Mathematics teacher capacity for change

Mathematics teachers across the western world are faced with an expectation they make significant change to their teaching, but repeated attempts have shown little embedded success. This paper draws on a longitudinal study of two apparently well-placed English mathematics departments attempting to make change aligned with both policy and internationally-valued 'good practice'. It suggests deep teacher change draws on a wide range of both social and affective characteristics, as well as sophisticated professional skills and knowledge. The study supports a construct of '(mathematics) teacher capacity for change' at both individual and group levels within teachers' 'personal domains', synthesising the range of characteristics apparently needed by teachers in times of change. In particular, it argues for the development of dispositions for collaborative learning and of other learning-supportive affect. Such an approach has the potential to place teachers in a better position to respond to demanding aspirations.

Keywords: capacity for change, affect, professional learning community, mathematics

Background

Recent years have seen global education policy attempt to move school mathematics learning towards deep conceptual understanding, rigorous reasoning, and genuine problem solving, in response to the perceived needs of twenty-first century society. Such changes, although widely embraced (Eurydice, 2011) have proved highly challenging and had very limited success at scale (Eurydice, 2011; Johnson & Millett, 1996) – even when teachers claim to both support the underlying principles and to be implementing new approaches as envisaged

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(Spillane, 2004).

Why, if teachers genuinely espouse such changes, do they not enact them? I adopt Ball's (1993) construct of a valid (but not deterministic) 'enactment' and argue that either there are other competing priorities (Leatham, 2006), or else teachers do not have the *capacity* to do so. I therefore asked what (individual or collective) teacher characteristics impact on the classroom-related actions adopted, and subsequently, how the answers contribute to our understanding of teacher 'capacity' that is, their available potential, for change. In Clarke and Hollingsworth's (2002) terms, in what ways do elements of the personal (individual or group) domain support or constrain goal-related enactment in the domain of practice?

Throughout, I make use of Clarke and Hollingsworth's (2002, p 951) 'interconnected model of professional growth' (Figure 1), in which change is translated between domains via enactment and reflection.

Figure 1: The interconnected model of professional growth (Clarke and Hollingsworth, 2002)

The paper draws on a study of two apparently well-placed mathematics departments attempting demanding professional change, to identify a range of differential teacher characteristics comprising apparently critical affordances or constraints for that in practice. It argues that the personal domain should be understood both individually and socially, and develops a model of teachers' capacity for change within that domain. It thus accommodates both the cognitive and situative approaches to teacher competencies that recent work by Kaiser et al. (2017) argues are necessary.

The Study

The three-year (2010-2012) study followed two English secondary departments ('Greenways' and 'High Wood') attempting first teaching for an aspirational 14-16 mathematics curriculum aligned with the above principles. I worked at a senior level within both departments. Both appeared unusually well placed for a valid enactment of these intentions (Ofsted, 2012), in terms of mathematical subject and pedagogical knowledge, prior experience, and stability. All teachers professed themselves committed to such a 'principled enactment', and proposed building on approaches they had jointly, and apparently successfully, developed in their 11-14 mathematics teaching. In Mitchell's (1984) terms, they formed a 'telling' sample. My work as a partial 'insider' to both departments had led me to conjecture that enactment would be dependent on differential knowledge and experience, with the High Wood department generally much more experienced as classroom teachers and apparently more mathematically and pedagogically knowledgeable, and I sought to explore how that impinged on enactment of the espoused change. It will be seen that, through the grounded approach adopted, my initial expectations were confounded.

Previous studies of similar attempts are largely over a short timescale, focused on individual teachers, and often of reported enactment rather than drawing directly on classroom data. Others, such as Cobb and Smith's (2008) study, and Stein, Silver and Smith's (1998) QUASAR project, although longitudinal and cognisant of groups of teachers, are of schools enjoying a scale of resource and support that means findings are often not transferable. In contrast, this study was of change enactment where the 'external domain' was common to all English mathematics departments. It was longitudinal, of both individual teachers and departments, and incorporated classroom-level data.

Spillane (1999) argues necessary conditions for deep teacher change include a social

rather than individual 'enactment' zone, high quality materials and rich expert-supported deliberation that is grounded in classroom experience: by focusing only on individual teachers we miss the significance of their immediate and wider social contexts. I therefore analysed at two levels – the individual teacher and the department. Johnson and Millett (1996) also cite the need for teacher motivation and for high quality time devoted to development. Prior knowledge of the teachers and their contexts suggested all these conditions would be met, at least to some extent. In particular, both departments had in their 11-14 work exemplified social enactment zones where rich classroom-focused deliberations were frequently heard: a supportive 'change environment'.

