborative and learning dispositions can serve to enable deep neighbour interactions.
Policy enaction	Roles relate to the division of labour. Boundary objects and boundary crossers enable communication between successive layers or systems of policy enaction.	Roles frame neighbour interactions; diversity and redundancy of roles needed for expansive change
Communities of practice/PLC	Provide the necessary social context: for a CoP the object is well-defined, goals are shared and learning teachers increasingly participate in the central activity. For a PLC there is greater structure (so a tighter activity framework and better defined espoused outcome), with reflective dialogue and deprivatisation of practice framing rules and acting as tools.	A CoP is a complex organism with collective behaviour framed by shared goals and values but uncertain outcomes; in a PLC a greater structure provides an enabling constraint which acts as an 'attractor'; reflective dialogue and deprivatisation of practice might boost both diversity and redundancy internally, so boosting the likelihood of expansive change of the sort espoused, though details will remain non-deterministic.

Appendix 2: Literature inclusion/exclusion

As suggested in Section 2.1.2, I conducted core searches using Web of Science, Googlescholar and ERIC, complemented by searches of recent issues of key journals (Journal of Education Policy, Journal of Mathematics Teacher Education, Educational Studies in Mathematics and Journal of Research in Mathematics Education): as an indication of the scale involved, I show returns from Googlescholar. I also drew on key texts as below, together with references from those, and literature used for the pilot study (Golding 2011). Initial search terms are indicated below, but I prioritised peer-reviewed papers by recency (post 2000) and apparent relevance, scanning titles and abstracts on the first 20 pages of each set of results. Large numbers meant I largely focused on key theorists, influential (widely-cited) papers and reviews, trying to focus tightly in line with Maxwell (2006). In order to counter Maclure's (2005) critique of systematic reviews in particular as resulting in superficial quality and evaluation I generally endeavoured to follow up and evaluate papers which seemed to have potential to add significantly to my understanding. My additional use of 'grey' literature was facilitated by my grounding in the study field – although that of course invites charges of bias which it's hard to rebut given the lack of comprehensive database for such sources. As in 2.1.1, I argue that my use of literature is not claimed to be comprehensive, but to include key ideas that frame thinking around the extent to which teachers enact (particularly mathematics) policy, and characteristics affecting their capacity to do so.

Focus area and key texts	***Search terms, sorted by 2000-, and relevance (Googlescholar returns)***	***Inclusion/exclusion criteria***
Education policy enaction Ball, Maguire, and Braun (2012); Supovitz and Weinbaum (2008); Spillane (1999, 2004); Cobb and Jackson (2012).	Initial searches on 'mathematics+education+policy'(1.38 million) were refined using 'implementation'(87,900), 'enaction/enactment'(17,300), 'context'(66,200) and 'roles'(17,600); +'England' produced little different that seemed relevant to the study	I excluded papers focused on e.g. social justice issues or very different policy contexts that appeared tangential to the study.
Teacher learning/development/change Wood (2008); Even and Ball (2008)	'teacher+(learning 1.44 mill/526k or development 1.45 mill/497k or change 1.36 mill/411k)', with or without 'mathematics', and 'occupation+(learning 942k or development 1.35mill or change 1.29mill)' 'Learning of groups' 912k (+'mathematics teacher' 18k) 'Learning communities' 1.4mill (+'mathematics teacher' 18k)	I excluded literature focusing on new or preservice teachers. Substantial overlap in key papers across these search terms.
Teacher occupational capacity/expertise/competence Rowland and Ruthven (2011); Young and Muller (2014); Kunter et al (2013); Leder, Pehkhonen and Torner (2002); Cochran-Smith et al. (2008)	'mathematics+teacher+(knowledge or beliefs)' 535k/67k 'Teacher capacity' 1.08mill (+'group 969k)(+'mathematics' 139k)(+both 19k) 'Teacher expertise' 238k (+'group'169k)(+'mathematics' 66k)(+both 29k) 'Teacher competence' 498k (+'group'127k)(+'mathematics' 20k)(+both 19k)	I excluded literature relating to preservice or new teachers. Substantial overlap in key papers across these search terms

Appendix 3: Memo - Johnson and Millett for secondary departments

Johnson and Millett (1996) suggest six linked constructs in coordinators that positively affected speed and effectiveness of change: to what extent do these apply to secondary Heads of Department? I used their analysis to catalyse parallel thinking and so sensitise me to aspects of the study leadership data which I might otherwise not have noticed. This is discussed in Section 8.3.2.

Primary	Secondary: Greenways	Secondary: High Wood
Enthusiasm for lead role	Nigel largely maintained enthusiasm for a principled enaction	Kathy's initial commitment to principled enactment dissipated within the first year and was not compensated for by others
Clarity of vision about priorities for action and pedagogy	Clear priorities agreed by almost all teachers, and maintained by Carol (and to a lesser extent by Gillian) when Nigel's focus wavered	Shared clear vision espoused but apparently fragile: it became diluted for all teachers once other unexpected stresses appeared
Balance between HT and coordinator	Nigel given messages of support for extensive autonomy from management: school enquiry based ethos, with (short-term) failure an acceptable phase	Kathy similarly supported from my viewpoint, but department felt not 'trusted' by response to dip in results.
Coherence and consistency within maths teaching in the school	Department managed to maintain strong PLC working for joint principled goals, tolerating some variations on enaction but challenging others (balance between autonomy and consistency). SoW exposes process as well as content.	Coherence threatened by lack of progress towards effective principled SoW; some recouped by 'minimal change' model. SoW delineates content only, but enactment largely aligned with historical approach to process at KS4.
High priority given to resourcing the coordinator role	Sufficient resources transacted by Nigel: mathematics considered by school to be a priority for resourcing.	Similar resources available to High Wood, but not perceived as sufficient.
Availability and use of external support	Actively transacted, both from outside and from internal AST.	Fairly passively received from external AST.

Appendix 4: Memo - PLCs vs Expansive vs Teacher Learning Environments

In section 8.4 I discuss various candidates for modelling departmental functioning in relation to this enaction, particularly trying to incorporate characteristics that differentiated between the two departments. Both my key theoretical lenses include notions of 'expansive learning' and I sought a model which would also accommodate that. Here, I consider the adopted 'best fit' construct of a professional learning community (PLC)(Vescio, Ross and Adams 2008), showing that it requires conditions reasonably consistent with the characteristics claimed by Hodkinson and Hodkinson (2005) to be necessary to support expansive teacher learning.

PLC (Vescio, Ross and Adams 2008)	***Expansive ---------- -----Restrictive continuum (Hodkinson and Hodkinson 2005, 124)***	
Focus on collaboration, with shared professional practice	Close collaborative working	Isolated, individualist working
Shared values and vision for student learning, supportive leadership	Colleagues mutually supportive in enhancing student learning	Colleagues obstruct or do not support one another's learning
Highly focused, structured work on developing teaching for student learning, including high quality dialogue leading to extensive and continuing conversations among teachers about curriculum, instruction and student development	An explicit focus on teacher learning, as a dimension of normal working practices	No explicit focus on teacher learning, except to meet crises or imposed initiatives
Supportive conditions to achieve improvements in teacher development for student learning. Distributed authority to change practice (Supovitz, Sirinides, and May 2010) but use of external expert	Supported opportunities for personal development that goes beyond school or government priorities. Out of school educational opportunities including time to stand back, reflect and think differently	Teacher learning mainly strategic compliance with government or school agendas. Few out of school educational opportunities, only narrow, short training programmes
	Opportunities to integrate off the job learning into everyday practice	No opportunity to integrate off the job learning into everyday practice
	Opportunities to participate in more than one working group	Work restricted to home departmental teams within one school
Visiting and learning from other classrooms: de-privatisation of practice; expectation of drawing on external expertise whether through established research or support in developing professional practice for student learning.	Opportunity to extend professional identity through boundary crossing into other departments, school activities, schools and beyond	Opportunities for boundary crossing only come with a job change

Collective creativity; delegated responsibility for changing practice in the light of reflection on student learning.	Support for local variation in ways of working and learning for teachers and work groups	Standardised approaches to teacher learning are prescribed and imposed
Continuous collaborative teacher learning focused on improvinging student learning	Teachers use a wide range of learning opportunities	Teachers use a narrow range of learning approaches

Appendix 5: Excerpts from diary

The research diary was kept as a Word document, with key ideas highlighted retrospectively.

15. 03.12 Gillian i/v3:
Lots of increasing SK and SPK exposed, but also a motivation for mastery (is that the right term? She says she'll not crack it), and a S-E in relation to the new SoW that's not seen at HW. Very conscious of the role of the whole dept, and complementary backgrounds. Up for risk-taking and an apparently self-imposed challenging enaction. Need to look for the extent to which that's mirrored elsewhere. Clear learning disposition. If apparent elsewhere**, *try new codes**** to capture that – and keep ears open.

17.03.12 GW Dept meeting (see minutes)
Distributed resilience seen very clearly (several possible gremlins in year 11 preparation: very solution-focused, and on several fronts, clear determination to see this mastered, with better learning and better results). Nigel tried raising doubts but several others weren't having any. Very positive emotions on back of last set of student self-evaluations.

20.03.12 HW Dept meeting including planning for exam prep.
Seem very unsure of themselves – doubts expressed re new exam papers – and they're still resenting SLT intervention, and concerned re results above all. Strange – they are ultra-experienced. No-one seems willing to take leadership on this – Norman critiquing accurately but wants to revise as he's always done with the students he knows, so talk rather silo'ed. Discussion very much framed by what they've seen of SAMs (classic performativity speak, and often negative – very critical, almost determined not to see any positive in SAMs yet they're not dreadful, and some improvement on past papers). Also slow to share what they've been doing, or have done historically, as if they're not confident to do so. Want me to do some revision activities with classes, which sparked sharing of thoughts on my ideas. They said they enjoyed that, so the appreciation of sharing is still there. Keeping intervention work separate from research thinking is hard!

Appendix 6: Diary Memos

Memos were interspersed in my Research Diary as I reflected on what it and other information was telling me; I also kept a hand-written file of memos, from which Appendix 22 is taken.

Memo 23.03.2012
Analysis of last i/vs re knowledge in relation to newer-style questions shows GW exhibiting much deeper SPK and K of students than HW!! But that's partly reflecting their enaction – HW have seen their students only in more structured situations, largely. H has some confident insights into her students, but in part based on 'they don't engage with this' – but then says she hasn't gone there, which I suspected – the teaching I've seen has been very solid, but hasn't pushed the thinking and metacognition that's needed for some of these. N seems intent on avoiding such questions, and training his students to recognise them, rather than learn to deal with them – and on these papers is confident it won't affect outcomes because of the limited profile of questions. K just seems to think they're too hard to be doing in exams, and that her students will be fully occupied learning standard skills and techniques for Higher level – where have her sense of purpose and values gone? Which is interesting, since GW teachers are saying 'yes they're hard, and we're tackling it like this'. HW are acting like 'survivors', all of them in different ways, though a slightly different sort of survivor from Dan: how to identify the difference? HW are recognising their policy subversion and justifying it; Dan was not overtly recognising it, especially in public fora – he was just peripheral, and tangential, to enaction. It's not about critique: GW are very ready with the critique of ideas, and of practice – their own and others'. So there seem to be two sorts of critique going on, the 'let's make it better' sort and the 'this is a silly expectation' sort. It might in part be tied up with repeated change: they've all seen too much of it. But it's resulting in much less positive affect than at GW.

Memo 29.03.2012
Re-coded last set of interviews with new affective/reflective codes: seems to make sense, and has exposed differences on department lines, though also between individuals. Was it there earlier? Need to ***go back to i/vs 1 and 2**** to see, and also probe further, and ***listen with 'affect-sensitised' ears****.

Memo 10.07.2012
From the last observations, and following interviews, there seem to be several aspects of reflection that are making a difference at GW. There's the obvious reflection (on/for/in practice – evidence of all of those) running through their interviews, and that you can almost feel coming into life as you talk – but there's also the language they're appropriating to express developing experiences in the classroom. That makes sense –they need language to express their thinking about that. And they talk lots, in corridors, in maths office, over coffee.. especially compared with HW whose talk is often (at least what I hear) organisational or factual. But they're noticing more, or else sensitised to look for more (attention?), partly because they've structured to hand over some responsibility, so that's freeing them up – also to listen to what individuals and groups are saying. So altogether, reflective practice, supported by paying attention, noticing, listening (active? What do I know about different sorts of listening? ***Pursue*)*** and then developing language to express all that. Feeds into K of students of course. ***Add in range of reflective codes.****

Memo 12.06.2013
Role typology working well: how does it tie in with other characteristics, especially affect? And leadership activity? Go ***back to data and tabulate simultaneously**** – look for connections. Gut feel is there should be fairly clear ones: ***doublecheck**** the evidence for any you think you find!

Appendix 7: Interview Schedules, with probes

As described in chapter 3, the interview schedules were developed iteratively, informed by intervening fieldwork. For High Wood, because of timing of entry to the study, Interview schedules 1 and 2 were combined, as shown in Table 1.

