Sheffield Hallam University

Complexity and leadership in teacher professional development : the case of the National Centre for Excellence in the Teaching of Mathematics

BOYLAN, Mark <http://orcid.org/0000-0002-8581-1886>, COLDWELL, Michael <http://orcid.org/0000-0002-7385-3077> and SIMKINS, Timothy

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Complexity and leadership in teacher professional development: the case of the National Centre for Excellence in the Teaching of Mathematics

Mark Boylan, Mike Coldwell & Tim Simkins
Centre for Education and Inclusion Research, Sheffield Hallam University

Contact: m.s.boylan@shu.ac.uk

Abstract

There has been considerable interest in the teaching of mathematics over the last two decades, both internationally and in the UK. This has led to a number of government sponsored interventions in both curriculum and teacher professional development. The establishment of the National Centre for Excellence in the Teaching of Mathematics (NCETM) in 2006, arguably, represented a departure from previous policy and initiatives related to professional development for teachers of mathematics.

This paper looks at what was distinctive about the NCETM approach (2006-2010) and the impact of its work, as well as exploring a number of theoretical issues that arise when describing these. The paper draws on data from a study of the impact of the NCETM that was informed by interview and case studies. Telephone interviews were conducted with 89 teachers and others with differing levels of involvement with the NCETM. In addition, 10 school-based case studies of different NCETM-supported activity were conducted.

This material was analysed using a CPD evaluation model (Coldwell and Simkins, 2011) and more generally in relation to literature on school and teacher change. In this paper, we explore ways in which theoretical tools drawn from complexity theory - complex adaptive systems and formal and informal systems - can be used to describe the nature and consequences of the NCETM's actions. Further, in understanding and assessing the impact of the NCETM intervention on subject leadership and teacher identity we suggest that parallels can be made with analyses of identity in social movements. Finally, we examine the concepts of dispersed and distributed leadership in relation to their applicability to the organic development of mathematics teacher leadership that the NCETM promotes.

The paper outlines both the type of outcomes of the NCETM's activity and the factors that supported these. Many of these are similar to those previously identified in relation to professional development that focuses on and supports school-based leadership and can be analysed in terms of theoretical concepts such as distributed and dispersed leadership. However, the NCETM's approach had some distinctive impacts and features that, we contend, are particular to the complex interrelationship of the different forms of NCETM activity.

Introduction

The aim of this paper is to trace the connections between policy, intervention and practice in relation to a specific teacher professional development initiative - the National Centre for Excellence in Teaching Mathematics (NCETM), established in 2006. In this paper, we explore the nature and some of the relational effects of the NCETM's activity. After discussing the establishment of the NCETM and the empirical study on which this paper is based, we offer an analytical description of the NCETM and its approach, informed by concepts drawn from

complexity theory. We describe ways in which the NCETM is a complex approach to professional development. This leads to discussion of the complex patterns of relationships that are engendered by its activities. Understanding the NCETM through the lens of complexity serves as background to a discussion of the forms and nature of leadership connected to NCETM activity. We begin this part with a brief discussion of recent literature on distributed and teacher leadership before discussing empirical data.

The context: Mathematics Education policy, and teacher professional development

The National Centre for Excellence in Teaching of Mathematics (NCETM) was established in a policy context of intervention into education by the 1997-2010 Labour Governments. Prior to the 1997 election, and immediately following it, the policy focus in mathematics education centred on primary education. The introduction of the National Numeracy strategy and its consequences have been widely reported and debated (see for example, Boylan, 2000; Brown, et al., 2000; Brown, et al., 2003; Earl, Watson, & Torrance, 2002; Earl, et al., 2003; Leithwood, et al, 2004; McNamara & Corbin, 2001). These policy initiatives were spurred by a number of concerns, including international comparisons of mathematics attainment in England with elsewhere - linked to the perception of a direct relationship between mathematical attainment and economic competitiveness - and a concern for raising mathematical attainment of socio-economically disadvantaged groups as part of the government's concern with 'social inclusion'.

At the start of the century, the focus within mathematics education extended into later age phases leading to the Smith report into 14-19 Mathematics education (Smith, 2004). Key issues identified in the Smith report were low take up of mathematics post-16 and concern with teacher quality, with a significant number of high school mathematics lessons being taught by non-specialist teachers of mathematics. Smith recommended the creation of a network of national and regional mathematics centres to support the professional development of mathematics teachers along a similar basis to the already established National and Regional Science Learning Centres. The report also recommended that resources for mathematics teacher professional development which were at the time spent through the National Strategies should be redirected to be spent through the NCETM. Rather than fully accepting these recommendations, the government of the day established a National Centre with funding for running costs but without the capital funds suggested by Smith for a physical centre or the redirection of National Strategies funds. The NCETM was established instead as an on-line 'virtual centre'. As an alternative to regional mathematics centres, funding was allocated for the employment of regional co-ordinators. Thus, the NCETM was charged with developing and co-ordinating mathematics professional development as an additional layer to existing initiatives rather than a replacement for them.

We include this detail here for two reasons. Firstly, because it is important to highlight that some of the characteristics of the NCETM's activity and structures were not necessarily intentional or policy responses based on evidence or consensus. Rather they emerged and developed in a situation of limited financial support and contestation about the preferred forms of mathematics professional development and in a complex ecology in relation to mathematics education in England. Secondly, because we later analyse the NCETM's approach to professional development by contrasting it with the different approaches of the National

Strategy, Best Practice Scholarships and Science Learning Centre network (initiatives discussed below).

The establishment of the NCETM and its approach also needs to be understood as part of an ongoing tendency internationally that emphasises the importance of teacher professional development that involves teachers in setting the agenda for development, interacting with peers and the encouragement of teacher leadership (Coolahan, 2002; Fraser, Kennedy, Reid, & McKinney, 2007). Although the establishment of NCETM was a policy initiative and so has characteristics of a 'top down' approach, its practice has many features of 'bottom-across' involving collaboration across school sites (Coolahan, 2002; Fraser, et al., 2007) and reflects the growth of interest in teacher and distributed leadership (Gronn, 2000, 2002, 2008; Hartley, 2007; Harris, 2003; McBeath, 2005; Muijs & Harris, 2006).