In England secondary teaching is usually organised via department-level 'schemes of work' which teachers interpret and adapt for use with their own classes. The 14-16 curriculum is assessed by high stakes 'GCSE' examinations. The study therefore incorporated responses to first GCSE results. Data included classroom observations, transcriptions of intervening interviews with three 'telling' teachers in each department, and documentary evidence, including emerging schemes of work and student questionnaires. In parallel I noted whole-department interactions such as department meetings and informal communications, using theoretical sampling and constant comparison (Charmaz, 2006) as I sought differential characteristics and enactments in the data. Pseudonyms are used throughout. The study, and the associated enactment, is described more fully in Golding (2016).

Theoretical approach

My approach was constructivist grounded (Charmaz, 2006), using open, axial and thematic coding of data to theoretical saturation, and this account parallels that grounded development. Interpretation employed activity theory (Engeström, 2001) and complexity theory (Davis and Simmt, 2003) lenses, bringing with that both richness and tensions, but allowing some

contrast, comparison, and complementarity (Prediger, Bikner-Ahsbahs, & Arzarello, 2008). These lenses both naturally accommodate a focus at two levels, as required, the former being top-down and structured, with teacher learning conceptualised as a disruption which necessitates reconfiguration of deterministic relationships, and the latter bottom-up, with learning an integral emergent adaptation.

Enactment

Both departments were overtly supported in their curriculum development decisions by school management practices. However, over time, as in other similar initiatives (Eurydice 2011, Spillane 2004) and contrary to my expectations, *High Wood* teachers, though more experienced and apparently more knowledgeable, adopted minimal compliance to policy intentions, with initial classroom-level change dissipating over the first eighteen months. Teachers claimed this was consequent on emergent examinations of limited validity, perceptions of limited bespoke resources, and some personal pressures. Department meetings suggested efforts to forge a principled enactment were also undermined by a dip in GCSE results in Summer 2011, which led to diversion of effort towards ensuring better Summer 2012 outcomes. The richness of teachers' interactions disappeared, with both formal and informal conversations observed to reduce to largely organisational issues. Teachers still claimed espousal of their original intentions, but with reduced urgency: 'It's just so hard, and there are other priorities' *(Heather, High Wood, Summer 2012).* The environment therefore became less change-supportive.

In contrast *Greenways* teachers, although generally less experienced and knowledgeable, and subject to similar pressures and constraints, were observed to achieve an apparently embedded and principled classroom enactment over nearly three years. In parallel,

they were seen to develop increasingly sophisticated pedagogical approaches and tools to meet the demands of their espoused enactment. Interviews and observations showed them maintaining a solution-focused attitude, so that for example in relation to resources, to which they had the same access as High Wood teachers, Nigel, the Head of Department, explained

'There are plenty of resources out there – for our needs, anyway. The fact they're not quite ready to go for our purposes is sometimes quite helpful because we can then make them work for us, and we've had some very useful conversations around that – it helps us hammer out just what we want to be happening, rather than accept someone else's approximation to that.' *(Autumn 2011)*

This comment is indicative too of Greenways teachers' sustained inclination to learn collaboratively. Such comments grounded a need to consider teacher 'capacity' beyond the subject and pedagogical knowledge and skills they brought to the change, which had been clearly more developed at High Wood.

Each theoretical lens appeared the better model at different times. Activity theory exposed key roles for tools (teaching, learning and assessment materials, but also teacher knowledge, affect and leadership characteristics), and also for 'boundary objects' such as schemes of work, linking different activity systems of individual teachers, classrooms, and the department. Complexity thinking illuminated conditions for expansive change, including the importance of close 'neighbour interactions' (ideas as well as people), the affect to maintain that, and 'diversity' and 'redundancy' of apparently available knowledge and leadership roles.