Interview 1 Master

- *Introduction:* You've very kindly agreed to be part of this project, which is really probing the reasons why teachers here have set about implementing the new KS4 curriculum in the way they have. What we say will as you know be recorded, so I can concentrate on what you're saying without having to write it down simultaneously. Just to re-iterate, you're very welcome to withdraw from the project at any time for any reason, but I do hope that you'll actually find it stimulating and that you feel you benefit from the reflection involved. Are there any questions you'd like to as at this point? (pause) OK…..
- Can you give me a rough outline of your teaching background
- And your mathematical background? *Probe:* Is your knowledge of maths sufficient for you to teach as you'd like in the classroom? Can you give me an example (I could throw in an ex) (complexity of this in relation to beliefs about whether it matters if teachers know) Tell me some maths that went really well. Tell me some that didn't. Remember a case where you made a mathematical mistake or didn't know what to do.
- So how do you conceptualise (think about) mathematics?... What is doing mathematics about then? Is maths created or discovered, for example? **Or use Swan statement??** Give me an example. When were you surprised when you were teaching?
- And then you trained to teach….?
- What would you say has most shaped the development of your practice? Tell me a time when colleagues have been helpful for your development… and a time when…courses…… plain experience….. reading….Any particular experiences that have catalysed significant change in outlook for you?
- So how do you now think about mathematics teaching and learning?
- *Probe:* Is your knowledge of pedagogy, and of student learning, sufficient for you to teach as you'd like in the classroom?
- (*'what I hear you saying', 'give me an example'…how students learn mathematics? …..what it is they should be learning?*) *Probe:* Does that reflect what you think maths is, or do you have 'maths' and 'school maths' as separate ideas? Do you think of students as 'making mathematics' at all?…..your role in and around the classroom? …..their role in a maths classroom?
- How would you describe yourself as a maths teacher? Could probe more here, in relation to their background of T&L maths. Multiple identities???. **Pleasure.**
- As you know, I'm interested particularly in the new KS4 curriculum. What changes do you think are implied by the new curriculum?.... Do you think they are desirable changes?... Why? Is the new curriculum consistent with your conceptions about what students should be learning in a maths classroom?
- What's your perception of how it relates to the recent changes at KS3?
- To focus then on your KS4 situation: Can you describe for me your year 10 class?
- Can you describe to me how you're prepared for the changes at KS4?
- (What do you think your role is as HoD?)
- What then are you trying to do students that's the same as what you've historically done, and what's different? (Prompts: tasks/learning environment/interactions in the classroom) What about the role of curriculum materials? Are there any that have been particularly supportive? Have you developed any yourself? (and what impact has that had on you?)

- (What have you used to support you in those changes? Why have you chosen to do that, as a HoD?)
- (Is there anything else that could have happened, or been put in place, of any scale, that could have helped you, either individually or as a HoD?)
- Is it working how you'd anticipated? Why do you think that is? Do you think things would have been different with a different group of students?
- Anything else you'd like to tell me about your experiences with the new curriculum? *Probe:* Is there anything you're still working on, or you'd like to develop further? Are you able to enact your beliefs about maths teaching and learning with this curriculum, on either an individual or a departmental scale? Why (not)? Role of students/parents/department/school in supporting that. **Thank you before switching off tape….pursue in case anything else thrown up.**

Interview 2 Master

- You did a lesson on…. Is there anything you'd do differently another time? Why (not)?
- Why do you make links with real life? Across the ability range? Can you give me an example? And another?
- Do you value discovering for all? Why? Can you give me an example of when that worked? And one when it didn't? How do you balance learning by discovery with ensuring students move on in a way which is aligned with the rest of the mathematical community?
- (You've obviously used ICT quite extensively *or appropriate*) (in exploring the roles of coefficients in the equations of graphs). Why do you do that? What works, for you? What have you tried that didn't work so well? What are the pros and cons?
- What about the use of ICT in maths more widely? What do you use, how and why? Have you ever been surprised when the students were using ICT? When would you choose old-fashioned methods rather than using available ICT?
- You went on to probe links between what different students had found, and to extend their thinking about modelling. Why did you do that? How important do you think it is that students make links across their learning, backwards and forwards? How do you help them do that (can you give me an example?)
- Since we last met, the department has done quite a lot of work that relates to teaching priorities and KS4 developments. Would you like to tell me about them? (probe) Why did you think it was important to do (AME's stuff)?
- Any other thoughts emerging re KS4 Curriculum as you're implementing it, e.g. anything that emerged when you were writing reports or marking exams recently?
- Thanks.

Interview 3 Master

- The new GCSE has more unstructured questions, and more functional maths. What do you think of those changes? Are there other differences you've noticed in the papers, or were led to believe were happening and haven't noticed in the papers?
- Are these changes the right ones for a 21st century maths education? Do they support what you think is important in maths education? Is it consistent with the school's educational philosophy?
- How have you changed your teaching to accommodate those changes? (Can you give me an example) Is that different from what you've done previously? So what role does problem solving play in your classroom? Can you give me an example? What are the challenges in that, and how do you address them?

- And is that what you do at KS3?
- Have you had the support (moral or resource-based) you need to enact this change as you'd choose? (Can you give me an example)
- The new GCSE completes its first cycle this summer. Would you do something different with the year 10s you now have? Why?
- Can you look at this question. So thinking of your year 11 students…How would you prepare them to be able to answer a question like this?
- Where does it fit with the rest of your teaching?
- What would you anticipate they'd find hard?
- And is it the sort of thing we should be teaching them?
- Would your answers be different for your year 10 group? Why (not)?
- Reflecting on the final assessments, was there anything there that surprised you? How well did you feel the assessments were valid for the specification agreed? (Use 2 particularly 'new brand' questions for focus) What, if anything, had you done differently to prepare your students to answer this sort of question? Is there anything you'd change another time?
- Why do you think students find it hard to answer these sorts of questions? (Probe particular students: anyone particular in mind?) What role do you think classroom ethos has in helping them learn? (What do you do to develop that?) Do you think it makes a difference how well you know the students? (So what's the role of continuity of a teacher with a class (or continuity of the makeup of the class)? +/-?)
- To what extent are lesson or resource planning, and individuals' content or pedagogical knowledge, shared in the dept? (Is that about the right sort of balance, for you? For others? What is your role in the dept, your contribution? What are the day-to-day interactions in the dept?)
- Do you have any other comments about the new curriculum, any constraints on implementation, any other benefits we haven't talked about?

  - Thanks.

Interview 4 Master

- Reflecting on your enactment of the new GCSE with year 11, what has worked particularly well for you and what would you do different another time with a similar group? (probe: in developing FS? In developing an ability to tackle unfamiliar or multi-step questions? To investigate, invent or discover?
- Can you give me an example of a particularly successful rich task you've used to further those aims?)(check each of – FS, multistep, unfamiliar, investigative, invention…)
- Remind me what you personally were setting out to prioritise with that group. (Were you able to maintain your preferred learning priorities throughout the course or were there any impediments at any stage?)
- How do you balance learning of process with learning of skills and content? (Can you give me an example? Do you ever teach with a pure focus on process? Role of metacognition (paraphrase)?)
- How would you explain how resources for GCSE are organized within the dept, and how you use them? (Can you give me an example of recently-developed resources you think have been particularly successful, and why).
- What about electronic resources? How have you, or would you like to, use those to support learning in KS4? Are there any impediments to that? Are there any ways in which you have reorganized your teaching, or your understanding of learning, to accommodate the use of technology?) So how is the dept working to develop KS4 further? (What needs do you personally have in relation to fully developing your teaching of it? What other input or

discussion or resources would support you, or others, in making an even better job of it?)
What have you learnt as a teacher in implementing the new GCSE?

Thanks

Interview 5 Master

- Tell me about the GCSE outcomes for your year 11 last year. Was that a fair reflection of their achievement? Did it reflect the balance in the curriculum accurately? So what went particularly well, and what would you do differently another time? Anything to learn from the preparation of the students last year?
- You'd already taken the decision to write a new SoW to fit linear assessment. Was there anything in the GCSE results that made you rethink, or on analysis make you want to alter the preparations you'd already made?
- So just remind me what changes you were intending to make with the new SoW?
- And how's that developed beyond when I saw you towards the end of last term? Have you actually been able to introduce more PS – how?
- And how's it working out in practice?
- What are the strengths of the department that will allow this to work?
- Re new EBC proposals, if you were answering in principle, what would your reaction be?
- Any particular implications for this department or for you personally? (What do you feel about starting again, or would you aim to morph what you have? What implications does another change have? You mentioned change fatigue, and limited time:
  if you spend time revamping, what goes? What are the costs of change?

  Thank you.

Appendix 8: 'New style' GCSE questions referred to in Interview 3

Chapter 3 explains the use of this tool, developed to probe teacher knowledge and beliefs about the new GCSE. ***Questions were taken from Edexcel 'Mock' GCSE Examination papers approved by Ofqual 2010, in the public domain.***

Teachers were asked to comment about questions their students might be tackling: those labelled 'FH' appeared on papers at both Foundation and Higher level; those labelled 'F' only on Foundation, etc. Presentation was maintained for teachers' use, but not here.

1F*. Maddie says that 0.3 is halfway between 20% and $\frac{4}{5}$. Is Maddie correct? You must explain your answer.

2FH*. Guy wants to find out how much time people spend watching television. He will design a questionnaire. Design a suitable question for Guy's questionnaire.

3FH* Mrs Miller is planning a party for 70 children. She will give each child a party bag to take home. She will put a hat and a toy in each party bag. Party bags are sold in packs of 12

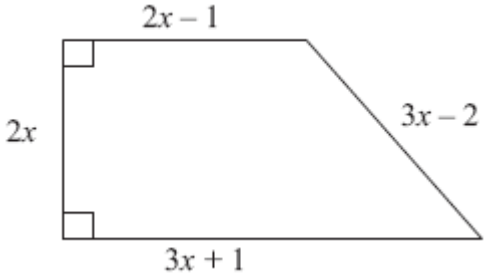
Hats are sold in packs of 8

Toys are sold in packs of 9

Mrs Miller buys the smallest possible number of packs of hats, toys and bags. She can fill more party bags than she needs. How many more?

4FH*. The diagram shows a trapezium.

Diagram **NOT to scale**



In the diagram, all measurements are in centimetres.
The perimeter of the trapezium is 38 cm. Work out the **area** of the trapezium.

5FH*. Tim is travelling home from holiday by plane. He buys some food and drink on the plane.

Price List

Cheese Roll	£3.50
Crisps	£1.20
Chocolate bar	£1.30
Coffee	£2.50
Tea	£2.00
Orange Juice	£2.20

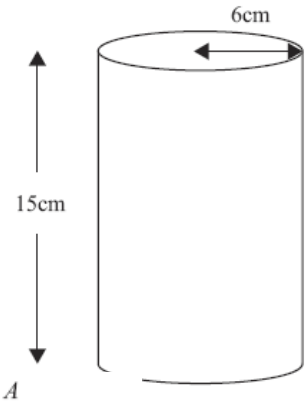
Exchange rate £1 = 1.25 euros

Tim buys two cheese rolls, a coffee and an orange juice.

He pays part of the cost with a 10 euro note. He pays the rest of the cost in pounds (£).

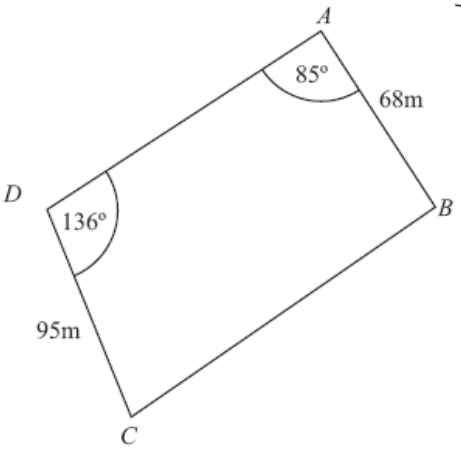
How much does Tim pay in pounds?

6FH*. Jenny fills some empty flowerpots completely with compost.



Each flowerpot is in the shape of a cylinder of height 15 cm and radius 6 cm. She has a 15 litre bag of compost. She fills up each flowerpot completely. How many flowerpots can she fill? You must show your working.

7H* The diagram shows the plan of a field.

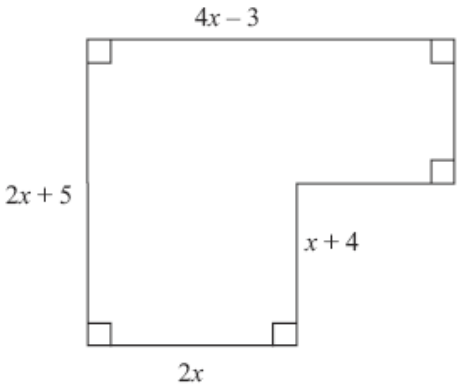


DB = 240 m. Work out the area of the field. Give your answer correct to 3 significant figures.

8H* The diagram below shows a hexagon.

All the measurements are in centimetres.

The area of this shape is 102 cm^2. Work out the length of the longest side of the shape.