The study

The data set we draw on in this paper was gathered during a study commissioned by the NCETM on its impact on teachers, their practice and on learners. The aims of the study were to gather evidence of the impact of the NCETM's provision on teachers, their practice, and outcomes for learners. The study used two main methods - telephone interviews and case studies - supported by documentary analysis. The suitability of telephone interviews for education research is an area of disagreement (Sturges & Hanrahan, 2004). However, in this case, we believe this is a credible method, given the semi-structured nature of the interviews and the focus on professional rather than personal issues and on the NCETM and NCETM connected activity. The telephone study consisted of 89 interviews of which 44 secondary were school teachers, 24 primary school teachers, 8 working in 6th Form/FE college, 5 teachers in other schools and 8 LA or other consultants. The teachers had a variety of roles, with an over-representation of those with leadership roles in mathematics than might be expected in the general mathematics teaching population, including some in leadership roles without current mathematics teaching responsibility. The interviewees were predominantly female (65%), although this broadly reflects the gender balance in the mathematics teaching population when primary and secondary populations are considered together. The sample was overwhelmingly white (95% of those who answered the ethnicity question). However, statistical analysis did not indicate any significant differences in responses in relation to the demographic factors. Nevertheless, it is clear that the telephone interviewees are not a statistically representative sample of mathematics teachers in England. For example, one significant constituency is missing - those who have no or little relationship to the NCETM - as a condition for inclusion in the sample was some involvement in the NCETM's activity.

The recruitment of telephone interviewees was done in a variety of ways. Most interviewees responded to a general request through the NCETM website and newsletters. This was supplemented by specific requests to participants in various NCETM activities either nominated by NCETM regional co-ordinators or identified by members of the research team from documents and some 'snowballing' (Hennick, Hutter, & Bailey, 2010) by asking interviewees for suggestions. The latter methods were used to generate a sample that would reflect the diversity of different ways of being involved (or not) with the NCETM from educators with a range of positions within schools and wider networks. The telephone interviews were digitally recorded and a summary of each written. Both a quantitative and qualitative analysis of the interviews was conducted. Quantitative analysis involved coding responses and was

used to give some measure of issues such as the level of involvement and impact. In addition, statistical variance between different groups of respondents was explored. The interviews were also analysed for common themes and features between participants. It is this second form of analysis that is generally drawn on in this paper. The sample is not necessarily statistically representative of people engaged with the NCETM. The analysis we present in this paper is a description and analysis of the types of relationships and forms of leadership that are found in connection with the NCETM activities, we do not make claims about the frequency of these relationships and forms of leadership.

In addition to the telephone interviews, 10 case studies were conducted in 4 secondary schools, 5 primary schools and one cross-phase school. In each case, data were collected mainly in the form of face to face interviews with a total of 40 interviews being conducted. One or more key recipients in each site were identified, usually those identified as grant holders in the case of projects and/or teachers or others leading in relation to NCETM connected activity. Additionally, a 'strategic lead' was interviewed, usually the headteacher in primary schools or in secondary schools a member of the senior leadership teams. Further, the perspective was sought of 'beneficiaries' - these being either teachers or teaching assistants who potentially benefitted from NCETM connected activity or pupils. These were either individual (n=25) or paired or group interviews (n=6), used, for example, when interviewing pupils. A total of 66 people were interviewed consisting of 10 strategic leaders, 32 teachers, 22 pupils and 2 teaching assistants. Key respondents were the immediate direct recipients of the NCETM's support. In most cases, these were grant holders for NCETM funded projects. The sample was recruited from five regions, with an over-representation in the secondary phase of selective schools in relation to the national profile (two grammar, two secondary modern). The case study interviewees represented similar types of demographics as the telephone interviewees and similar relationships to the NCETM (see below). One difference was that in two of the case studies the Advanced Skills Teacher in the school was sponsored by the NCETM. However, given that the NCETM only sponsored 6 Advance Skills Teachers nationally at the time, this is not representative. This was designed to help assess the impact of this innovation. The interview and case study data were supplemented with other sources of data on the NCETM's impact including data participation data provided by the NCETM, and other internal surveys and a recent study of the NCETM's teacher enquiry funded projects (Joubert & Sutherland, 2010). Note that in both the study report to the NCETM and in this paper pseudonyms are used for research participants.

Our intention was to utilise a 'level model' framework developed over a number of leadership development programme evaluations (Coldwell & Simkins, 2011) for the analysis of the case studies. As we note in that paper (p. 153), such level models are helpful in evaluating well-defined, bounded professional development programmes, but are less useful in relation to multi-faceted, interacting interventions into which category the work of the NCETM clearly falls. Therefore, we subsequently utilised a largely inductive thematic analysis, drawing, to some extent, on categories derived from the telephone study analysis and other sources (such as the NCETM's own user survey questions). Although the main focus of the study was on assessing the impact of the NCETM. Two issues that emerged during the study were, firstly, the challenge of conceptualising the nature of the NCETM as an approach to professional development, and, secondly, the forms of leadership that the NCETM was variously,

supporting, enabling, prompting or inspiring. In this paper, we draw on this data corpus to analyse and discuss these issues.

About the NCETM

The formal stated aim of the NCETM was and is to support mathematics-specific professional development. It aimed to do this through:

> The coordination of existing provision; the promotion of government initiatives; the identification of areas where more resources are needed; and the creation of an online learning environment and interactive, tailored tools including a professional development framework and a directory of all professional development available to teachers of mathematics (NCETM, 2011).

Hoyles (2010) provides a detailed description of the NCETM's activities (relevant to the period 2006-2010) which we summarise here. Note that many of the features of NCETM activities continued under a new contract after 2010, however for simplicity we refer to the NCETM in the past tense.

The NCETM styled itself as a virtual centre; its website and related on-line resources were its key visible on-going presence. The website advertised the NCETM's and other organisations' professional development events and activities. It also provided a range of professional development resources including individual access for registered users to a 'Personal Learning Space' for self assessment and reflection. It hosted a number of on-line communities. The website provided a gateway to information on and reports about NCETM funded projects which were, in most cases, led by school/college-based teacher practitioners. Registered users regularly received e-newsletters with a regional focus. In addition, four different e-magazines focused on age phases were published quarterly. These included suggestions for classroom activities as well as for professional development activities.

A significant aspect of the NCETM activity was centred on a grants programme to support teachers engaged in school based or cross school professional development and enquiry. These projects had a number of different foci and names. Teacher led enquiry projects received grants of up to £3000 and had an action research element. Mathematics knowledge networks received smaller grants and could be situated in a particular school or be cross school. The knowledge networks had a particular mathematical or pedagogical focus. Some grants were targeted at Further Mathematics Knowledge Networks and STEM Knowledge Networks, thus addressing perceived particular professional development needs. In addition, a number of national and regional projects were also funded. The grant programme, in general, promoted teacher led, school based change and distributed leadership.