Constant comparison of data exposed an emergent significance for differential affect and goal-related reflection. In Greenway's case, characteristics I term a '***deeply reflective palette'***, a '***virtuous circle of positive affect'***, and a ***social learning capacity*** appeared critically change-supportive, and I discuss those below. In terms of knowledge, but also learning and affect, the department largely appeared to function as a complex entity at a number of levels (the group of teachers, the individual teacher, each mathematics classroom,

individual students …). Some aspects of leadership, for example Nigel's interface with senior leadership, were overt, individual and stable, while others were distributed although often dormant until called-for. For example, when talk showed commitment to the espoused enactment wavered or was in danger of being 'trumped' by accountability considerations, fresh leadership roles emerged and re-established focus. In complexity terms (Davis & Simmt, 2003) there was sufficient both diversity and redundancy to support expansive change through close interactions.

I discuss, and situate, the evidence for such differential characteristics before drawing them into a putative framework for teacher capacity for change.

Differential characteristics and discussion

Knowledge and Skills

The 2010 14-16 curriculum makes extended demands on both subject-related and subject pedagogic knowledge (ACME, 2011), and these two departments were very aware of the demands of the enactment they were espousing:

> '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 …but it makes enormous demands on your knowledge – of the subject, and of students and how they work' *Kathy, High Wood Head of Department, Autumn 2010.*

> 'It's about being prepared in a depth you didn't need before… it really tests the depth of your knowledge... and often extends it – we often have to go away and talk with colleagues, there are so many hard pedagogical issues thrown up…. ….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.' *Gillian, Greenways, Summer 2012.*

Such claims were validated by classroom observations. So an adequate *knowledge base* is clearly important, but so too is teacher capacity (and disposition) for professional learning.

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Observations and interviews over the three years showed Greenways drew heavily on the department distributed knowledge base and from that appeared to build a knowledge greater than the sum of individual knowledge, as might be expected from a group functioning as a complex entity. Borko and Koellner (2008) and Horn (2005) show mathematical knowledge is deepened through planning and discussing lessons, and also through reflective interactions with colleagues in parallel with implementing new teaching practices. These interactions between the wider personal domain and the domain of practice were more consistently evident at Greenways even from the start, though High Wood, initially apparently more mathematically and pedagogically knowledgeable, might have felt that they had less need.

Reflective palette

Most Greenways teachers increasingly exhibited a range of reflection-supporting characteristics – habits of overt and shared reflection on proposed and experienced practice, language developed further to support that, increased sensitivity to and attention to/noticing of words or actions of colleagues or students (Ainley & Luntley, 2007; Mason, 1998), profound listening (Davis, 1997) – again, to both colleagues and students. For some teachers, as Gillian above, an inclination and capacity for deep reflection appeared to support progress towards a demanding and principled enactment. 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.

'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 entailed response implies an ability to analyse and address professional problems, and to construct professional knowledge before, during or after their enactment - reflection

for, in and on action, respectively (Cochran-Smith & Lytle, 1999). Both Schon (1983) 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 can be hard to observe even indirectly. 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, observations showed 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?
> *Carol, Greenways, Summer 2011*

It is striking that no later interactions with any of the High Wood teachers showed autonomous teaching and learning-focused 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, not made overt, or out-privileged by other, perhaps performativity, considerations, as described above.

I frequently heard Greenways teachers developing shared language for group reflection: teachers talked about a 'rich but skills-based KS3, but rich-with-skills-in KS4', developing 'a greater fluency in accessing algebra as a tool' and 'a natural algebraic thinking'

as they wrestled with a perceived need to improve learning of algebra. Such phrases became 'classification systems' in Horn's (2005) terms, and appeared a tool for teacher learning. Differences in understandings were exposed in informal and formal conversations in a highly interactive and apparently increasingly reflective department. These were observed often argued through in relation to specific classroom situations, and there was a will to find at least a consistent set of understandings.

Such language development is similar to that identified by Watson and de Geest (2014) and Horn's (2005) 'replays and rehearsals' as their departments 'shifted' from talking about tasks to talking about learning. In contrast, teachers at High Wood typically showed little emergent social construction of language for thinking about teaching and learning, and the language they did use did not reflect the depth and richness of enactment initially espoused: predominant talk became administrative or organisational, and participants answered comparatively superficially when probed about such matters. Such resources are clearly fragile.