Appendix 9: High Wood Department Development meeting November 2011

As explained in chapter 1, I was directed to work in High Wood in Autumn 2011, with a brief to evaluate department functioning and their analysis of GCSE outcomes, following an unexpected dip, and to support further development of both. In section 3.5.2 I discuss the tensions this 'insider researcher' role created, and in chapter 5 consider the impact such an external intervention appeared to have on the teachers concerned. Here, since the outcomes formed part of the documentary and informal observation base drawn on in chapter 5, I include the structure for the only department meeting run by me during the intervention (although it was negotiated with Kathy): other whole-department contacts were as part of meetings run by Kathy. Here, the object was to acquire a shared understanding and basis for future intervention work, although as described in chapters 1 and 5, we had worked together on a different basis for several years.

My role: fruits of Thursday's work (outline).

Structure this pm: ***Period 4*****:** The 'big picture' for the department. Developing independence, including book scrutiny. ***After school:*** *Revision*: what ideas do we have between us for ways to make revision engaging and memorable to the students? How can these be synthesized into a positive experience over the period a) before Mocks on 14 March and b) after mocks and into study leave?

Session 1: Consequences: Answer next question, then fold over and pass to your left.

- We're very aware of exam results and clearly those are important for the students. What else are you aiming to do as a maths teacher? What's the 'big picture' for you, in terms of teaching maths and of teaching young people?
- Is there a difference between school maths and 'mathematics', other than in complexity and sophistication? Is maths created or discovered? How should that play out in a classroom?
- How do you understand the changes that have been made to GCSE mathematics for the students currently in year 11 onward? Are they the right ones? Why(not)?
- What do you think are the strengths of this department in developing young people and developing their mathematical skills and concepts? (think of these either separately or together, as you prefer)
- What do you think the department could usefully work on so that the students get a better maths education? What support/resources would you need from outside the department in order to do that? Include here any skills, knowledge or abilities you would like to develop individually (and then talk with your line manager about them!).

Round the table: what do you do (individually or as a department) to develop students' skills for independent (lifelong) learning? *Ensure we include* formative feedback, discipline in setting out and communicating solutions, self- and peer-marking, SSR as JG

Book Scrutiny: a) *formative feedback* (how frequently can/should this be done, realistically? b) *what is students presentation and clarity like?* Of notes? Of worked examples? Why does it matter? What do you already do that works well? How can it be improved?

Revision ideas/planning for active engagement

Appendix 10: Characteristics of individual teachers at Greenways

15a Nigel, the Head of Department

Chapter 2 shows how with either a Complexity Theory or an Activity Theory lens, the role of the Head of Department may be critical, either as an 'attractor' facilitator of goals or as an imposer of systems to support change, respectively. In either case, the Head of Department has considerable responsibilities for the 'zone of enactment' in Spillane's (1999) terms. I showed above that in Greenways' case the leadership appeared well distributed, and that is borne out by interview data below, supporting a complexity model of leadership. Implications of that are discussed in chapter 9.

Nigel was inexperienced when appointed to the role, but described himself as 'dynamic, whizzy….I think the students enjoy doing maths with me' (interview 1), and that positive self-image persisted throughout the study. He was primarily a *narrator* in Ball et al's (2011a) terms, although he also had a significant role as a *transactor*, for example convincing the Head to support this approach to the new GCSE despite a clear risk to outcome grades. Although constrained by my continuing presence and influence in the department, he habitually led from the front, 'joining up disparate policies into an institutional narrative' (Ball, Maguire, and Braun 2012). He seemed very aware of the advantages of promoting both himself and the department to a range of stakeholders, and was also skilled at 'rehearsing a preferred presentation' (Ball et al. 2011a), with an obvious threat to authenticity of interview data. His final interview appeared considerably less 'rehearsed': perhaps because he felt more secure after successful first results, perhaps because of my own greater distance from the department by that time.

What did Nigel believe about mathematics, teaching and learning? He described mathematics as 'a toolkit for solving problems' (Interview 1), though his student-focused talk was framed very much in terms of 'it's important they succeed – ideally I'd like to think they got it all by understanding, but in the end that's not how they're measured' (interview 1) and his classroom showed a mix of open invitations of 'what do we think about that? Anybody like to add, or comment' with 'if that doesn't make sense, just try to remember it: you'll very likely need it for the exam' (observation 4). Even in this comparatively risk-taking department, we see how assessment can frame what happens at classroom level: as Hernandez-Martinez and Williams (2009) argue, the high-stakes nature of GCSE mathematics for all concerned means it's critical therefore that summative assessment is consistent with curriculum intentions.

Nigel appeared confident he had sufficient knowledge for teaching, though unclear about how he acquired that: 'experience, probably, just doing it'. His pedagogical responses to 'new-style' GCSE questions in interview 4 showed competent and confident handling of the range, but unsurprisingly given his relative inexperience, a limited repertoire of approaches to link-making across the curriculum, or to describing the building-up of understanding of e.g. algebraic fractions in context. On probing about his professional learning, he claimed 'it's very supportive as a department, very supportive as a school' and that his own experiences at school were, in contrast to what the department were targeting, highly procedural : he seemed unwilling, or unable, to describe his pathway to current beliefs. He also claimed good knowledge for his role: he had followed an unusually (Ofsted 2008) extended development course undertaken in preparation for it, though he did not refer to that until Interview 5.

Nigel's apparent confidence about his knowledge-base was reflected in the way he responded to questions about new assessments, variation in colleagues' implementation of the Scheme of Work, plans for the future. He talked about himself as a 'facilitator' of independent learning, building up 'learning strategies', though elaborating

> ‘they have to learn strategies, and that’s our job as a teacher, to teach them the strategies…if you realize they need something else to say ‘OK you need something new’, and then to teach it to them’ *Interview 2,*

which is not as entirely student-centred as his rhetoric. By interview 5, he responded less assuredly, though in greater depth, and acknowledged development and support from elsewhere:

> ‘I think, along the way, I’ve been given lots of prompts of confidence, for example X confirming things and encouraging, and saying ‘have you tried this’’. And later, ‘and then you gain lots from talking about the different ways you do things, sharing all those ideas that otherwise might not occur to you, including those bits of maths you never really mastered properly.’

Nigel’s trajectory in reflection about problem solving, as in Chapter 3, shows clear progression: in interview 3 he said ‘all this problem solving in the papers, that’s what it’s all about’ (pointing to an example of a standard mathematical exercise presented in words), and followed this with a ‘problem-solving’ lesson based on a ‘murder mystery’, where the overall structure is of a ‘mystery’, but individual components are actually routine examples couched in attractive terms. By Interview 5, he was saying,

> ‘they’re most alive when they’re thinking about real problem solving: that’s when you get their very best thinking…. We have developed so much as a department in what we’re attempting to do in that line, but there’s so much further we could go: our expertise will develop further as we work with it …it’s important that we as teachers always feel we have …new things to discover…thinking, I’m going to have to dig deeper to really challenge that student, that makes them think harder – perhaps harder than you think you can cope with even.’

Even from early on he showed confidence in the department’s ability to make good use of, and extend, externally-provided materials:

> ‘actually, if we want to own them, we need to make them fit our needs, not let them be the master of what we do, and we can do that because we talk quite a lot actually, and that’s important’ *Interview 2*

- an approach clearly consistent with Spillane’s (1999) necessary conditions for change, and with Watson and de Geest’s (2010) ‘critical professionalism’. Because he believed the department needed high quality time together to develop that ownership, he several times negotiated sustained periods of timetable release for several teachers at once, arguing from the high stakes nature of mathematics GCSE – clearly the transactor at work. Nigel’s confidence in the innovations faltered in the term leading up to first examinations, as described above:

> ‘we have to focus down a bit, at the end of the day they have to pass the exams, and they haven’t always covered in as much depth or as thoroughly as I’d choose. The fact is, the specimen papers don’t need the sort of thinking we’ve been trying to develop, and if they’re not going to get credit for it…’ *Interview 3.*

In talking about ‘new-style’ questions in that same interview, he acknowledged constraints between supporting students in optimizing their understanding, and maximizing marks:

> ‘actually, sometimes you just have to tell them this is how to do it, or even, ‘leave that sort of question out’. It’s not ideal, but it’s important to get the marks.’

As a facilitator of goals (from a complexity perspective), Nigel worked hard to enable colleagues to enact the scheme of work in a way they felt comfortable with, and to build up

confidence with it, though he added 'sometimes I worry they aren't really teaching for application and the bigger picture' *(Interview 5).* As an 'imposer of systems' (with an Activity Theory lens) he was solution-focussed, negotiating beyond the department where necessary, and claiming that teacher 'waywardness' had been addressed in part by revisiting internal half-termly assessments and re-focusing those more on the valued outcomes, in a way which mirrored bigger-scale drivers. Of the list of leadership roles identified by Watson and de Geest (2010) in successful (autonomous) change, Nigel appeared most comfortable as 'overt change agent, inspirer-leader, presenter' and had a lower profile as 'participant, listener, tea and cake provider, and learner' – which roles were undertaken by others.

In the last area, he developed significantly over the course of the study at least in his talk, dealing with issues of teaching priorities in a more nuanced way. Similarly, in the classroom he developed much more subtle and sophisticated ways of asking questions and perceiving and responding to student thoughts. What he chose to expose in interviews was initially at odds with what was observed in the classroom: this morphed over time to the promotion of a more collaborative and developmental one, perhaps with the development of a more deep-seated confidence and professional knowledge base.

15b Carol

As described in Golding (2011), Carol was acutely aware of nuances and quality of language, of rigour in response, and of a positive role for both challenge and enjoyment in her classroom, despite her limited experience (less than three years at the start of the study). In interview 1 she described mathematics as 'discovering a language which is not necessarily complete, you're creating tools for yourself to express what's going on in the world', and her first observation was consistent with that, with students modelling either depth of water in a bowl as it filled, or the path of a rugby ball using graphing software: she probed, questioned, demanded evaluation, prediction and extension of current skills. She had a well-developed pedagogical toolbox, valuing link-making and breadth and depth of understanding, and explicitly working to build up positive affect, for example building up confidence by supporting students through challenging situations rather than avoiding them. Initially I wondered if this was in part a function of the nature of her students (a top set), but such thinking was at least as clear the following year, when she was teaching a challenging, less academic group. Throughout the study she talked about building core skills so they became automatic tools, freeing students to think more deeply, and had clearly reflected in some depth on her own development, citing for example a lesson she observed where a colleague taught for metacognition, so the students focused on underlying structures rather than particulars of a situation.

Carol was explicit about feeling liberated by the new Scheme of Work, 'as if we have permission to teach more holistically' *(Interview 2),* and was deeply committed to the principles behind it, perhaps underpinned by her significant contributions to the development of large tracts of it, as suggested by Hodgen and Askew (2007). She evidenced many of Brown and McIntyre's (1991) 'expert teacher' characteristics, with a range of tacit and sophisticated pedagogical behaviours underpinned by deep reflection, and she developed those further during the course of the study. On several occasions when I probed observed pedagogical behaviours, including both her sophisticated link-making and her use of teacher modelling, her responses showed clearly these were now tacit: 'I honestly don't think I knew I did that' *(Interview 4).* She was throughout, actively reflective in her responses: 'I slightly messed up their learning. I would in future phrase it slightly differently.. so that we could explore it, without me giving an indication of what I thought was going on' *(Interview 1)* and 'if a couple of them are convinced of its authenticity' (as a problem) 'then it acquires that for the whole group' *(Interview 5).* Her responses to 'new style' questions were typically deep: 'it has the kernel of a good question, but

they've over-structured it, so they've shut down some of the opportunities for thinking: I suppose it must be hard to write really probing questions that can be marked fairly in a limited time – as we're discovering!' *Interview 3.*

Carol has a deep belief in the value of collaborative learning – both for colleagues and for the students. 'We all have to be part of the development and evaluation, so that we can learn from one another and build up a community that's robust enough to support the range of students effectively…I think we're all stronger when we talk about it' *(Interview 5),* and she repeatedly argued for structures to support that in both formal and informal departmental discussion. Reviewing the effectiveness of her entire provision for her first cohort of students, she said

> 'I was.. pleased with the collective learning, the group behaviour, and that was..' (outlines some structures she thought particularly effective) '- I do think those played a part in forming two particular groups, that were quite supportive of each other...and developed resilience in working independent of me.'

She also valued student perspectives, and was not only assiduous in implementing department policy on student self-assessment and other student voice structures, but sought out student lenses:

> 'they said they could have done with more time to reflect, and meeting some of the harder stuff earlier, so they had time to digest it, so I'll try to build that in next time round.' *Interview 4*

As a 'policy actor', then, in Ball et al's (2011b) typology, Carol was an enthusiast/translator, 'speaking policy into practice' and working to encourage others to make enactment a collective process, with a sizeable influence that was acknowledged by others (e.g. Gillian in Interview 3). She regularly acknowledged external constraints of a performativity culture and having to work with another's interpretation ('their version of real life' – *Interview 1*), as well as the inevitable time constraints, but tried very hard to work around them and was the only teacher in the study whose commitment to a principled enaction did not appear to waver in the approach to external examinations. She was particularly articulate in the language she employed to talk about classroom practice in both her Interview responses and in conversation in the department, and this appeared over time to support the development of generally more perceptive and nuanced language in the department.