The NCETM's formal structure consisted of a small central directorate and a team of regional co-ordinators. The NCETM also drew on a wider network of associates who were experienced mathematics teachers and educators, contracted by the NCETM to support specific activities. In addition, the NCETM sponsored a small number of Advanced Skills Teachers - a teaching grade developed in the UK with a responsibility for professional development of colleagues in their own and others' schools (see Smith, Simkins, Coldron & Aspinwall, 2002). Towards the end of the period in question, the NCETM developed a national network of 'Ambassadors', serving teachers who act as promoters of NCETM activity for a year. The NCETM paid

schools to release Ambassadors to carry out this work. As well as directly organising and funding professional development activities itself, it also explicitly supported a variety of forms of professional development, for example, by advertising events by a range of providers in its Professional Development Calendar.

In the relatively short space of time the NCETM had a significant impact in terms of involving teachers, with approximately 60% of those who might be expected to potentially be involved in that period becoming involved, with a total of 40,000 registered users. Further, a sample of those engaged with the NCETM were almost all positive about the quality of its activities, and reported professional development impacts with approximately a fifth reporting profound changes in their teaching and/or their view of themselves as teachers of mathematics (Coldwell, Boylan, Shipton, & Simkins, 2010).

Complexity theory

Our perspective is informed by understanding organisations through the lens of complexity theory. We characterise the NCETM as an example of a complex and ecological approach to professional development. Linking the word complexity with the phrase teacher professional development in the title of this paper is, arguably, almost tautological, as teacher professional development is intrinsically complex (Opfer & Pedder, 2011). However, our use of the term points to the appropriation of a number of theoretical tools drawn from complexity theory.

The meaning, credibility and applicability of the many different versions or understandings of complexity theory (see Stacey, 2003) within educational research are the subject of debate and argument (Morrison, 2010). The application of complexity theory to organisations can entail at least two different types of claims.

The claim may be an empirical one. A particular organisation, system or situation may be more or less complex, its different aspects as more or less interconnected. This, then, is contingent on the particular features of the phenomena. Alternatively, a complex approach to understanding organisations can rest on generalised ontological and epistemological claims about the nature of social phenomena. From this perspective, all organisations are complex and can best be understood through the use of systemic and ecological metaphors or other social theory which embraces a holistic perspective. Even when the composition of a system, or the nature of activities that constitute it, appears to allow for a description of the system in more linear terms, the nature of social reality means that a more complete account of a system will reveal complexity. Even what may appear to be a relatively stable and definable physical artefact can only be understood in relation to complex associations (Law, 2002). In the context of teacher learning, multiple dynamics interact in many different possible ways in the context of systems which are nested within other systems (Opfer & Pedder, 2011).

This viewpoint does not preclude using theoretical models that focus attention on particular aspects of systemic process. Such models may be themselves address multiple features in a systemic process so can be of different degrees of complexity. However, such models are approximations or are akin to a two dimensional section through a multi-dimensional system.

Both of these perspectives on the nature of complexity inform our account of the NCETM and it activity. We begin by treating the notion of complexity as a contingent, empirical feature. We review the NCETM as a professional development intervention in comparison with three other

recent interventions. We then extend this discussion to consider the NCETM as a complex adaptive system. One aspect of this is the NCETM as an organisational system that consists of both structural and formal aspects and informal networks of relationships. The NCETM existed as a relatively well bounded organisation with a definable set of activities and practices that were, to a greater or lesser extent, interrelated. The formal system, in the case of the NCETM, included those who had a contractual relationship with the NCETM, its website, its publications and sponsored activities. The informal system included a variety of relational effects for example groups of teachers engaged more peripherally in professional development activities in relation to the NCETM. The NCETM existed as a loosely bounded and intermeshed sets of individuals, networks and clusters most of which were situated in, and have primary identification with, other organisations. Thus, the forms of relationality that arose through the NCETM's activity were complex. The informal system was an emergent system. Using the metaphor of a complex adaptive system suggests attention needs to be paid to the quality of boundedness in the system, the openness of the system and relationality. Complexity theory points to the way in which the form of structure and action develop and emerge in relation to the environment that is in turn influences and changed by such activity - a co-evolutionary model.

The NCETM as a complex approach to professional development

Here we focus on the NCETM as an organisational entity constituted in relation to other organisations and systems. The NCETM did not explicitly take a position on what constitutes effective mathematics professional development. Moreover, its purpose was not to advocate for a particular approach to teaching mathematics. Although its formal position was that it focused its provision on areas 'where more resources are needed', the situation was somewhat more complex than this. Although formally the NCETM took a stance of agnosticism in relation to favouring or supporting particular approaches to mathematics teacher development and to mathematics teaching, teachers and others interviewed during the study, spoke in terms of an NCETM approach. We surmise that this perception was based on the resources available on the NCETM portal, contact with NCETM representatives and the nature of project themes encouraged for teacher led funded projects.

Further, the NCETM philosophy was described in one of its publications as "based on the notion that understandings and knowledge growth concerning the CPD of mathematics teachers are co-constructed by teachers, researchers and other stakeholders" with an "omnidirectional knowledge flow" (Back, et al, 2009, p, 4.). The NCETM commissioned research into effective CPD in mathematics, promoted professional development that was focused on teacher concerns and had a significant school based and teacher led element. The NCETM also produced a document, *Mathematics Matters: what constitutes effective mathematics teaching* (NCETM, 2008), that set out a vision for mathematics pedagogy. Ostensibly, the document was the outcome of a research project; its origins lay in an NCETM initiated National Conference followed by a number of regional events. One way to conceive of *Mathematics Matters* is as an organisational policy initiative that could also, potentially, influence government policy, through the bottom-up distillation of agreed practice of those who engaged with the NCETM.

The NCETM combined features of a variety of other recent professional development initiatives in education whilst being distinct from them. Contrasting the NCETM with the

National Numeracy Strategy, we see some significant differences. The National Numeracy Strategy was a centralised and directive approach to change with a clear and relatively prescriptive set of policies and a cascade model of professional development (Brown, Millett, Bibby, Johnson, 2000; Earl, Watson & Torrance, 2002; Earl et al., 2003; McNamara, & Corbin, 2001). The NCETM, in contrast, had many of the features of an adaptive or decentralised change initiative (Smith et al., 2002). These features included a contested set of goals and means and an aim of developing a high level of learning in participants through loose institutional coupling in relatively unstable environments. At the same time, the 'National' in the title of the NCETM acted as a powerful warrant for teachers in persuading school leaders to support initiatives in a similar way to the National Numeracy Strategy (see McNamara, & Corbin, 2001).