Effective reflection depends on *paying attention to* (Ainley & Luntley, 2007; van Es & Sherin, 2002) and then *noticing* (Mason, 2002) the thoughts/actions/situations which are the object of reflection, including deep listening (Davis, 1997) to students. It depends on the motivation to engage in that reflection, and on having the knowledge tools to do so effectively. For individual teachers, I observed depth of noticing skills to correlate well with depth of reflection, as well as of pedagogic knowledge exhibited, perhaps because 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: interviews showed it apparently linked with individuals' beliefs and priorities – gender-related issues for one teacher, metacognition for another, for example – and the sharing of these added to richness of talk.

A capacity for noticing appeared to contribute to the embedding of Greenways' enactment by affirming teachers in their experiments: valued outcomes were emergent, and reflection allowed teachers in department talk 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 enactment. Further, such reflective behaviours can spawn additional benefits: 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. Such benefits were also identified in interviews and observations at Greenways, and appeared to affirm them in their efforts.

Virtuous cycle of positive affect

As the study progressed, Greenways' pedagogical growth appeared sustained by access to a range of positive affective traits emerging from the data, including resilience to contextual factors, motivation claimed 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. Variations between individuals and over time appeared to be compensated for by a social effect, as if these traits were distributed: a 'group affect' which occurs naturally within a complexity framework.

Most Greenways teachers also appeared better equipped for resilience to curriculum challenges. *Resilience* is an ability to bounce back, to recover strengths and positive attitudes

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in the face of challenge or adversity (Henderson & Milstein, 2002). Gu and Day (2007) show that is relative, dynamic and developmental, and supported by positive emotions; they extend their definition to include persistence in the everyday challenges of teaching. 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 a goal-supportive professional community can enhance that effect, and also that resilience is necessary to support a deep sense of vocation for teaching, and good self-efficacy, motivation and commitment. They show resilience can be undermined by tensions with teachers' moral purposes, as in for example excessive performativity demands: resilience in this context could then perhaps be conceptualised as the degree of stability of equilibrium of the personal domain in pursuit of professional goals.

Teachers at Greenways were largely 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, November 2010.*

They worked on the new curriculum in ways which the Curee/QCDA (2009) 'challenge' project shows to be constructive for students, interpreting it as both an opportunity and a deep challenge. Talk showed they became 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'. Their reflective palette appeared, particularly in curriculum planning and evaluation sessions, to interact with their sustained inclination to learn collaboratively, and to be maintained through a clear principled motivation (a 'mastery' orientation), resilience to challenges or setbacks (as above, often addressed through a 'redundancy' of capacity), embrace of risk and challenge, and increasing self-efficacy (Bandura, 1986) in relation to the

change, supported by positive student feedback: maintenance of teachers' capacity for change was supported by reflection from the domain of consequence.

As with Gu and Day's (2007) teachers, the described threats to High Wood's espoused enactment appeared to feed into a negative spiral of minimal compliance. Greenways teachers' talk appeared increasingly tolerant of both risk and challenge, whereas the talk at High Wood became not uniformly, but increasingly, 'downtrodden'. Reflective conversations in Greenways frequently led to the constructive critique of approaches or materials adopted, but this was typically also constructively received, resulting sometimes 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, constructive criticism was observed poorly received on several occasions.

The relative inexperience of the Greenways department means that policy fatigue might have been less likely: emerging High Wood talk about future developments often featured 'we've seen it all before, and it will come full circle eventually' or similar, as with Gu and Day's (2007) most experienced teacher. In contrast, most Greenways teachers talked about proposed further curriculum 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. Resilience appeared boosted by their immersion in a goal-supportive professional learning community (Hord, 1997) 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.

Core to Spillane's (1999) necessary conditions for deep change is *motivation*. With Spillane and with Lai (2011), I 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. Much of the literature stems from work 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 over their own learning by allowing them to make choices, and using collaborative or cooperative learning approaches: enactment at Greenways suggests this might be extended to teachers, with management at both schools supportive of the proposed developments, even though they entailed some risks to student examination outcomes.

Such intrinsic motivation leads to greater persistence with a task than extrinsic motivation (Capel & Gervis, 2009) and additionally, it appears that tasks perceived to have only a moderate chance of success are generally found more enjoyable (Middleton & Spanias, 1999): success in a challenging task is all the sweeter, though failure can be demotivating. It would appear then that Greenways placed themselves in a good position for a 'virtuous circle' of enactment.