As a single 'complex system', Carol clearly displayed both diversity and redundancy of various kinds of knowledge, and this, coupled with a deep reflectivity, enabled her to make active choices between pedagogical approaches, and to evaluate and re-cast those selected. This was supported by the relative autonomy allowed by Nigel as Head of department, and others. From an 'Activity' perspective, the critical notion for Carol appeared to be that of 'tools': she herself was active in seeking out and adapting externally provided resources, but also saw colleagues' ideas and experiences, as well as students' inputs, as indispensable to better enactment of valued approaches. Her aspirations, and dogged persistence in always returning to principles, served to complement Nigel's role as a 'transactor' in the leadership of the department, and she was observed on a number of occasions to build up colleagues' confidence in their capacity to enact the emerging scheme of work in an authentic way.

In contrast, the initial study in Golding (2012) shows Dan to be highly experienced and yet very passive, sometimes appearing oppressed, in his approach to the new curriculum: 'you weren't expected to be creative…. it makes a heck of a lot of work, because you're teaching in the dark sometimes' *(Interview 1).* He described his change over time as in response to external demands, though claimed allegiance to the beliefs underpinning the new GCSE: 'the broadening out is a deeper education… the connections make for better learning'. Further, he espoused such an approach as aligned with his own beliefs about mathematics:

> 'I think that mathematics is a really creative subject… and the way you get the creation and the enthusiasm is by having a broader knowledge…in its application' *Interview 1.*

However, this approach was not evident in his classroom, with students given largely closed, teacher-led and procedural tasks. Although he referred in initial presentation to some applications of mathematics, which he later referred to as 'surprising' and motivating', these were strictly on a 'hands-off' basis rather than for students to engage with themselves. His reasons, on probing, were straightforward: 'these students don't do risks' and 'they prefer to be told how to do it – they don't really want to think for themselves' *(Interview 2).* He was observed using multiple representation materials that had the potential to support both good link-making and cognitive conflict, yet he did not capitalize on that potential, closing down discussion and allowing fundamental errors to pass without comment.

Curiously, Dan seemed unaware of the multiple external support resources that had been discussed in department meetings: 'nearer the time… we need outside resources – exemplar papers and so on', and had made little contribution to the Scheme of Work, though he appeared to 'deliver' both that and other departmental structures such as student self-assessments, in a minimally-compliant mode. He talked about the importance of developing student autonomy, and of learning to take risks, but showed little evidence of either in observation. Student feedback showed they felt very secure in his classes. He was clear about his belief in the adequacy of his own knowledge of mathematics, and his role as 'expert' in the classroom:

> 'my role is to inspire them to take things further… (theirs) is to give everything they can…show a commitment…to what they're learning' *Interview 1.*

In Autumn 2011 Dan went on longterm sick leave apparently unrelated to work pressures, and was unavailable for the rest of the study. However, this first year's participation showed him superficially compliant with the principles of the new GCSE although in fact acting out 'self-imposed marginalisation' in Watson and de Geest's (2010) terms, and this department was able to tolerate that. His espoused beliefs were aligned with departmental rhetoric, yet in many ways not reflected in observations of his practice, which showed very limited deep change, as in many studies in the literature (Askew et al. 1997, Swan 2006, Hernandez-Martinez and Williams 2009).

Dan did not fit any of Ball et al's (2011b) typology of 'policy players', although he showed something in common with a 'receiver', together with a passive resistance insufficient to label him a 'critic': in chapter 7 I suggest a further type, which describes not only Dan but other study participants. Nigel and Carol were both observed to make significant efforts to induct Dan as a 'translator' of the new GCSE, but despite his good subject knowledge, abundance of rich talk in the department, and availability of a range of support resources, that did not succeed: he appeared to lack Spillane's (1999) necessary motivation. Spillane (2004) suggests Dan's limited change might arise because an experienced teacher has mis-identified change as already familiar, or has focused on superficial features; alternatively, as suggested by Leatham (2006), his enaction might reflect insufficient or different thinking: unless he was consciously dissembling, interview

evidence shows he believed he was carrying through the principles of the new GCSE even though those appeared insufficiently robust to withstand even the gentle probing ethically justifiable.

15d Gillian

As a consequence of Dan's absence, I sought to replace him with a further participant who would, together with Nigel and Carol, form a 'telling' (Mitchell 1984) sample within the department. As explained in chapter 3, this proved ethically challenging, and I was pleased to accept the offer of Gillian, as second in department, to participate from Autumn 2011.

Gillian at this time had completed five years of teaching, having been mentored by me from her PGCE year. She was generally perceived to be reflective and ambitious in her practice (department informal talk), and to be deeply committed to the principles of the new GCSE, so was expected to add depth rather than breadth to the Greenways sample. As a management graduate she had less formal subject knowledge to draw on than any of the rest of the department, but in informal and formal department discussion overtly drew on a range and depth of well-articulated pedagogical knowledge, and acknowledged that:

> 'I feel reasonably strong pedagogically: I'm interested in how we learn, how learners learn, and particularly how we invent, reinvent, or develop our ideas in maths. I'm always recycling, questioning my ideas on that…one of the great things about this job (is) there's always the capacity and opportunity to learn further'. As a teacher, she described herself as 'I think I'm accessible. I think I'm committed and determined. I am quite challenging but at the same time, always with a smile and supportive. That's what I aim at' *Interview 1/2.*

Lesson observations largely supported those assessments.

Because of her late entry into the study, Gillian experienced interviews and observations parallel with those of High Wood participants, and one fewer observation. Her responses show her valuing classroom-focussed professional talk – the 'opportunistic sharing – that's where I draw a lot of ..(reflection foci) from' *(Interview 1/2),* but also collaboration through joint observations and planning, as well as team teaching, although recognizing that her own family commitments significantly limit her own capacity for working with others in non-core time *(Interview 4).* She talked about progression in learning, both between and within Key Stages:

> 'now I'm getting a much better flow through – that's partly the new scheme of work, partly me capitalizing on experience to take a new slant or pop bits in because it's a hook for later..' *Interview1/2*.

She was very aware of social, cultural, commercial pressures and of policy parallels with other occupations *(Interview 5);* and recognised the role of affect: 'emotionally it's aligned with where we want to be' *Interview 5.*

As the study progressed, Gillian showed a slight 'wobble' in terms of principled enactment but recognized it for what it was ('I found myself doing too much of the guessing game of 'I wonder what are good bets for coming up in the exam'), and she claimed to have reverted to 'aiming to give them a mathematically bigger, rounder picture' *(Interview 4),* which judgement was consistent with observations. When probed about 'new' questions, she showed confident and deep pedagogical knowledge, relating suggested approaches to previous experiences using a detailed knowledge of her students and their learning, and to future mathematical and other needs; and talking about possible threats to confidence with the questions and ways to address those. Lesson observations largely reflected her expressed beliefs, showing an engaging and

creative classroom in which 'average' students were confident to take risks, to question and to work together in quite challenging situations to produce solutions that they then evaluated and critiqued. Only with a top set in year 10, the next year, did her limited subject knowledge surface, with an unexpected question eliciting a contingent but inaccurate response that she then referred to me. Previous experiences suggest that had I not been there, she would have solicited greater understanding later and returned that to the students: this was a teacher confident to show her own limitations:

> 'I think it's good for them to realise we're learning too – we never stop, that's what's so exciting' *Interview 3.*

In terms of problem solving, Gillian was clear that the new Scheme of Work was 'rich task-supported', rather than 'rich task-led', and that getting stuck, having to select appropriate mathematics from their toolbox, and recognizing when they need new tools, whether concepts or skills, were essential experiences for developing a robust mathematical functionality *(Interview 3).* As the study progressed she recognized that the Scheme of Work as yet had an insufficient supply of appropriate genuine problems:

> 'we're a bit lax in our use of that word: you've made me think, we need to distinguish more routinely, between what are applied or even pseudo-applied exercises, and genuine problems, where they really don't know how to start and have to work their way into possible approaches… and allowing, even welcoming, getting completely stuck, for the learning that it can bring' *Interview 3.*

She acknowledged that such an approach was demanding:

> 'it's about being prepared in a depth you didn't need before…you have to put in a lot of time to prepare the task in depth, particularly for weaker students if you want it to be both meaningful and engaging.. you have to anticipate where they're going to get completely stumped and be prepared to support them in finding a way through it, or at least some signposts or some readiness-to-pick-up, so they do sometimes get a slightly artificial or slightly structured experience, but they've still said how massively valuable they've found for instance working through buying a first car and thinking about the finance options available and so on…. We're looking for depth and robustness.. not for people who will leave here and not want, or be able, to do maths again' *Interview 5.*

Gillian was scathing about the actual profile of questions on the terminal examinations:

> 'There were far more traditional exam questions than we'd been preparing them for. Actually – if I'm honest – I thought they had been rushed out, and there was box-ticking' *Interview 4;* and 'it almost made me think, 'well if I don't get time to do things properly, they'll get away with it'. But for us it was a choice of approach, and it was the right choice' *Interview 5.*

Note the awareness of how assessment can frame teaching, and her consistent distancing of herself from that: in 'policy player' terms, Gillian acted as an enthusiast and a potential entrepreneur, though in practice her influence appeared limited by her time-constraints. The impact of a second enactment was clear to her:

> 'I'm adjusting my mix of what's routine skills development and application, and …I'm working harder to ensure core skills are embedded, robust and fluent. I'm more relaxed about it … I can be flexible without longterm loss, so I don't' feel tense if I have to add a bit longer than I'd planned ..because the students need it' *Interview 4.*

The implied benefits of curriculum continuity are clear.

We see here a teacher very well aware of the wider scope of the profession, confident and creative within it, able to synthesise policy and experience and very conscious of the benefits of reflection in depth: 'it helps to clarify…'*Interview 1.* She was conscious of the role of transaction: 'negotiating permission to think in depth about what we do… it has helped so much', and valued what she sees in the department: 'the department has enormous strengths in terms of coherence and consistency of philosophy… that won't dissipate – it's a rock on which we can move forward and build' *(both Interview 4).* She clearly viewed the department as a complex structure, adaptive and emergent, but that is also clear within herself, with internal diversity and redundancy apparent, as well as active engagement with ideas and questions, all facilitated by a departmental- and school-level sufficiency of autonomy.

Appendix 11: Characteristics of individual teachers at High Wood

16a: Kathy, the Head of Department

Kathy was highly experienced and historically successful as a teacher; authority Heads of Mathematics meetings showed her well-respected by peers for her reflective approaches and deep knowledge of young people learning mathematics. She had a good degree in mathematics, and curriculum-focused work and questions about 'new-style' GCSE questions showed her quickly accessing a range of both deep subject knowledge and evidence-founded pedagogical considerations. In informal interactions she showed herself very aware of the 'whole young person', typically setting any student new to me in their context, and when we worked at analysing the previous year's attainment data she showed a detailed and empathetic knowledge of each of the students concerned.

Kathy's espousal of the new curriculum was initially whole-hearted:

> 'I'm absolutely sure it's the right way to go: it's no good just being able to regurgitate things about the angle sum of a polygon, they need to be able to think with the information they've got, and use it in new situations, and develop skills, real skills of problem-solving in situations they haven't met before, and that all takes conscious time and development of confidence, and group working, and all those lovely things we've worked on with Bowland and the Challenge stuff, so it's great that at last they've seen the light and we can do things in a way that will be really useful to them, useful in their adult lives but also useful across the curriculum and interesting for them' *Interview 1/2.*

Her commentary on the lessons I observed showed a similar 'big picture' response both to students and to the curriculum, yet often returning to accountability issues:

> 'It's a start – just a start, doing it like I did. But I'd like to see money given a higher focus - you don't get a paper which is a third salaries and so on… but IT aren't teaching them how to get the best deal. Nobody is. And there are lots of ways of going about that… Do you look it up on the Internet? Do you believe what you see? Is it trustworthy? …Who's ripping you off, and who are you actually paying? …but these are real life skills that actually are not specified…and nobody's teaching them….they need the experience of trying to solve a problem this way or that way…the confidence to have an intelligent go at it, and if that doesn't work, to try another way' *Interview 3.*

Here we see the 'translator' and 'enthusiast' at work. The lessons observed could be construed to be aligned with the principles of the new GCSE, though not in an ambitious way, and Kathy's interpretation of 'problem-solving' was again conservative. In formal department meeting (written) responses, as in 'meeting 1', or when interviews returned to specifics of her Head of Department role, she sometimes appeared constrained in her thinking, for example her claimed understanding of the changes inherent in GCSE was not about content, but about form: 'structure of questions, not leading questions to the ultimate answer'; her claimed strengths of the department were on an operational rather than principled level:

> 'we try to use a range of resources…workings are emphasized, clarity of work', and again her areas for priority development were prosaic: 'resource development….SMARTboard, access to Mymaths, time to teach and develop real-life maths – financial maths and so on: is there an exam this could link to?' *meeting 1.*

Note she did not appear here to conceive GCSE as meeting this need, so was already showing mixed interpretations of the affordances of the new curriculum.