An important aspect of NCETM activity has been supporting teacher enquiry in schools. This is similar to, and builds on, the legacy of the Best Practice Research Scholarship (BPRS) programme funded by the TDA (Furlong & Salisbury, 2005). The BPRS programme supported teachers to engage in enquiry that led to accreditation with support, therefore, of an academic as both a mentor and tutor. Although the focus of that scheme was on 'teacher as researcher', evaluation indicated that for teachers involved the primary focus was on the improvement of practice in their own school rather than contributing to public knowledge (Furlong & Salisbury, 2005). The NCETM funding for teacher led enquiry through the national and regional grants scheme (Joubert & Sutherland, 2010) was a continuation and development of this approach. The NCETM also encouraged and supported the development of networks of teachers both within schools and between schools through it Knowledge Network programme. Here, we possibly see the influence of another professional development initiative - the development of Networked Learning Communities that were a major initiative of the National College of School Leadership (Carter & Paterson, 2007). Examples of both enquiry projects and of teacher networks supported by the NCETM are referred to later in the paper when evidence from case studies is considered.

In addition, the NCETM also used what might be called a pedagogical approach to professional development. An example of such an approach is found in the work of the Science Learning Centres (SLC), in which the professional development focus is on short or extended courses where teachers work with tutors chosen for 'expertise' and the learning is linked to classroom practice (see Kudenko, Ratcliffe, Redmore & Aldridge, 2010; Bennett, Braund, & Lubben, 2010). A pedagogical approach has two possibly contradictory attitudes to teacher leadership and teacher authority. Firstly, the close connection to classroom practice supports the development of teachers as authorities in relation to their own practice. However, the role of the expert tutor points to the importance of external leadership in terms of professional development and teacher change. The first way that the NCETM enacted such a pedagogical approach is through a range of professional development events that it organised. For example, one teacher in one of the case studies took part in a course focused on creating a primary maths week. The course consisted of a first day workshop, on-line communication through an NCETM community and a second follow up day. However, insofar as the NCETM used such a pedagogical approach, the form experienced more commonly by users was through the opportunities for distance or self directed learning accessed via the web.

As a prelude to the later discussion about the type of leadership the NCETM's activity generated, enabled or supported, it is interesting to consider the role and position of NCETM

'experts' in comparison with that found in other professional development initiatives. There were a number of 'expert 'roles in the NCETM. By expert we mean people who may be experienced by teachers as experts: the Regional Co-ordinators, NCETM Associates and Ambassadors, authors of web materials (some of whom overlap with other categories), and, for those grant holders who chose to involve them in their projects, higher education academics. However, what is common to the role of 'experts' in general is to support the development of teacher expertise and leadership by, for example, enabling a grant holder to enact their project. This principle is similar to that found in the BPRS programme and the SLC pedagogical approach. However, the specific role of expert in those other approaches was somewhat more stable in contrast with the multiple and more fluid roles found in the NCETM's initiatives. All of these contrast with the role of the expert National Numeracy Strategy consultant which was linked to school improvement and the 'standards' agenda and so also has some disciplinary function.

In describing the NCETM as representing a complex approach to professional development, we are making two claims. Firstly, that the NCETM initiated a number of different programmes that were all, in different ways, adaptive and responsive to particular conditions. The initiative and focus for projects comes from teachers and schools. The NCETM was, to an extent, agnostic about the focus of projects and funded initiatives that, ostensibly, do not accord with the pedagogical principles in *Mathematics Matters*. Secondly, the different projects that were initiated also influenced each other or, in systemic terms, have a range of feedback loops. These feedback loops happened at various levels in the NCETM system. One of these levels is the individual teacher or school level. For example, in one case study, the recipient teacher's involvement with the NCETM began by subscribing to the NCETM newsletter after learning about it at an LA meeting. She then saw an advert for a course on running a 'primary maths week' run by an NCETM co-ordinator and associate who worked in an HE institution. During this successful project she accessed and shared resources via the portal. She then applied for a grant to initiate a Mathematics Knowledge Network which met as an on-going network with support from an NCETM sponsored AST and also used some of the grant funding to host a CPD event in her own school. The effect of this activity in this teacher's school included dramatically changing one teacher's relationship to mathematics so that now mathematics was "out of the box" and so this teacher was contemplating running the next primary mathematics week in her school herself.

These feedback loops also operate at an organisational level for the NCETM. So for example, the form of Mathematics Knowledge Network programme was in part influenced by the research strand of its activity - the RECME project, which in turn was influenced by what researchers reported as outcomes from projects some of which were funded or influenced by the NCETM and some which were not. We thus see the NCETM adapting and responding to the outcomes of its own and others professional development activity.

The NECTM ecology

In this section, we discuss the NCETM as an informal system of the wider layers of teachers and others who had a relationship with the formal NCETM structure and activities: the NCETM ecology. This informal system had loose boundaries that allowed for different forms of relationship with the NCETM and are related to various possible ways of engaging with the NCETM and different forms of engagement in professional development.

The meaning and importance of the NCETM in the lived worlds of those who engaged with it was fluid and the forms of relationship that developed were complex. One aspect of this relationship pertains to the formal or structural relationship of those engaged in NCETM or NCETM connected activity. By formal or structural relationship we mean the participant's relationship with the NCETM organisation in terms of roles that were formally recognised or were derived from the type of participation (or non-participation) in NCETM activity. We propose four types of relationships that were significant in understanding the positions of study participants. The term '*outsider*' describes those, mostly LA consultants, who spoke about the NCETM from the perspective of their relationship to another organisation or grouping involved in mathematics education. These were the National Strategy, the Local Authority, mathematics teacher professional associations, and in one case Higher Education community. For some more than one affiliation was important. The category '*user*' refers to interviewees who were recipients or consumers of NCETM generated activity. This category includes those whose involvement was limited to use of the portal, attendees at an NCETM event or a relatively passive participant in an NCETM project. However, this does not necessarily mean that the impact on teachers' practice was low:

> The conference made me think outside the box and motivated me to try new things. The children have become more interested and receptive to new materials (ID74 Secondary teacher).

The term '*contributor*' refers to those who were more actively engaged with the NCETM and contributed to its work in some way. In most cases they were grant recipients of projects on knowledge networks, or regular contributors to NCETM community. The fourth category of '*insider*' describes those participants with a contractual relationship to the NCETM. One such roles were those designated an NCETM associate. These were a pool of experienced mathematics educators employed by the NCETM to carry out specific, generally short term, tasks. This role would often be combined with another role in education or mathematics education. Another type of 'insider' were the NCETM ambassadors discussed above. These were practicing teachers of mathematics, whose schools received payment to release them to act as representatives of the NCETM to promote its work and projects. There were further types of insiders who were not interviewed as part of this study, those who were in on-going employment with the NCETM such as Regional Co-ordinators, Administrators and the Directorate. Note that although we have used a category of 'insider' the interviewees did not necessarily think of themselves as inside the NCETM. Indeed, we did not find any examples in this category of interviewees who used the term 'we' to talk about the NCETM.