As I probed these motivational traits, independently identified from fieldwork in a grounded way, it emerged that there were links with the literature on goal theory, which

embraces 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. 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 frequently heard in casual conversation, in contrast to High Wood, where, eventually, performance outcomes were overtly privileged. At Greenways, it appeared that developing and enacting a principled scheme of work for the new curriculum 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, & Anderman, 2006), since goal achievement is perceived to co-vary with effort, and is therefore linked with a high degree of self-efficacy (Bandura, 1986). The same paper shows student goal orientation is heavily impacted by their perceptions of the goal orientation of their learning environment. For teacher learning here, the critical word seems to be 'perceptions': Greenways *perceived* they had effective autonomy in choosing mode of enactment, 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.

The contrast is clear: at Greenways perceived goal-oriented success 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. The

nature of one's goals is 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 here, exposed priorities are time- and context-dependent.

A construct of confidence in relation to, as here, a planned teaching action in a limited field, 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 by 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, Greenways, November 2012, good self-efficacy in relation to department enactment;*

> '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.' *Heather, High Wood, July 2012, poor self-efficacy.*

Bandura (1986) defines self-efficacy 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'. Moreover, he 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).*

In summary, this literature taken together suggests that resilience, motivation and mastery goals interact with teachers' self-efficacy in a virtuous network, as represented in Figure 2, and in this case it would seem such a network was central to a change-supportive personal domain. Two structures in the change environment appeared to support that

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network: within the school, leadership for teacher learning, and at department level, the adoption of a professional learning community structure (Hord, 1997), discussed below.

Leadership for teacher learning

The impact of school leadership promotion of teacher professional learning is clearly articulated in Robinson, Lloyd and Rowe's (2008) generic synthesis. For example, they identify leadership which values effort as a mediator of ability, and failure as an acceptable phase, as critical. Such leadership was evident at both schools, though the related autonomy was perceived differentially at Greenways, and differentially enacted by department (distributed) leadership there. Indeed, much leadership in English schools, understood as activities which are designed to influence colleagues within a network, is enacted at a department level (Hodkinson and Hodkinson, 2003). Both departments initially appeared led primarily by the Head of Department, though at that stage 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) shows that leadership is systemic, relational, and attributional, so that teachers typically must both allow and recognize leadership. He suggests professional leadership in schools is largely exercised through social interaction with colleagues, and evaluates consequential development of capacity for learning among teachers, citing evidence that leadership targeted at teaching and learning is unusual. Kathy's leadership at High Wood was initially very 'central' (de Lima, 2008) to developments, with the rest of the department accepting of her leadership and working to support her decisions, in a typically hierarchical department (Hodkinson & Hodkinson, 2003). Such hierarchy meant that when she encountered pressures diluting her leadership, the deficit seemed naturally, if reluctantly and

fairly passively, filled by the second in department, and he appeared critical to the limitations of 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, but the core leadership work of interpreting the curriculum for classroom enactment was driven and shared by several teachers, so that at times when Nigel's commitment to a principled enactment 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. In complexity terms, distribution of leadership served to offer both redundancy and diversity, as well as supporting development of the wider professional capacity of teachers.

Distributed leadership at Greenways was also seen to influence transactions with senior management: Nigel was the interface 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 instead concentrating on addressing root causes. 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.

As in Spillane (1999), rules relate in part to the provision of sufficient *time* for non-superficial learning (Stoll, Fink, & Earl, 2003, p. 240), and for High Wood, complaints about lack of time for a principled enactment were persistent, and increasingly interspersed with a 'survivor' discourse, with interactions in the department coming to focus on 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, June 2012*

A professional learning community

Greenways' emergent goal-related social learning structure is well described as a *professional learning community* (Hord, 1997), sharing goals focused on student learning, professional practice, vision and values, and with supportive leadership. Vescio, Ross, and Adams (2008) show such functioning typically requires distributed authority at both department and individual levels, with de-privatisation of practice, active critique of one another's ideas and perceptions, and drawing on external expertise. It will be seen that a number of Greenways' particularly productive differential characteristics appeared to be both enhanced and sustained by this structure. Observations showed they habitually worked in collaborative problem-solving ways, sharing both successes and perceived failures as opportunities for learning and addressing emerging problems proactively.

Such an approach appeared to further support knowledge and pedagogical developments in a virtuous cycle of enactment, robust enough to tolerate isolated teachers on the margins of the change, as described also by Watson and de Geest (2010) in departments successfully enacting autonomous change.