I have referred above to Kathy's reservations about the staging of this change, and the demands of further change to a linear structure soon after; also to the pressures of senior management scrutiny affecting her transactor role. Over the course of the study personal factors outside school also appeared to impact the confidence and time which she could access, and that caused some friction within the department, particularly with Norman: such issues affect the capacity of a group of teachers, and that is likely to be particularly exposed when big demands are made on that capacity. Kathy became less proactive leading change, and increasingly appeared to be suffering from 'battle fatigue':

> 'I'm amused by the full circle…(but) to be honest, there have been so many changes in maths…that I've just got jaded with them, and I think it's a good job that you were here this year, leading up to this one, because I think that my motivation to engage in yet another change, even one I see so positively, is just about gone' *Interview 4.*

Over time, then, Kathy increasingly became an apparently reluctant participant in change, frequently undertaking writing or task development commitments she did not fulfil. In terms of a leadership role, critical to both a complexity and activity-theoretic model, this left a void only partly filled by Norman. From a first interview claim of 'there are lots of resources we could be harnessing, things we've worked on with you, for instance..' she moved by Interview 5 to

> 'we haven't time to write the resources we need to do this properly, or even to re-write existing resources: there's just not the capacity: we could have done with the exam boards producing some useable resources'.

Tools, including resources, are an integral part of an activity-theoretic model, and a necessary aspect for Spillane's (1999) deep change: this perception seem to have much in common with Dan's.

16b: Norman

Norman's espoused beliefs about school mathematics were skills-based: 'numerical skills for real life; logical, step by step approaches; problem-solving skills; discipline; structure; tenacity; thoughtful; listening, reading and thinking skills' *(meeting 1),* and his claimed departmental strengths consistent with that: 'simple clear syllabus with staff working tougher with similar groups; similar standards in terms of basic rules and similar methods; drive towards independent though through questioning teacher and 'give it a go' attitude' *(meeting 1).* As a highly organized teacher observed to be well-respected by colleagues and students, he prioritized for department development

> 'even greater consistency, improved behaviour from year 7, and a focus on pupil responsibility for their learning, via topic lists, assessment reflection and homework help' *meeting 1,*

and this valuing of common structural approaches was evident throughout the study. His knowledge of department data was forensic and highly analytic, and in many ways at the beginning of the study he appeared to complement Kathy's 'human' and 'big picture' approach to department projects, keeping the department grounded in realities. He was fully supportive of the principles of the new GCSE, but sceptical about realities: 'we'll see how it turns out we've seen promises before' *(Interview 1/2)* and, as above, scathing about timescales and workload. In

practice he was an efficient 'alternative' narrator, initially arguing for producing documentation that showed minimal compliance but that could later be built on further. While effectively maintaining the profile of a critic, he appeared to use that at least in part to maintain a resilience in the face of repeated changes, but it did mean he was not contributing optimistic interaction to the department. In terms of tools, he perceived no obvious lack of resources but argued repeatedly within an assessment-driven framework:

> 'there are plenty of exam body resources we can use, as well as our own experience: we don't have to have it all written down. The real meaty problems are just the icing on the cake really, we can put those in as we get time but the exam papers we've seen so far don't need them - there are only minor changes' (*Interview 5,* a complete two years after first enaction of the new GCSE).

Increasingly, he, with Kathy, appeared to make less use of the maths office or the corridor for classroom-focused talk: tensions about perceived workload and distribution of responsibilities surfaced, and with Kathy experiencing pressure on non-teaching time from outside sources, Norman over time appeared to distance himself from non-necessary interactions. His frustration with school-level, as well as department-level, (lack of) structures surfaced frequently, and contrasted with his own very procedure-based approaches to management – of the department and of his classroom ('no-one else seems able to focus on just what they need to get it' – *Interview 5*).

In terms of knowledge, Norman, although with a degree in Business Studies, showed fluent and flexible pedagogical awareness of the demands of GCSE questions, of (deep) problem solving, and knowledge of individual students. Although he was outspoken in his espoused valuing of both 'functional' mathematics and of genuine problem solving, he was consistently overt in his privileging of the needs of the exam: 'that's what we're here for, number one'. These traits were reflected in each lesson observation, where students were taught with overt expectations of the development of understanding and application, within a clear, mutually respectful disciplinary framework and with liberal explicit reference to GCSE papers.

As the study progressed, though, tensions emerged between Kathy and Norman, overtly in relation to priorities, with Kathy arguing for a principled scheme of work (though making little practical contribution towards it) and Norman pressing for at least an outline structure on which they could later build – 'better something in place than nothing because we're waiting for the chance to make it ideal' *(interview 4).* Norman appeared increasingly the pragmatist, frustrated at the limitations on leadership of the department, and this split appeared to fragment the whole department. His talk became less overtly critical, instead of which he appeared to move into a passive acceptance of the situation, doing what appeared necessary to give minimal structure to department working and with his own lessons, by his own claim, heavily framed by emerging GCSE papers.

16c: Heather

Heather had joined them two years before my arrival, coming from a varied teaching background with a degree in mathematics, and valued much of what she saw in the department:

> 'They have an excellent grasp of the subject – some of them are examiners – and a variety of strengths that complement each other. Thy have aspirations for themselves and for students, they're caring – and want to help students develop their independence' *(meeting 1).*
> 'They're really open to new things, they like to try things out and talk about what they're doing and how else they might do it, though they don't use ICT a lot. You feel you're trusted

to know your students and they accept you know what works best for you in your classroom, which I like. That's partly Kathy and partly a whole-school thing' *Interview 3.*

She was wholeheartedly in favour of the changes made in GCSE, and impatient of the slow progress towards reflecting that in GCSE questions: '*Of course* GCSEs matter, and if you don't have proper demanding questions in GCSE the kids will think they're not valued' *(interview 3),* as well as persistent changes:

'you don't get a chance to make a better job of it for the students: it takes all your time and energy just to keep up with the changes. Even if they're an improvement in principle, the kids might get a better deal if they'd just leave things alone so we can work out how to do them well' *Interview 4.*

The lessons I observed showed her trying to follow her principles, but making compromises she justified by pressures on time, and less perceptive in her observations of students' learning than Kathy sometimes was, or several of the Greenways teachers regularly were. For her, time was a recurring theme, brought to the fore by the clear pressures on Kathy's capacity, but also pressures on her own time as mother of three small children. A linear scheme of work drafted in Summer 2012 had not been expanded as planned:

'Kathy's had so much on, she wasn't getting anywhere, so Norman and I said we'll run with what we've got and build on that, …we got fed up…' *interview 5.*

Over two years after the start of the new GCSE, she was saying

'problem solving is still happening as and when we come across it. We haven't had a chance to actually sit down and say, we want to put problem solving in there…. It's hard, it's hard – just because we're trying to get our heads around what we can and can't do at the moment, and we don't *have* to do problem solving' *Interview 5*

– note again how the demands of accountability frame her response. It was clear, too, that her use of the nascent scheme of work was drawing heavily on her substantial experience: 'I think it starts too easy for mine, so…I just stretched them a bit more, took it a bit further…' – reflecting limited organizational paperwork that in a less experienced department might have been costly.

Heather appeared to have sound subject and subject pedagogical knowledge, as reflected in her responses to 'newer' GCSE questions, where she responded with a variety of approaches, making several comments about how questions could have been developed in ways better aligned with stated curriculum intentions, and also relating those to her own students:

'now Jack, he'd have demolished that because although he's not academic, he has a real feel for how things work out in practice, whereas C, he'd just have done random things with the numbers that are there – he doesn't yet understand that it can all make sense, so that's my goal with him' *Interview 4.*

As a policy player, Heather showed some traits of an enthusiast, particularly in regard to the use of ICT for teaching and learning mathematics and the use of novel resources, though as a relative newcomer she sometimes appeared to hold herself at a distance from discussion, sometimes acting as a 'receiver' of department decisions, and was rarely proactive at a department level. She was clear in her espoused beliefs about teaching and learning mathematics and able to defend those with classroom examples, but sometimes made poorly justified compromises with espoused beliefs. As time went on, though, she appeared to make fewer suggestions and to focus her efforts on her own classroom rather than sharing ideas; this was in parallel with the other tensions in the department.

Appendix 12: Greenways student questionnaire, May 2012

Greenways as a department habitually sought student views in termly or half-termly 'student self-assessments' but also in yearly interviews of students from each year group by the Head of Department. I did not always have access to those, but the electronic questionnaire below was aimed at the complete year group as Year 11 Maths Opinion Questionnaire and completed by virtually all of them in class time, very near the end of their GCSE course. I draw on it in chapters 4 and 6. (n=146)

Please complete the questions below thinking about all of your Maths work during Year 10 and Year 11. Thank you. Mr Z

1. Ways of working

How often in Maths do you...? (1= Often, 2= Sometimes, 3= Rarely, 4= Never)

	(Average score)
Work in groups	2.0
Work in pairs	1.4
Work individually	1.2
Assess your own work	1.5
Work actively	1.3
Have to think through problems on your own	1.4
Explain your thinking (this can be verbally to class, partner or written words or written workings)	1.8
Discuss your ideas with a partner	1.2

2. Amount of challenge

How often in Maths do you...? (1= Often, 2= Sometimes, 3= Rarely, 4= Never)

Choose work that is at the appropriate level for you	1.4
Have extension work available	1.7
Have to think through real-life problems	1.6
Practice key skills through routine work	1.7
Think about the use of maths in another subject	2.1
Get challenged to think independently	1.4
Feel stuck and resolve it independently (maybe by discussing with a partner)	1.4
Feel stuck and not resolve it	2.6
Get encouraged to look at something differently	1.7
Share different methods	1.3
Feel alternative methods are shared and valued	1.3
Feel encouraged to explore or try to work out an answer, without knowing the route to an answer	1.6
Feel errors or misunderstandings are positively developed.	1.5

Use a range of maths covering different topics to answer a problem?	1.4

3. Feeling
How often in Maths do you...? (1= Often, 2= Sometimes, 3= Rarely, 4= Never)

Do an enjoyable activity	1.2
Get a sense of satisfaction	1.3
Get a sense of progress	1.3
Feel frustrated at home trying to do homework	2.0
Find it hard to get engaged with the lesson material	2.5
Feel positive	1.3
Feel confident (within your class)	1.3

4. Finally,
What one thing do you like and think should be in all maths lessons?

5. And what one thing from other lessons would you like to be part of maths lessons?

6. Any other comments?

Appendix 13: Student views from High Wood interviews, May 2012

Seeking student views on a formal or semi-formal basis was less engrained as part of High Wood department culture, but Kathy wanted more information in particular in relation to management-identified foci, and asked me as neutral to run short student focus groups for each set. This fed into understanding of department impact and relationships as referred to in chapter 5. I interviewed a teacher-selected spread of 4 students from each year 11 maths set.

- Introductions both ways. (Seeing them so that they can feed into the way things happen without embarrassment or identification.)

- *Tell me the sort of things you most enjoy doing in maths.*
- *And are those the same as the things that help you to learn best? (probe: groupwork, use of ICT, work in silence, investigations, problem-solving, functional maths)*
- *What does your teacher do that helps you to learn for yourself?*
- *Is there anything else you'd like them to do to develop you as an independent learner?*
- *How does your teacher use homework to support your maths learning?*
- *What sort of feedback from written work helps you best? (probe: what use do you make of feedback)*
- *How do you think your understanding of maths has changed this year?*
- *What things could you do differently that would help you to learn maths better?*
- *What else could your teacher do that would help you prepare better for GCSEs?*
- Thank yous.

Appendix 14: Extract from new Schemes of Work September 2012 Greenways

(Shaded cells hyperlinked)

	GCSE	*Title:*	*Packaging*	Guide length:	8 lessons

Learning objectives										
Foundation		Ch	Foundation plus		Ch	Higher		Ch	Higher plus		Ch
GM d	Recall the properties and definitions of special types of quadrilateral, including square, rectangle, parallelogram, trapezium, kite and rhombus		GM d	Recall the properties and definitions of special types of quadrilateral, including square, rectangle, parallelogram, trapezium, kite and rhombus		GM d	Recall the properties and definitions of special types of quadrilateral, including square, rectangle, parallelogram, trapezium, kite and rhombus		GM d	Recall the properties and definitions of special types of quadrilateral, including square, rectangle, parallelogram, trapezium, kite and rhombus	
GM i	Distinguish between centre, radius, chord, diameter, circumference, tangent, arc, sector and segment		GM i	Distinguish between centre, radius, chord, diameter, circumference, tangent, arc, sector and segment		N r	Use *pi* to give an exact answer for a calculation		N r	Use *pi* to give an exact answer for a calculation	
						N r	Calculations with surds		N r	Calculations with surds	
						N r	Use surds to give an exact answer for a calculation		N r	Use surds to give an exact answer for a calculation	

						GM bb	Solve mensuration problems involving more complex shapes and solids		GM bb	Solve mensuration problems involving more complex shapes and solids	
	Representing		Analysing -reasoning		Analysing – procedures						
	Interpreting & evaluating		Communicating & reflecting								

Revisiting objectives from earlier in KS4 SOW									
Foundation	**Ch**	**Foundation plus**	**Ch**	**Higher**	**Ch**	**Higher plus**	**Ch**		
Connected Topics		**Related Starters**		**Key mathematical terms and notation**					
PHASING - FOUNDATION									