Clearly, these categories do not describe all aspects of participants' relationships to the NCETM. We do not have space to discuss these fully here but important features included the alignment of participants' purposes with the purposes of the NCETM and the degree of affinity or identification felt with the NCETM. Further, the nature of these dimensions were related to different forms of engagement with the NCETM, for example involvement in different types of NCETM activity, the focus of activity, the chronology of involvement and the degree of personal contact (or not) with NCETM personnel or representatives.

Aspects of the relationship of participants to the NCETM, when considered individually, echo ideas of trajectories of participation as found in community of practice theory (Lave & Wenger,

1991; Wenger, 1998). However, the way in which aspects of relationships interconnect and involved, for some participants, tensions suggests a more complex web of relationality.

We now go on to focus on aspects of the activity and identity of NCETM participants that we have described as 'contributors' by drawing on data from the case studies and interviews (we include summary descriptions of two of these case studies as an appendix to the paper). A key emergent effect of engagement in NCETM connected activity was the way in which this supported, enhanced or led to changes in forms of leadership. In the next section we continue with a discussion of literature on theories of distributed and complex leadership and then go on to discuss one aspect of this - the arena of leadership.

Distributed and complex leadership

The growth of interest in concept of distributed leadership in organisational and leadership studies generally is reflected in interest in education (see Gronn, 2000, 2002, 2007; Hartley, 2007, 2010; Harris, 2003, 2007; McBeath, 2005; Muijs & Harris, 2006). Although the term has gained currency both in academic literature and has appealed to policy makers there exists a degree of conceptual confusion and quite wide variations in meaning and purposes in the way it is used (Gronn, 2008; Harris, 2007; Hartley, 2007, 2010). The concept of distributed leadership can be used in a number of ways. Gronn (2008) contrasts the more recent uses of the term as an empirical description of particular forms of leadership and, related to this, an advocated approach to leadership with a methodological/theoretical approach to understanding leadership which has many antecedents in social scientific theory/research. Harris (2007) similarly contends that it is important to differentiate between empirical, normative and theoretical frames in discussing distributed leadership.

The empirical meaning in education points to an understanding of the ways that leadership can be distributed (or not) by a variety of actions by senior leadership or activity by teachers (MacBeath, 2005). This conception of distributed leadership draws on more traditional concepts of leadership based on relations between leaders and followers in which power to lead is held by individuals or roles. The empirical questions that then arise are about the extent, scope and focus of distribution and the outcomes of different distributive models (Harris, 2007). Such questions are relevant to analysing NCETM activity. The involvement of many in NCETM activity was related to pre-existing leadership roles for example Mathematics co-ordinator in a Primary School or Head of Mathematics or AST. Further, some of those with school leadership positions saw the NCETM as a route to develop more distributed leadership within their schools. For example, in one Primary school (Case study 9) NCETM funds supported reorganisation the coordination of mathematics so that it was the responsibility of a team rather than a single teacher or senior leader. The success of this initiative has led to it being extend to other subjects in the school.

The above interpretation of distributed leadership in schools implies the transfer of leadership from the top downwards. However, the development of distributed leadership can also be understood as 'opportunistic' or 'cultural' (McBeath, 2005). McBeath's description of opportunistic leadership recognises the possibility of bottom up development of extended leadership through teachers extending their roles to take on greater leadership and suggests that this is better described as dispersed rather than distributed. One example of this was found in case study 6. Here, the Head of Department was able to resist pressures to teach in

the way advocated by the senior leadership. For example, by not entering pupils for exams earlier and legitimising alternative approaches to raising attainment such as much more group work and activities with practical elements. The Head of Department was able to contest with senior school leaders the practice in his department by being able to show, through involvement with the NCETM, that his preferred approaches were being successfully used elsewhere.

Distributed leadership and the related concept of teacher leadership (Harris, 2003; Muijs & Harris, 2006) has tended to be discussed in relation to leadership within a particular school. The focus on the individual school or organisation means there are gaps in the literature about the relationship between external prompted activities in schools such as that of the NCETM and the development of teacher leadership as well as the extension of leadership beyond a specific site. Although recent analysis of leadership in networks has begun to address this (McCormick, et al., 2011). We return to a discussion of this below.

However, our use of the term 'leadership' in this paper departs from an understanding of the term based on leading and following. Rather we draw on notions of distributed leadership informed by theoretical perspectives which critique the concept of leadership focused on individual roles. The notion of distribution here points to leadership not being held by particular people or reside in particular places but rather to be found or at least potentially to be found throughout the organisation. Harris (2007) notes that theoretical roots for this concept can be found in theories of distributed cognition (Spillane, 2006; Spillane et al., 2004) or activity theory (Gronn, 2002). Understanding distribution of leadership as akin to situated distribution of cognition points to understanding leadership activity as constituted in the interaction of different actors involved in a particular context (Spillane et al., 2004; Harris, 2007). Thus, it broadens the unit of analysis in understanding distributed leadership. It also suggests a similar widening of understanding of the empirical nature of the phenomena. Given that activity theory has overlapping theoretical roots as theories of distributed cognition it is not surprising that Gronn's (2000) perspective has similar consequences in terms of widening the unit of analysis.

Such understandings point to a conception of leadership that is focused on activity that either maintains the reproduction of practices or instigates or guides change in them. Such a view connects to systemic analysis of social relationships such as actor network theory (Latour, 1999; 2005; Law, 2004) in which all actors in the network are potentially agentic. Similarly, MacBeath (2005) proposes that that one possible outcome of the development of a distributed leadership culture is to understand distributed leadership as enmeshed in activities rather than held by people.

Although we do not have space to fully develop our discussion here, in the NCETM study we noted the importance of the professional development processes and activities as important mediators in supporting changed practice and relationships. One notable example of this was the use of lesson study (see Burghes & Robinson, 2010 for description). In one primary school (case study 7), as well as positive changes noted in terms of teacher practice, collaborative relationships and pupil outcomes, specific effects on, and changes in, leadership roles were noted. The mathematics coordinator described how their role changed since the introduction of lesson study. Previously, it focused on managing and checking resources and "rolling out" national programmes. Although this continued, the role now extended to be "a person who supports, perhaps guides, adds mathematical knowledge to discussion. Somebody who

makes suggestions, it's much more of a collaborative thing than a managing sort of thing"**.** It was asserted that this was because lesson study was not just about working on the school improvement plan – "it gives it energy, it gives it more purpose and a structure".