Such characterisations also appeared to be critical in that their comparable presence at High Wood at the beginning of the study dissipated there apparently as a consequence of the variety of disruptors described. Clearly, disruptors to good potential for change, such as those identified at High Wood, should be avoided, or their impact minimised, where possible.

Synthesising these differential characteristics of a network of positive affect supported by appropriate leadership and professional community and leading to effective professional learning, we have Figure 2.

Figure 2: A virtuous cycle of positive affect for deep change, with some related constructs in the change environment

Such a model was validated by participants from both departments in interviews and informal talk.

Teacher capacity for deep change

Growth and change

Clarke and Hollingsworth refer to established teacher change as 'growth'. I have here refrained from using that terminology since High Wood's exhibited change also became

established, but not in the direction they initially espoused. The purpose of the undoubted 'growth' (in personal domains, domains of practice and of consequence) evidenced at Greenways was to achieve a particular, widely-espoused but demanding, change in practice across the department (with anticipated resulting change in student learning and affect, as well as associated change in the teacher personal domain), and to embed that: I use 'deep change' to represent that goal.

For Greenways, an affectively-supported professional learning community appeared to both draw on and catalyse development of a range of professional knowledge and skills, including, centrally, a reflective palette. A characterisation of Clarke and Hollingsworth's (2002) 'personal domain' necessary to support such demanding change would therefore incorporate knowledge and beliefs, generic capacities such as reflection, affective traits, and also collaborative and learning dispositions and capacities, each considered at both individual and collective levels, as supported by the theoretical frameworks adopted. Cited fieldwork shows these facets of capacity interacting in both directions. Such a domain would then operate at both levels, with the domains of practice and of consequence similarly enhanced. Note the importance of the wider (school and beyond) change environment, its affordances and constraints, and in particular, as in Clarke and Hollingsworth (2002), teachers' *perceptions* of those. For example, the external domain was the same for both departments, yet perceived by Greenways teachers to be far more goal-supportive than it was by those at High Wood. Diagrammatically, I propose:

Figure 3: Teacher capacity for deep change

Within this construct, a teacher or group of teachers will exhibit a profile of

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characteristics, with the optimal profile, I'd suggest, dependent on the context: for example, I conjecture resilience and self-efficacy are central to aspirational embedded teacher learning, although the 'positive affective network' (Figure 2) is deeply networked, as shown in this study and supported by the literature. In more stable contexts, another profile will be optimal. There is no claim to completeness: there may also be other characteristics integral to the construct.

Conclusion

The research question remains an urgent one in England. The national enactment of which this study presents a snapshot was judged ineffective in delivering key objectives at scale, so from September 2015 mathematics teachers again grappled with the demands of a re-presented 14-16 curriculum, for first examination Summer 2017. This study highlights affordances and constraints for such teacher change at both an individual and collective level.

The change envisaged in the study makes considerable demands on teachers' knowledge, including deep subject-specific knowledge, where 'knowledge' is conceptualised as a variable profile of generic and subject-specific 'know-how' and 'know-that' understood at a range of granularities, depths and sophistication. Committing to such change is risky, and this study shows it benefits from management support and clear, constructive and flexible leadership in the change environment. Additionally, it shows demanding change appears to draw on a range of positive and supportive affective traits, including positive dispositions for reflective practices, for learning, and for collaborative working.

These can be summarised as teacher 'capacity for change', embedded in teachers' personal domains and operating at both an individual and a group level. In principle, a similar construct might be applicable not only to teachers of mathematics in different contexts, but

also to other teachers attempting challenging change. It certainly has implications for both

initial teacher education and ongoing teacher development, since it foregrounds not only the

knowledge (of all sorts) and professional abilities usually focused on in teacher education

models, but also a range of affective and collaborative characteristics. It needs further

development and testing as a general model for teacher professional capacity, but if found to

have potential, gives a minimal tool for understanding what teachers need and what should be

built up through initial and continuing teacher education. It therefore has potential as an

analytical, predictive and potential developmental model within the design and study of

teacher growth.

One key message seems to be that good intentions, even when accompanied by

extensive knowledge and substantial experience, are fragile. They need also to be supported

an effective professional learning community which nurtures a wide range of change-

supportive affect. Teacher development, at whatever career stage or scale, would appear to

have much to gain by promoting the value of such communities and working to build up

teachers' development-supportive affect.

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