How will this be phased?	**How will the pupils learn?** (Pupil tasks/activities)	**How will learning emerge?** (Key questions/assessment)	**How will this be adjusted?** (Support/Extension)	**Resources** (Practical, texts, ICT)
2D problems - Square peg round hole - emphasise proportion: it does not matter what circle and what square they all work the same	*A starter task to get students thinking spatially. Important concept that proportion is what is important so students should try to work with general formulae after an initial play with particular lengths and radii.*	*Reminder of circle formulae. Discussion to draw out the use of generalising.*	*3d - sphere and cube?*	http://nrich.maths.org/553
2D problems - circles and part circles in a box - an example is linked in the resources box.	*Students deal with multiple areas including circles*	*Reminder of circle formulae. Discussion to draw out the use of generalising.*	Alternative 2D problems are listed below	http://nrich.maths.org/634
Review of shape properties	*Murray activity based on the diagonals of shapes leading to discussion of properties of shapes*	*Is a square a rectangle? What is the difference between a kite and rhombus?*		

Applied problems to practise the basics	*The article linked here could be a starter for work on basic revision of simple 3D shapes so students are confident to start the tennis ball packaging task*	*Students and staff identify students' individual weaknesses - review assessment sheets.*		http://people.maths.ox.ac.uk/dusautoy/Jenny's%20Scans/Sexy%20Maths/Times2-20091007-The-shape-of-things-to-pack.pdf
Calculation of volume of different 3D prisms	*Popcorn packaging - which is the best way?* *Ribbon decoration.* *Both from the challenge index of figurethis website linked here.*	*Students gain confidence in working out volume s and not just widthxlengthxheight*		http://www.figurethis.org

PHASING - HIGHER

How will this be phased?	**How will the pupils learn?** (Pupil tasks/activities)	**How will learning emerge?** (Key questions/assessment)	**How will this be adjusted?** (Support/Extension)	**Resources** (Practical, texts, ICT)
2D problems - Square peg round hole - emphasise proportion: it does not matter what circle and what square they all work the same	*A starter task to get students thinking spatially. Important concept that proportion is what is important so students should try to work with general formulae after an initial play with particular lengths and radii.*	*Reminder of circle formulae.* *Discussion to draw out the use of generalising.* *Work with pi and leaving answers exact using surds*	*3d - sphere and cube?*	http://nrich.maths.org/553
2D problems - circles and part circles in a box - an example is linked in the resources box.	*Students deal with multiple areas including circles*	*Reminder of circle formulae.* *Discussion to draw out the use of generalising.* *Work with pi and leaving answers exact using surds*	Alternative 2D problems are listed below this phasing grid	http://nrich.maths.org/634
Applied problems to practice the basics	*The article linked here could be a starter for work on basic revision of simple 3D shapes so students are confident to start the tennis ball packaging task*	*Students and staff identify students' individual weaknesses - review assessment sheets.*		http://people.maths.ox.ac.uk/dusautoy/Jenny's%20Scans/Sexy%20Maths/Times2-20091007-The-shape-of-things-to-pack.pdf

What is the best way to package tennis balls ?	*Shell file (linked here but also filed for ease) - thorough guide to the task with teacher notes, sample work and markers comments.* *The file includes the following alternative Tasks* *-Packaging - may be useful* *-Pop-ups - may be suitable for higher*	*Work with range of shapes including sphere, pyramid, tetrahedron, cone, frustum? Work with pi and leaving answers exact using surds Revision and confirmation of use of 3D pythag and trig*	*Alternative tasks not likely to be needed - instead keep the 3d shapes simple if needed.*	http://www.nationalstemcentre.org.uk/elibrary/resource/4376/practical-geometry#error-scroll
Tea bag design - why did Tetley switch to 2D circular bags (to be different and save material); PG Tips then set about 3D design liking the tetrahedron because it is most surface area to least volume so greatest flow of water: See the book, The Num8er My5teries by Marcus du Sautoy p69-72	*Additional task for interest to review 3D understanding*			http://www.unilever.co.uk/brands/foodbrands/pgtips.aspx

Other good 2D problems http://nrich.maths.org/1947; http://nrich.maths.org/352; http://nrich.maths.org/2160

Appendix 15: Extract from new Schemes of Work September 2012 High Wood

Autumn Higher to half term: Pythagoras Rule		
Finding length of side	Find any side of a right-angled triangle Use Pythagoras' theorem in isosceles triangles and practical problems	B
Distance between 2 points	Find the distance between two points from their coordinates	B
3-d situations	Use Pythagoras in 3-D problems	A
Trigonometry 1		
Find length of a side	Use sine, cosine and tangent to calculate a side in a right-angled triangle	B
Find an angle	Use sine, cosine and tangent to calculate an angle in a right-angled triangle	B
Use in 3 - dimensions	Use trigonometry to find sides and angles in three dimensions Find the angle between a line and a plane	A*
Area of triangle	Use formula Area = ½absinC	A
Area and volume		
Perimeter and Area	Find the perimeter and area of a triangle, parallelogram, kite, trapezium, circle Find the area and perimeter of compound shapes	D-C
Area of triangle	Use ½absinC for area of triangle	A
Volume and Surface Area	Calculate volumes and prisms and cylinders Convert between measures of area and volume Solve problems involving surface areas of prisms and cylinders	C,B B-A A-A*
	Find the volume and surface area of spheres, cones and pyramids	A
	Find the volume and surface area of a hemisphere, frustum and shapes made from the above.	A-A*
Dimensions and formulae	Distinguish between formulae for length, area and volume by considering dimensions	B

Appendix 16: Memo - Clearly evidenced teacher characteristics, end of the study

(Evidenced capacities only are indicated: may actually have greater potential than that seen in fieldwork). Drawn on in chapters 4,5,6,7

Theoretical and operationalised Subject Pedagogical Knowledge (SPK) relative to field of Subject Knowledge (SK); 1=high, 3=low

SK: 1=mathematician, 2=extensive maths (may not be deep), 3=adequate (may be deep) for most GCSE

M= Motivation for principled enactment

'Noticing/attention' uses Davis (1997) hierarchy of effectiveness in this area:

3. Teacher is sensitized to a small range of intended responses which allow access to the next part of what is planned: a student offering that does not fit, is often either marginalised or 'shoehorned' into that framework, maybe digging beyond the surface to find that link.
2. Active interpretation, negotiated communication so that teacher accesses the sense of what is being said.
1. Greater fluidity including multiple opportunities to interact, renegotiated roles to focus on student constructions, with negotiated and participatory interaction: an attentiveness to the historical and contextual situations of one's actions and interactions??? (enactivist framework?) Individuals are each subsystems of a complex system: ideas cannot be silo'ed, and together a greater than the sum of the parts outcome is achieved: teacher engages in a transformation of her mathematical knowledge.

Teacher	Years	SK	SPK	M	Characteristics including resilience (as a maths teacher but also interpersonal), reflection, attention, confidence as a maths teacher including attitude to risk and challenge	Policy Role(s) in relation to this policy
Nigel HoD	6	2	2	1	Resilient, superficial reflection, attention 2, confidence 1	Narrator, transactor. Moving towards entrepreneurship
Gillian 2iD	7	2	1	1	Highly resilient, deeply reflective, attention 1, confidence 1	Enthusiast, potential entrepreneur but limited time
Carol(0.6 fulltime equivalent)	5	1.5	1	1	Moderate resilience, confidence, very willing to take on challenge and undertake considered risk, deeply reflective, attention 1	Enthusiast/translator. Potential entrepreneur but limited power

Dan	2	1	3	3	Lacks resilience, little reflection, attention 3, averse to challenge or risk (battle fatigue?)	Survivor (self-imposed marginalisation)
Jack	4	1.5	2	1.5	Lacks resilience and confidence, happy to take on risk and challenge if suggested by someone he respects, some reflection, attention 2	Enthusiast (lacks affective and organisational tools 4 translator, in part because of limited experience)
(0.7fte) AST	36	1	1	1	Resilient, deeply reflective, attention 1 from outside observations, confidence 1, risk-taking and challenge 1 if well-considered, otherwise 2	Entrepreneur historically; limited scope in department Acts as outsider to High Wood dept.
(0.5fte) Gerry	24	2	2	2	Resilient, some reflection, attention 3, confidence 3, averse to challenge and risk-taking	Hybrid receiver/translator with limited capacity of scope to influence in department because of major responsibilities elsewhere – institutionally marginalised
(0.4fte) Layla	18	1	1	1.5	Lacks resilience, confidence 2, deeply reflective, attention 1, challenge 2, risk-taking 3	Relatively new to department, hybrid translator/receiver depending on time and energy available
(0.3) Sylvia	38	3	3	2	Highly resilient, reflection 3, attention 2.5, confidence 1, challenge 1, risk-taking 2	Largely receiver/coper, wanting to comply but having limited internal resources to do so; as SLT, often institutionally marginalised
6.5 fte	Years	SK	SPK	M		
Kathy HoD	27	1	1, but..	2	Lacks resilience(at present), deeply reflective(re past situations; lacks reflection (re present), attention 2, confidence 2, averse to challenge and risk-taking at present	Survivor (historically, narrator/translator)
Norman 2iD	22	2	2	3	Highly resilient, superficial reflection, attention 2, confident, averse to challenge and risk-taking	Translator /critic/survivor (at times ideologically marginalised)
Heather (0.8fte)	17	2	2	2	Some resilience, some reflection, attention 2.5, confidence 2, challenge 2, risk-taking 2	Hybrid enthusiast/survivor: 2nd/3rd year in department

James	39	3	2	3	Resilient, little reflection, attention 2. Confidence 2, averse to challenge and risk-taking,	Survivor (self-imposed marginalisation)
(0.7fte) Adam	37	1	1, but	2	Some resilience, some reflection, attention 2, confidence 1, averse to challenge and risk-taking	Survivor/critic (self-imposed marginalisation)
Desmond Assistant Headteacher	31	2	2	2	Highly resilient, superficial reflection, neutral re risk and challenge	Non-participant in policy work – marginal coper – organisational marginalisation
4.9 fte						
As departments….						
Greenways is	Narrator relative to Local Authority; big element of both enthusiast and narrator at a school level; has a good capacity for noticing and for reflection: together these are quite powerful (does reflection need noticing as well? Yes, to be effective in classroom). Also sizeable store of confidence, and of positive attitude to risk and challenge. Adequate SK and SPK, boosted by willingness to share. A 'young in experience' department, not yet battle-worn? Marginalised teachers tolerated by the critical mass of those well-motivated for a principled enactment.					
High Wood is	Predominantly a survivor, necessary elements of translator; good store of SK and of APK although not always fully harnessed. Infrequently obviously actively reflective, even when pushed in interviews; moderate degree of noticing evidenced. Overall, averse to risk and challenge with a critical mass of survivors; only moderate motivation for principled enactment; highly experienced (and suffering from policy change fatigue?)					

Appendix 17: Memo - CUREE challenge project: extension to teachers

Fieldwork exposed attitude to risk and challenge as a differential characteristic (chapter 6). In an effort to better understand how this arose, I used the outcomes of the CUREE Challenge project, on which both departments had worked, to hypothesise how those outcomes for students might relate to teachers in this study.

Adapted from Curee/QCDA (2009)

What it says for students	What it might say for teachers in a time of policy challenge	Field Evidence to support this interpretation?
Definition: …challenging young people in curriculum terms means designing T&L to elicit from students their best efforts (i.e. challenge needs to be motivating) and to enable them to think and act in ways that are transferable and/or discipline-specific, and which are progressively more complex, critical, creative and independent	Designing policy so as to elicit from teachers their best efforts and to supporting them to develop in policy-consistent ways that are transferable and/or discipline-specific, and which are progressively more complex, critical, creative and context-specific.	√ or teachers choosing to challenge themselves to such efforts
Constructing challenge is related both to curriculum design and to its enactment in the CR	Setting up challenge for teachers is related both to the content and to the manner of communication and delivery of curriculum requirements	√
By introducing challenge, teachers aim not only at performance gains but also at improving engagement and motivation	Challenging policy innovations should aim not only at improving teacher performance but also at improving their self-efficacy in relation to mathematics teaching	√
Kyriacou and Goulding (2006): engagement and motivation does not equal better learning: also need depth of curriculum challenge	Well-motivated teachers also need to be challenged if they are to optimise functioning	√
Collaborative inquiry and problem-solving are (seen to be) key learning processes for constructing challenge	In a challenging policy environment, professional collaboration, good facilitation of that, and embracing the addressing of the inherent policy problems are key	√
Personalisation is important (and so individual learning needs require diagnosis)	One-size-fits-all is unlikely to be successful: giving scope for school-specific interpretation and enaction of policy is important (cf complexity theory	√

	redundancy/organised randomness); leaders at all levels need to know how to adapt enactions to support engagement by their teachers	
Revealing and addressing mistakes in a supportive classroom is important in harnessing challenge for learning	Professional reflection, and collaborative engagement with emerging issues, important in terms of PD: sharing and addressing both successes and failures supports this	√
Constructing challenge often requires teachers to shift to a more facilitative role with students taking increasing responsibility for their learning	Constructing effective policy challenge often requires policymakers to shift to a more facilitative role with teachers taking increasing responsibility for their interpretation and enaction of broad policy requirements.	√? Do HW have the capacity for this?
Woodward and Brown (2006): Students need to experience periodic challenge and even failure in order to develop higher levels of self-efficacy and task persistence	Significant challenges in policy expectations should not be avoided: they are actually learning opportunities (cf GW developments), but should be prioritised: moderation in quantity and pace of change can be constructive	√
High content knowledge appears to be key in making judgments about levels of support and challenge (Flores and Day 2006)	Policymakers should seek, and act on, informed expert guidance in relation to the ways in which policy is framed	√
Anagnostopoulos (2003): Accountability pressure re student attainment can reinforce poor practice, as teachers feel less autonomy in making curricular adaptions to include challenge	Accountability pressures at dept or school (or LA) levels can, paradoxically, reinforce superficial rather than deep engagement with policy change	√
Students believe they are better motivated when lessons are fun, varied and participative, use collaborative methodologies, and activities are authentic (Smith et al. 2005)	Teachers are more likely to engage with policy change if it is aligned with their beliefs (and implicitly, experiences); if they feel involved in its genesis and enaction; if it contributes to job satisfaction; and if they work out its implications, including challenges and solutions to those, collaboratively and for their own context.	√

Appendix 18: Memo - Departments and Change

As discussed in chapter 8, I sought to establish to what extent department response to change was aligned with other empirical evidence, notably that in Spillane (1999) who suggests minimal necessary conditions for deep change, and in Watson and de Geest(2010), who studied departments attempting autonomous deep change. The table below shows a high degree of consistency.