Activities such as lesson study and other teacher generated professional development activities accord with theories of complex leadership (see Uhl-Bien, Marion, & McKelvey, 2007; Uhl-Bien & Marion, 2009). They enable the development and enactment of 'adaptive leadership': "leadership that occurs in emergent, informal adaptive dynamics throughout the organization," (Uhl-Bien, Marion, & McKelvey, 2007 p.300). Considering such situated and adaptive modes of leadership points to the importance of participants' purposes, the focus of activity and forms of relationship with the NCETM. In the remainder of this paper, we develop a discussion of one of these that relates to participants' purposes which we term the 'arena of leadership'. This has not, we believe, been previously developed in literature on distributed leadership in schools. In addition, the outcomes we report contribute to developing an account of subject leadership, a topic that has been relatively neglected in more recent research on leadership developed in terms of a concern for general school improvement.

The arena of leadership

By arena of leadership we refer to the scope or field in which leadership is exercised. This is related to the participants' intentions and purposes for engagement with the NCETM and can be conceptualised in terms of micro, meso or macro social levels. The table below gives a summary of the different arena in connection to these levels and a selection of illustrative examples.

Table 1 - Arenas of leadership

Level	Arena	Examples
Micro	Self	Own professional development, own classroom
	Others	Working with others as individuals
Meso	Group - in situ	Secondary department, whole school
	Group - wider	Networks, clusters of schools, Portal forum
Macro	System	Mathematics education as whole

For some participants the scope was focused on the self, either as a classroom teacher or as part of a specific role:

> I think it's just keeping up to date with the latest developments within maths education. As a head of department I'm responsible for keeping my department up to date with these kinds of things (ID73 head of mathematics, secondary).

For others the effects were more dramatic. We referred earlier to a teacher for whom mathematics had been taken "out of the box".

By the category of 'other' we refer to leadership in relation to a particular individual or other members in the school as individuals, sometimes this could be a relatively low key interaction:

> I picked up stuff and shared it with my subject leader for maths (ID84 headteacher, primary).

This individual focus contrasts with some situations in which teachers engaged with the secondary department or primary school team, (or subset of it), in collaborative work together, for example in lesson study. Such collaborative activity was an important aspect of the majority of teacher enquiry projects (Joubert & Sutherland, 2010). We classify this as a meso level, focused on group development. A further category in the meso level extends teacher leadership beyond a teacher's own school. Short-term examples of this discussed with participants included presenting at conferences. However, mathematics knowledge networks and projects that involved teachers from more than one school represented more ongoing opportunities to work beyond the single school context.

Whilst in some cases the form of networks were relatively simple - teachers leading projects that involved teachers from a number of other schools - in other cases complex patterns of relationships with wider networks were reported. For example, an AST in one school (case study 8), Pat described setting up a Mathematics Knowledge Network, funded by the NCETM within an existing network that:

> was set up partly because the LA not providing what CPD we wanted. We are now working with NCETM on another little project with the LA, but only as a result of the previous two projects after which we invited the LA adviser on board. So a two-way relationship is building with the LA now.

> I heard about an LA maths talk course across the county, and I thought 'we are doing this stuff!', so I said 'can we help you do this since we are doing the MKN on this?' The person moved from being defensive to saying, oh can we meet up and have a talk, so I thought, this is really nice, because- there was a dialogue going in with the authority, whereas before it was all a bit us and them, [our network] doing their own thing. (Pat AST, case study 8).

Although an account of power in educational networks is underdeveloped (McCormick et al. 2011), Pat's description of the relationship with the LA suggests that, in at least some of the activities related to the NCETM, this was important, as she moved into taking a brokering role (ibid). We have pointed earlier to the complexity of purposes of the NCETM and this relates also to those engaged in NCETM activity. Although, this is perhaps more transparent when the arena of leadership extends beyond the particular school, we suggest this is potentially an important area to investigate across all levels. Here, the notion of translation - drawn from Actor Network Theory - is potentially useful as actors redefine and translate meaning and activity in relation to their own purposes (see Boylan, 2010 for an example focused on an NCETM project).

Interestingly, although Pat clearly had the most significant formal leadership role in the project and appears to be engaged in strategic action in terms of development of networks, other teachers involved also experienced a sense of leadership:

> Going into this made me realise there is a lot more to teaching than just working in the classroom, that you can go off and run projects, working across the group… it made me feel more like a professional teacher rather than just someone who goes into school every day and teaches (Lisa, KS2 teacher, case study 8).

Extending the political sense of leadership points to a further arena: the macro or the wider system. The type of distributed or dispersed systemic leadership found in NCETM related activity contrasts with accounts of system leadership based on more traditional heroic

leadership concepts (for example, Higham, et al. 2009). By macro leadership we refer particularly to those interviewees who spoke in terms of wider dimension of development of mathematics education.

> Going into the NCETM made me think about maths in a more holistic way, and it gave me the confidence that we were actually doing the right sort of thing. Because we were getting whopping pressure saying 'you have to teach [the] strategies this way'….and I said 'we're not going to, we're going to do it this way', and I had enough confidence to do it by then (Primary headteacher ID 56).

This sense of identifying with, or using the NCETM to give, as one interviewee put it "legitimacy to the way we wish to teach" (John, case study 6) was a theme of many of the participants in the study for whom there was an alignment of purpose with the NCETM. This alignment of purpose was often in relation to teaching mathematics, and, in John's case, consisted of finding support for existing beliefs. Similarly, for Pat there is a focus that goes beyond her particular school and is rooted in her own educational history:

> Two people from my year went to uni in a school of 1500 so I was one of the very lucky ones to escape. My motivation is to give children choices later in their lives, that's why reducing girls drop out from maths after GCSE is important to me (Pat, AST, case study 8).

Note here that Pat, a Primary school teacher, has a focus on gender patterns in post-16 take up of mathematics. Gender in mathematics education and indeed post-16 participation patterns are macro issues. For others the explicit focus was on the form of professional development and teacher learning that the NCETM was experienced as promoting and could involve a change of beliefs:

> We had a top down approach [to CPD] over 10 years - we were afraid to do things differently, but had to make changes. Now, I'm more inclined to give teachers more freedom to do what is right for the children and how they learn best and can be better learners. I take a back seat on it. … maybe it was a fortuitous liaison [with the NCETM] or maybe they helped it but we have latched onto their approach - and maybe if they weren't working in the way the way they do we wouldn't have latched on to it (Richard, headteacher, case study 8).