Spillane (1999)	Critical professionalism (Watson and de Geest 2010)	Greenways at end of study	High Wood at end of study
Social rather than individualistic 'enactment zone'	Maintain quality intra-departmental dialogue	Highly collaborative, with shared department space and most teaching in one corridor. Most teachers confident to share everyday experiences (successes and failures)	Share physical space (departmental and teaching) and organisational dialogue; some sharing of experiences.
Rich deliberation – with experts	Engage with a range of current research; use outside experts to challenge and inform	Choose to engage with LA input, outside experts as in CUREE 'challenge' work; HoD keen to participate in LA and wider interchanges; other teachers all participate at least annually in CPD opportunities addressing identified developmental needs.	Engaged with LA AST to address one-off drop in measurable outcomes. HoD often 'too busy' to participate in LA meetings; other CPD largely focused on assessment requirements. *Historically,* have shared collaborative PD sessions with GW, using expert research-based materials.
-and grounded in classroom experience	Dialogue focused on teaching and learning	Interaction frequently focused on deep discussion of e.g. how to facilitate the learning of particular individuals or groups, how learning takes place, why a given approach appeared to work well, how media stories might be harnessed for the classroom….	Interaction often focused on procedural matters, or if on teaching and learning, then relatively superficially
Quality support materials		Seek out a variety, use them critically, share informally and formally, edit or if necessary write own materials. Use textbooks critically, as one resource. Experiment with new technologies for learning, but confident to be selective in their use.	Begin with textbooks, use somewhat selectively, make considerable use of Awarding Body resources. Share, and sometimes use, particular electronic resources brought to their attention (only one teacher actively seeks those out).
Motivation	Choose to attempt	Conform to externally-imposed constraints, but proactive about making	Reactive, conforming to minimal requirement to

	principled change	those fit their espoused model of teaching and learning: interpret change as an opportunity to address that in more depth	change as evidenced by assessment materials
Quality time		Quality interaction supports day-to-day changes; ring-fenced time sought out for developing enaction framework and some further development work	Considerable pressure of time perceived

Appendix 19: Memo - Motivation for Students applied to teachers

Similarly, in section 6.2.3 I discuss motivation as a differential characteristic. Again, I wanted to know why such differences might have arisen, since they were not evident at the start of the study. To catalyse my thinking given a paucity of motivation literature related to teachers, I went to the literature on motivation for school student learning, and asked 'what would this look like if it transferred to teacher learning?' The results are summarised below.

What works for students?	***Reference***	***Greenways***	***High Wood***
Focus on mastery and understanding.	Ames (1992) Meece, Anderman, and Anderman (2006): no impact on achievement Middleton and Spanias (1999): positive effect on achievement	A core belief: they also apply to their own learning, and value professional understanding	An espoused belief, but superseded in hierarchy by need to maximise attainment. Not overtly focused or valuing own learning
Framing of tasks that highlight the relevance of mathematics: contributes to ID as mathematician	Kaplan, Gheen, and Midgley (2002)	See new GCSE as aligned with preferred ways of T&L. Builds up ID as a successful maths department	Perceive new GCSE as valid educationally, but an imposition practically. Undermines confidence in their integrity as successful maths department, at least in terms of espoused values
Balancing the level of challenge to the ability and attitude of the group.	Middleton and Spanias (1999): must have occasional appropriate challenge for motivation – but also success. Boaler, Wiliam, and Brown (2000): some groups have too little	Perceive sufficient challenge to get sense of satisfaction but not so much feel can't succeed:	Feel overwhelming challenge in principled enactment: prefer to settle for minimal compliance

Promote (lived-out CR as well as exhortation) view that the application of effort will lead to higher attainment along with strategies to support this view (e.g. effective self regulation, and formative feedback).	Effort and link to goal orientation: Dweck (2006, 2008) Self-regulation: Kyriacou and Goulding (2006) Formative feedback: Kluger and De Nisi (1996) Persistence: Meece, Anderman, and Anderman (2006) (virtuous circle)	This is underlying message of current policy but depts. need the capacity and support to do that: Greenways had sufficient capacity and the attempt has increased that	Accept premise; formative feedback available though SLT input may be counterproductive; have historically self-regulated effectively so have the capacity but not harnessing it doing so in respect of this
Teaching methods that allow students a degree of autonomy in terms of what maths they do and how they approach subjects. Focus on mastery and understanding; by a variety of actions which contribute to their identity as a mathematician, including the use of tasks perceived to be relevant, development of self-regulation, formative feedback, and the promotion of belief in the efficacy of effort; and by the use of appropriate challenge together with sufficient success.	Kyriacou and Goulding (2006) re identity	Range of valid interpretations possible: Greenways perceive this to be so, experiencing autonomy and often expressing a wish to make a thorough job of their enaction. Express SE in relation to enaction and a confidence they are succeeding in supporting the maths learning they value, and will continue to succeed if they make sufficient effort.	Understand their enactment not valid interpretation of intent but content to enact minimally.

Appendix 20: Memo - Departments' appropriation of tools

Evidence initially Autumn 2011; revisited Autumn 2012 for currency, and used to catalyse thinking about departments as activity systems in chapters 5,8,10.

Tool or 'instrument'	Use by Greenways	Use by High Wood
Curriculum and assessment guidelines	Principles absorbed from various professional networks and LA meetings; implications for action discussed by HoD and 2nd in dept then presented to whole department for further discussion. SAMs from the variety of boards evaluated for demand and approach; accessible ones aligned with new curriculum ethos chosen. H and 2nd developed model for SoW w was agreed – conceived as an opportunity for reframing approach to GCSE given existing approach no longer available so change forced to some extent; thereafter, little reference to core curriculum and assessment guidelines, but exam papers used as proxies for checking level and type of learning required.	Summary received second hand from exam board, without primary engagement. HoD and 2nd discussed implications, decided to keep SoW as intact as possible (no structural change forced initially), just to monitor any changes in exam papers so SAMs critical to them. Post-hoc report: how reliable?
LA and other external support structures	Have opted into outside affordances to work as a dept on e.g. questioning for learning, challenge. Invited Adviser in to work with HoD and 2nd in dept when results didn't look too great. HoD regularly attends HoM meetings and other local opportunities (cf policy player role). Department has membership of MA, ATM; several individual members are active in NCETM (and used that as a pathway to cross-phase work) and some individual interaction with professional assns. PM derived from whole-school priorities used to identify devt priorities for individuals and moving towards supporting that fully with use of outside opportunities for development. Internal school structures used for developing cross-curricular and in-department priorities via trio work.	Passive: accept LA intervention when imposed, but don't seek it. Little (no?) engagement with other outside professional bodies evident but have worked extensively and enthusiastically with Greenways over a number of years. HoD now rarely attends LA HoD meetings although she used to. School trying to establish effective in-school professional engagement but maths engagement with that is currently passive cf Norman– roles? *How much is this reported use influenced by my own role for LA?*

Exam papers	Used to inform as to whether SoW includes learning necessary, ensure student have experiences to answer questions but use as a threshold; fairly high-level analysis afterwards	Used as a ceiling: monitored carefully for change in demand, analysed forensically post-hoc and for individual students
Department SoW	Conceived as a PD opportunity although in practice eternal constraints meant there was variable investment in producing it and so variable benefit. Used as a medium-level guide to structure areas of work, lift horizons re related learning activities and resources. (This is recognised good practice and underlines HoD's described policy role: how deep does it really go?)	Conceived as a necessary support to enaction of minimal compliance with curriculum as revealed in exam papers. Some collaboration but only for those teachers' groups: some degree of each for own. Outline of content rather than focus on teaching.
Textbooks	By most but not all: Deeply conceived as one of a number of available resources to support learning, e.g. a source of examples and of organised presentation of core facts and knowledge	A (often, the) core resource and first port of call for planning. Source of differentiation and of progression, SoW closely linked to it to ensure consistency in progression and dependency
Sum of Teacher knowledge	Knowledge of key people drawn on in depth and synthesised; other affordances less well mined, or only periodically, e.g. when need to bolster teacher confidence became apparent	Teachers largely working in isolation, eventually: attempt to gain work with a consensus was hijacked and then abandoned
Other resources, including electronic	Use a variety of resources from course, Internet, various professional networks: beginning to organise them for communication for shared use and incorporate into SoW but still a way to go	Some basic, largely longstanding hard copies filed; some electronic resources circulated by Heather but little uptake
These next ones build on Venkatakrishnan (2005)on leadership, beyond Engeström (2001)	Relate to policy roles. Very conscious of appearance and ambitious. But a clear leader, complemented by 2nd . Gung ho, confident, personable, negotiates well with senior management. 2nd gives reflection. Distributed leadership embraced at a school level, less so at a dept level.	Treading water, reactive rather than proactive, dilutes messages from SL, doesn't' lead unless forced to. Role? Espouses distributed leadership?
Shared physical space (McNicholl, Childs, and Burn 2013)	More sharing during non-contact time, but in part due to pressure on space which means there's little else available. Now has drinks facility driven by C who deeply values colleague interaction. Talk there very often CR-focused. CRs largely on one corridor which facilitates interaction – sometimes admin but often T&L. HoD devotes some effort	Used as storage space and as short-term working space: CRs largely available and used when free, so no great sharing during non-contact time. All maths teaching in maths corridor so physical potential for interaction; in practice it's largely administrative and

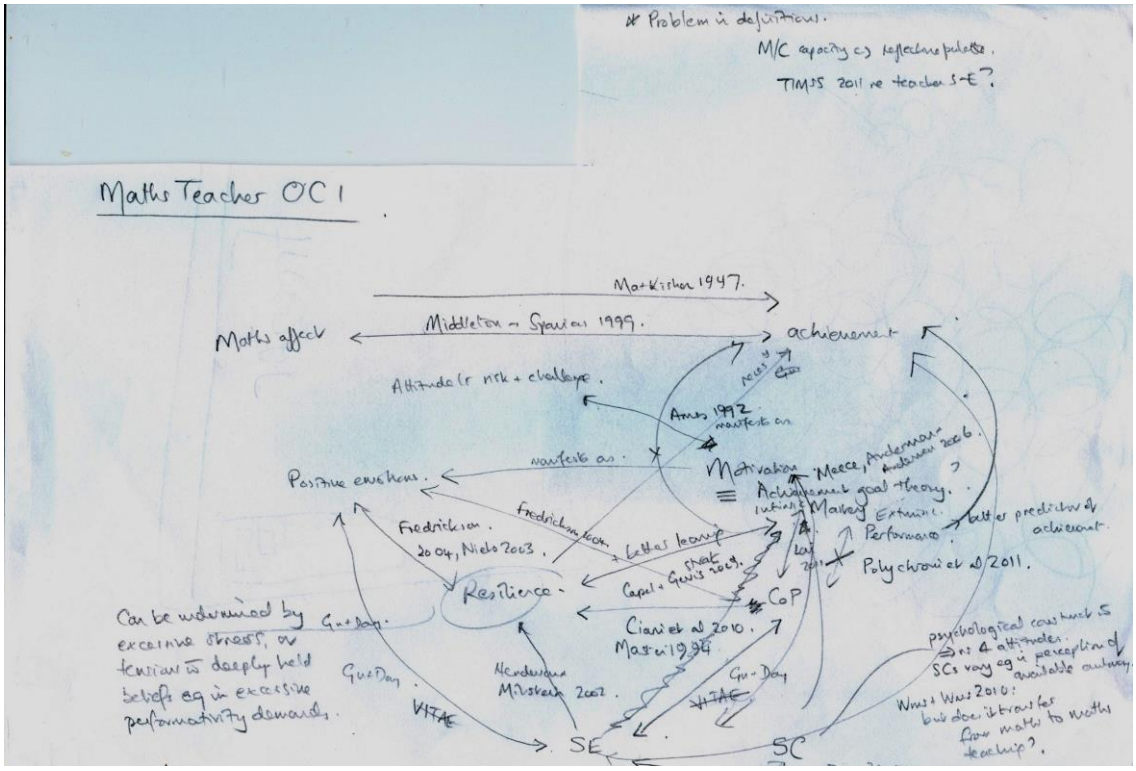
	to including teacher based elsewhere in some discussion but that is limited; itinerant teachers based in office	organisational.
Student summative assessments	Analysed at a 'big idea' level as well as at smaller scales; during discussions and in subsequent informal talk links made with classroom 'noticing' to make process-level as well as content-level developments to SoW.	Micro-analysed at small question and content level; adjustments made to SoW references.
Potential for teacher learning community Engeström (1999) to compare what happens at student level with what happens at teacher level during a period of planned change	Serendipitous opportunities mined for teaching implications; teaching successes and failures (largely learning-focused) happily shared by most, in corridor, in office, in SR, including time before and after school. Includes maths problems which may or may not be related to current teaching. Teachers share media clips, discussions on radio, ideas from networks, in an ad hoc manner: some participate more than others. Efforts made to include maths-focused discussion at dept meetings as well as T&L-focused; progress in demoting admin to electronic communication but some teachers better at absorbing that info than others. Links made of teacher learning with learning by students	Interactions largely procedural although K says she wants to introduce more T&L into dept meetings. Challenges shared if there are possible institutional ways of addressing them (e.g. should student be moved, sent to Head of Year, parents rung); but not in general otherwise and maths not a general topic of conversation of focus in dept unless teacher stuck on exam or book question. Little apparent culture of deep reflection.
Potential for shared support of students	L/t and A/s support offered and supported generously by teachers; teachers feel free to wander into other lessons, most but not all confident to send students to ask a colleague; students largely feel they can approach anyone in dept if they have a query and are largely encouraged to do so.	L/t support and HW club staffed in turn by different teachers, and largely attract own students, but this is early days – that's just developing. Students in general, though, turn to own teacher and do feel free to approach them at any time re maths queries
Potential for shared lesson or sequence planning	Rarely used (enormously helpful when done, but time militates against)	Rarely used (dismissed – different groups have different needs). When >1 teaching group is sharing LOs etc., any sharing is likely to be sequential rather than in parallel
Beliefs	Strongly or at least weakly social-constructivist. Student-centred, claim value 'deep' learning. Can-do attitude, confident, willing to consider new ideas e.g. be pushed re challenge, reflect on them in varying depths	?cognitive-constructivist rather than deeply valuing social learning (concerns about not learning when in groups) but not currently deeply reflective. Claim valuing of principles behind new curriculum.