We suggest that here we see a move beyond leading within school or networks of school to some sense of being part of a larger or wider movement with an expansion of focus from school to school system and from mathematics in a school to mathematics education as whole. The dispersion of leadership here is across and between schools. Participants in the NCETM activity are not alone in this. A similar sense of wider purpose and commitment to wider change can be found in the accounts of those involved, for example, in networks focused on assessment for learning (see McCormick et al., 2011). There are parallels here with the development of social movements (Crossley, 2002). Extending the notion of teacher to leader to teacher activist drawing on social movement theory may be a worthwhile direction for future research not only in relation to the NCETM but also other educational initiatives.

The development of such an account would need an explication of the interplay of leadership within schools and inter-school networks and subject teacher identity in developing a more extended sense or practice of leadership. We have not had space here to discuss the way in which a, sometimes intended and sometimes emergent, aspect of NCETM activity was the promotion of mathematics subject teacher identity. Accounts of distributed leadership focused

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on the distribution of leadership by headteachers and senior leaders may not be able to account for ways in which teachers exercise leadership who have a strong subject specific identities.

Ways that the NCETM supported the exercise of leadership were varied. For example, in case study 8, the NCETM provided opportunities for, supported and guided leadership via motivated activists exercising agency within a sympathetic setting. The influence of the NCETM was complex in relation to the number and type of relationships it engendered within the school. For example, the NCETM affirmed and supported changes to the school's CPD culture, provided resources for the key leaders including funding the AST aspect of the key leaders post, helped develop and extend existing networks, and influenced and shaped pedagogical approaches of teachers and leaders. In case study 6, the NCETM supported the development of a committed leader working in a different environment, one that was unsupportive but not actually hostile to changing approaches to mathematics teaching and its organisation. Here, the NCETM also provided resources, and, as in case study 8, helped to create, develop and extend networks and influenced the pedagogical approaches of leaders and teachers. In addition, it gave legitimacy to make changes, by both the strength of its reputation, its 'national' status and providing evidence for the efficacy of such changes.

Conclusion

In this paper we have offered a description, informed by concepts drawn from complexity theory, of the NCETM, its activity and the patterns of relationship to the NCETM of participants in this activity. Analysis of forms of leadership that arise or occur in relation to the NCETM connected activity suggest the need to enrich accounts of distributed leadership by considering different arenas of leadership. In particular, we have highlighted the way in which some teachers appear, in their descriptions of their purpose and practice, to have an activist orientation.

Through its activity the NCETM has generated and enabled forms of teacher learning and professional development that contrast with those found in recent professional and curriculum development initiatives in mathematics education in England. In part, this appears to be because of the type of mediating activities encouraged, such as collaborative professional development approaches such as lesson study, teacher enquiry and knowledge networks. Such approaches encourage teachers to develop their own authority and agency. It has been outside the scope of this paper to discuss the evidence of impacts on teachers' practices. However, in general teachers who valued such approaches to professional development similarly pursue or have adopted pedagogies which encourage learners to engage in dialogue and develop their own authority. We suggest that this is not only because of the particular forms of activity the NCETM encourages but are also rooted in its form as a complex approach to professional development. The choice of type of activities and supporting a variety of ways to engage with them are supported by analysis of conditions for teacher learning informed by complexity perspectives. These contend that there are multiple ways for teachers to learn and that prescribing the form or amount of professional development activity is not necessarily helpful as it is systemically contingent (see Opfer & Pedder, 2011). The NCETM, whether by accident or design, has offered both a narrative and a vision for how mathematics can be taught and teacher professional development conducted without prescribing such approaches and has provided opportunities for engagement in multiple ways.

Relative to other professional development initiatives the NCETM has proved a cost-effective approach.

We note that current government plans for the future the NCETM involve a significant reduction in funding, that has already led to the loss of the regional co-ordinator network, and, in the future, will lead to some withdrawal of the NCETM's role in direct CPD provision and support for individual schools and teacher leaders in favour of concentrating resources on supporting existing established networks and those being promoted in current policy around teaching schools (DFE, 2011). This may simplify the form of government supported continuing professional development in mathematics. However, this could be at the expense of the positive outcomes in terms of the atrophy of the developing cadre of teacher leaders in mathematics committed to change. It will be interesting to see whether the new arrangements will continue to facilitate the developments in practice that arise from the adaptive and organic approach of the NCETM that has characterised its work up to now.

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Example 1 - Case study 6

C6 is an 11-16 rural mixed comprehensive with high achievement (75% of pupils gaining 5 A* to C grades, 70% gaining these including Maths and English). The main NCETM contact noted that the biggest problem for the school at the time of our visit was demographic: local numbers were falling. They had already reduced from 6 form entry to 5 form entry and from the next year they would be reducing again to 4 form entry.

David, the Head of Maths - a teacher with 15 years experience and a previous HoD role behind him - was the main contact. Having joined the school 12 months ago, he had been engaged in an LA course for new Heads of Mathematics. He was introduced to the NCETM by the LA adviser, and subsequently used a combination of support via local networks and use of the NCETM website to try to make changes within his school. His main focus in engaging with the NCETM was on developing both his own practice and practice within his department, in a number of areas. First and foremost, he aimed to change pedagogical practices. In his own classroom, this meant using NCETM resources to help him to use more group work, rich tasks, and self and peer assessment. But the main impacts were on trying to move pedagogical practices amongst others in the department:

> *I contribute to forum discussions and obviously I gain from that the latest developments and ideas which then I will use to share at department meetings… the first half hour of every meeting is looking at learning… we use lots of ideas from the magazine… in our next meeting we'll be spending time on the 'always, never, sometimes' activity' for year 11 revision (David, Head of Maths).*

> *[We] always have learning as the first item on any department meeting and we share good practice […] lots of different rich tasks and how we assess them… without the NCETM I wouldn't have found most of those links - some are on the NCETM and others are elsewhere (David, Head of Maths).*

The second key area that David had tried to develop was to develop a sense of shared ownership of changes in the department:

> *People feel as thought they've got a role that's valued. We have CPD learning from each other […] I feel that I'm able to offer more but I'm more alert to what they can offer and give time in meetings for people to share expertise and everyone's got something to offer (David, Head of Maths).*

> *It's things they would be doing within their normal workload: the benefit was sharing and getting the benefits from others. Because the problem with collaborative activities is they often take a long time to make and they might only be used once so we felt that by pooling our resources that's an effective way of having some CPD and getting some resources to trial and use and develop (David, Head of Maths).*

The teacher beneficiary we spoke with - John, second in department, with 20 years teaching experience - had joined the school 6 months before David, and had been able to witness significant changes to teaching in the department since David's arrival. John had observed the changes in the school, noting that:

> *David's personal influence has been huge, but in the bigger picture, NCETM has enabled him to make changes (which he wanted to make anyway) faster with greater legitimacy within the maths department.(John, second in Maths department)*

John noted that when he joined the school he "*hated*" the way Maths was taught: it was very "*skills based, trick jumping*", with very prescriptive tests. Pupils used to get good results in key stage 3 through 'forcing' of learning, but not carry the understanding necessary to good results in key stage 4 through. This may have been because pupils were forced into level 8s in KS3 when they weren't ready: "*Accelerated learning with a crash at the end.*" Pupils were also entered for GCSE in November, the gap to starting A levels in the Autumn meant they were not well prepared for A level; and the Colleges "*[weren't] happy with this*".