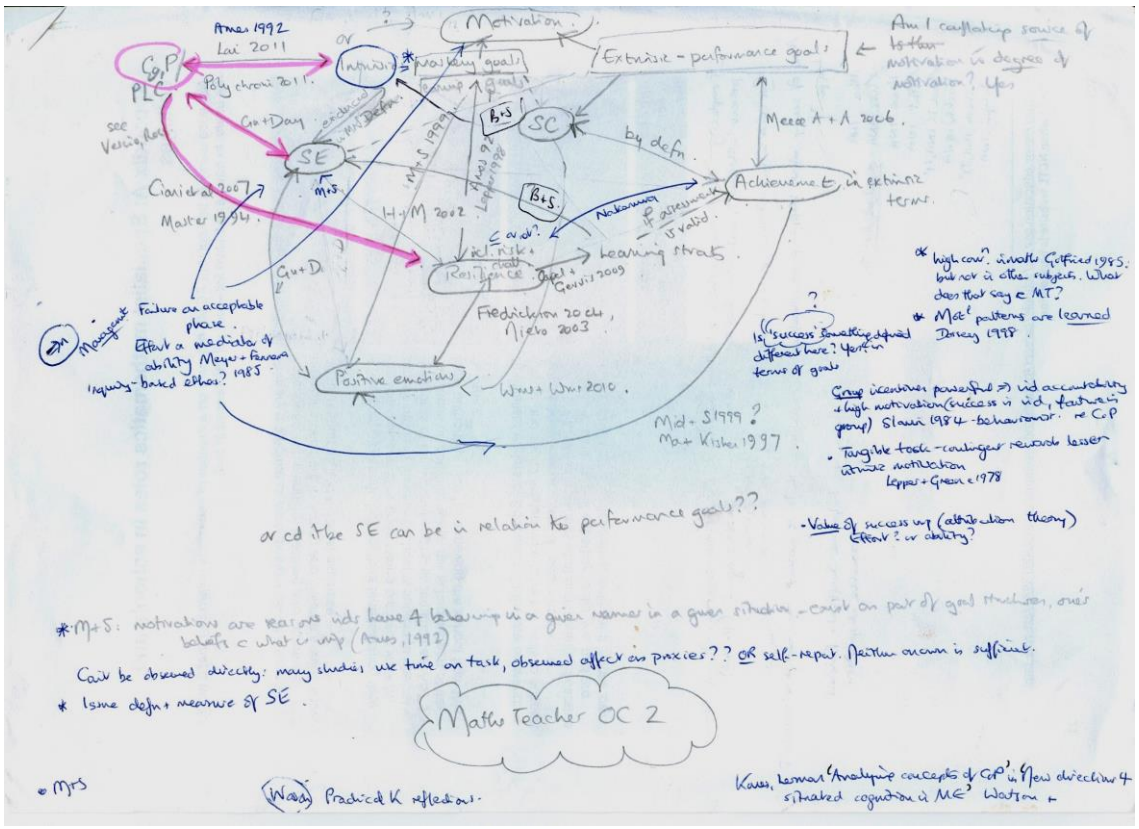
Appendix 21: Memo - Departments and Complexivist Change

Complexity theory (Davis and Simmt 2003)	***For mathematics departments in this situation, drawn on in chapter 8:***
Internal diversity refers to the idea that parts or members of a learning (=adaptive, self-organising) system have different capabilities. When there is a high level of diversity, there are more opportunities for a system to develop new and creative responses to situations. In the classroom, internal diversity is linked to a range of possible innovations and thus to the range of experiences and skills of the agents	A department has high internal diversity if teachers have a range of different experiences, strengths and capabilities, thus affording the development of more creativity in response to challenge. Too much diversity is a threat in times of challenge.
Redundancy is a characteristic of biological systems. Nature produces many more organisms than necessary to ensure that enough survive. Davis and Simmt (2003) suggest that shared vocabularies and experiences are examples of redundancy in the classroom.	They possess redundancy if there is more capacity than minimally required: Davis and Simmt (2003) suggest that shared language and experiences are examples of redundancy; shared knowledge, priorities and beliefs would also contribute. Too great a degree of redundancy can limit creativity.
Control in complex systems is decentralized. There is no "king" who sends out commands to every working part; instead, the response of the system depends on the interactions of individual agents. The counterpart in the classroom is that learning emerges from shared mathematical insights (Davis & Simmt, 2003, p. 152). In other words, the focus of learning is neither the teacher, nor the individual.	In complex systems, control is distributed, with interactions between individual agents driving response. Davis and Simmt (2003 p.152) suggest that in a mathematics classroom this is exemplified by learning emerging from shared insights, for which both teacher and students have responsibility. In a mathematics department, then, it might be characterised by distributed embracing of the responsibility required for initiating and developing a project. That is not to say that there is no role for the Head of Department: a complex system can be seeded with *attractors* to increase alignment with purpose, and the Head of Department or another might, inter alia, take responsibility for that.
Complex systems grow and develop within boundaries, but by random processes—that is, they display organized randomness. In education settings one might think about organized randomness by focusing on the idea of constraints. Within the boundaries of particular tasks students can respond and react with varying degrees of freedom.	Departments as complex systems work under enabling constraints: in this case these could be Awarding Body specifications, school codes of conduct, student and parental expectations… These limit the enaction of diversity to maintain a manageable and constructive degree of redundancy.
Neighbour interactions, in a biological sense, concern the impact of one organism on another and the effect of such interactions on development and behaviour. In the classroom, neighbour interactions could be interpreted as peer-peer interactions, but another option is to consider ideas that interact or "bump against one another" (Davis & Simmt, 2003, p. 156).	Departments only develop as an entity if there is potential for physical and emotional or intellectual interactions: these can be facilitated by working in close physical proximity, having shared classrooms or office space, choosing to engage in shared planning or discussion, physically or electronically… and that choice is important: the existence of shared physical space does not necessarily imply shared meaningful discussion – and that of course requires some shared language (redundancy) as well as sufficient diversity to enable a creative outcome.

Appendix 22: Memo - Development of affective framework

Drawn on in chapter 6, developed in chapter 8. Memos from handwritten file.





Appendix 23: Memo - Winch and Knowledge Quartet for Mathematics Teaching

In chapter 9 and Appendix 5 I claim that Winch's occupational construct can be construed to accommodate existing high-level models for mathematics teacher knowledge or expertise: here I exemplify that for The Knowledge Quartet (Rowland, Huckstep and Thwaites 2005)

<table>
<tr><td colspan="3">Classroom -focused know-how (may not mean conceptual, but rather, can devise a way to…)</td><td rowspan="3">Occupational Capacity
This is a potential from which actions are chosen dependent on beliefs and values</td></tr>
<tr><td>Skills ⊆</td><td>Transversal abilities ⊆
(Including processes)</td><td>Project management ⊆</td></tr>
<tr><td colspan="3">Each draws on a range of fields of propositional knowledge. Much is held tacitly. Classroom manifestation as:</td></tr>
<tr><td>Foundation, some transformation K – but broader than propositional SK: practical also (e.g. core PK and SPK), so more than can be learned in the academic institution.</td><td>Transformation K

Connection K

Contingent K

Largely at a lesson or sub-lesson level; includes small-scale problem solving. This draws on PK and SPK at a more developed stage, but many transversal abilities are only implicit in CR action.</td><td>Bigger scale and more synthesized pedagogical design. Transformation, Connection, Contingent K: sustained and coherent.

This includes PK and SPK at an integrated and more sophisticated level, including more demanding professional PS: again, largely implicit in CR action.</td><td rowspan="2">Winch: Scope of Transformation, Connection, Contingency increased further, including large-scale PS going beyond teacher's classroom; range of knowledge synthesized with the demands and affordances of the situation. engaging with the broader issues of the profession, leadership and development, ethical issues (which impinge on CR activity): a threshold level. Teacher is implicitly an effective learner: an adaptive expert. Normative, and technically, morally and aesthetically dependent.

Golding: a continuum of these attributes up to that above. Also a range of positive affective characteristics needed to support maintenance and development of such attributes. Explicit drawing on collaborative and learning dispositions. Much may be socially held, supported and/or developed; teachers can then access a capacity greater than they hold individually.</td></tr>
<tr><td colspan="3">Increasingly draw on a range of other, broader, knowledge. We see a range of K needed with increasingly deep understanding: that's important for engaging successfully with increasingly sophisticated professional problem solving.</td></tr>
</table>

Appendix 24: Postscript - two years on.

Serendipitous contacts in June 2014, eighteen months after the conclusion of study fieldwork, enable a rather more longitudinal lens to be used: I draw on participant comments with permission. As reported in Section 10.2, Greenways appeared to be committed to developing their scheme of work to further embed the principles on which it was developed, and had received a glowing Mathematics Ofsted subject report in September 2013, affirming their enaction. Nigel was confident about what that enaction, and claimed it was becoming embedded:

> 'It's still changing!' *(laughs)* 'And getting better: as we go on, we're learning more about how to make it work. We're determined to make the next change fit this model: we do think it's right' *Nigel, June 2014.*

High Wood claimed to have made some progress towards their original intentions, though quite how much is not clear:

> 'We've introduced some more problem solving into it: nothing world-shaking, but it's going OK. Give us time, we could easily go further, but of course now we've got to rewrite again, for the next GCSE, and getting that working is going to be a real challenge' *Kathy*

Both departments were beginning to engage with the next iteration of GCSE, for first teaching in year 10 in September 2015 and building on new curricula being introduced from September 2014. Teachers clearly articulated the commitment needed to do so productively (these were not recorded, but have been validated by participants as aligned with intended meaning):

> 'It's a real challenge, actually: we have a Key Stage 3 that seems to be working well, although there's always room for improvement – and we do always look for that, so it's not as if we're standing still. But every cohort that comes into year 7 over the next few years will have had a different curriculum experience, so as well as the usual variables we have that to feed into new versions of our schemes of work. *Of course* we'll try to limit the unforeseen consequences in our teaching, but it's going to be a challenge, it really is, and it can divert resources away from our efforts to constantly work for better learning. Essentially, we're convinced we're trying to do the right thing, so we'll aim for evolution of detail, rather than revolution of approach.' *Gillian, June 2014*

> 'It'll be interesting to see what happens: at present we haven't seen the Primary assessments so don't know what feeders will be doing, and the new *(submitted)* specimen assessment materials from (*their historic Awarding Organisation*) don't look too different, so we'll see. It would be good just to have some stability and work on making a good job of what we're doing, though – there's no doubt about it, the students miss out with this incessant change.' *Heather, June 2014*

At the time of writing (September 2014) submitted specimen assessments have been rejected and it remains to be seen whether assessment evaluators will demand high validity: without it, this study demonstrates clearly there is little hope for widespread enaction in the classroom.