An interesting issue in this school was that John observed David being able to resist pressures to teach in this way (e.g. entering pupils for exams earlier) and legitimise his approach (e.g. much more group work, activities with practical elements) with senior school leaders by being able to show through the NCETM that his approaches are being successfully used elsewhere. So the NCETM was *"giving legitimacy to the way we wish to teach"*. John perceived that senior management approaches to teaching tend to involve *"book trawls, looking for evidence in books"* whereas John, David and others "*have been able to say 'No, the evidence is in the classroom'."*

In addition to the use of the portal to enable changes to be made, David became involved in an NCTEM professional enquiry project across 6 local schools, which produced resources to be shared across the authority and - more importantly, - supported collaborative activity in the classroom:

> *They [the pupils] have lots more groupwork because we've had the benefit of the Shropshire network, we've got 29 ready to use collaborative activities […] all have used them but some more than others - I'm aware I need to hyperlink them to the scheme of work so the awareness is greater, that will increase further (David, Head of Maths).*

> *Lots of different rich tasks and how we assess them […] without the NCETM I wouldn't have found most of those links - some are on the NCETM and others are elsewhere (David, Head of Maths).*

Furthermore, in addition to legitimising change with the school, David found that working with the NCETM gave him confidence to build links beyond the school:

> *"[well known maths educator] came here last year, and we had teachers from other schools in Shropshire - that was a result of the 10 day course […] looking at assessment, looking at APP, peer and self-assessment of rich task […] I knew her before, but through the NCETM I felt confident to ask her views (David, Head of Maths).*
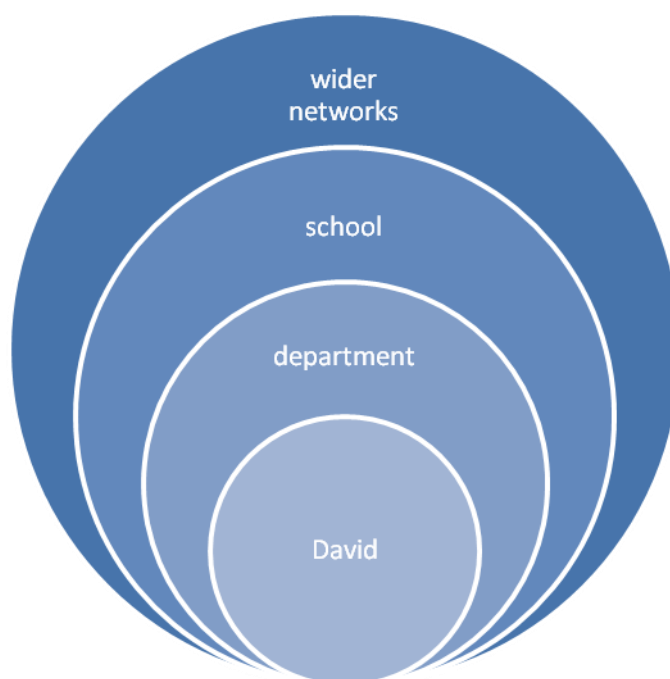
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Fig 1. Showing David's arenas of leadership

Example 2 - Case study 8

C8 is a is a one form entry 5-11 primary school with about 230 children on roll in what the headteacher referred to as the *"leafy suburbs"* of a small midlands city in *"a very nice middle class area, very supportive parents"*. The school's results are slightly below national average, with Maths below English and IT.

The driving force behind the work with NCETM was Pat, a Maths AST teaching in Key Stage 2, now funded by the NCETM. The locus of leadership begins with her identity and sense of mission. A mature entrant in her 6th year in teaching, she had numerous jobs including some high status roles in colleges and the civil service, but what motivated her to make the career change was maths:

> *I'm interested in maths because I think maths is the thing that got me out of the East End of Glasgow, and if it hadn't been for having that confidence in something others find scary [i.e. Maths] then I most likely would have been in the biscuit factory or the bank or the shop - or unemployed or a druggie or dead! The options were narrow for me - two people from my year went to uni in a school of 1500 so I was one of the very lucky ones to escape. My motivation is to give children choices later in their lives, that' why reducing girls drop out from maths after GCSE is important to me (Pat, AST).*

She was ambitious, and seeing that the opportunities for advancement were limited, she *"looked around for things I could deliver in school. I'd been through Leadership Pathways with NCSL, and felt I had some skills I wanted to use somehow in school."* This self-initiated move towards leadership was supported by the headteacher:

> *NCETM came to school and spoke to us only last year. Pat wanted to advance herself but also to move the school on… [being an NCETM AST] gave her higher profile in the school and had more clout and kudos to push things forward. There were a couple of years before this where she was making changes to her own teaching but didn't have the clout to make changes throughout the school. Now she has grown into that role and she is making it a senior management role (Richard, headteacher).*

The main activities sponsored by the NCETM were two pedagogy-focussed cross-school projects, and for the second of these Pat recruited Lisa, a young teacher in Key Stage 1 in her 3rd year of teaching. Like Pat, she had a strong commitment to self-development, although her background was quite different:

> *I was doing 2 days a week helping out in school in Y6 for a year, and [the headteacher] saw me then… and I went straight into large role in my training [GTP] year - I threw myself into it. I did throw myself into everything, but learned how to say no - but this [NCETM opportunity] came along and it is different for me, but I wanted to do it […] as a child that didn't have the confidence in maths, still didn't after secondary school, going into something like this I thought it would benefit me (Lisa, KS1 teacher).*

Pat noted that she and Richard had strategically decided Lisa should move from working in Year 5 (where she had previously team taught alongside Pat) into Year 2, so that Pat and Lisa should work together as influential practitioners in each of the two key stages, thus enabling changes to maths teaching to happen throughout the school in *"a pincer movement"* as Pat described it. This created a strong, intimate relationship between the two, with Pat leading Lisa, and then jointly creating leadership of the wider school and network.

> *I think I wouldn't have said yes to the NCETM if I didn't have such a good working relationship with Pat - we are very different people, but make a fantastic team - a powerful team (Lisa, KS1 teacher).*

The leadership influences of this "powerful" team were evident in relation to self, the school and beyond. Lisa articulated significant changes to her teaching:

> *I was confident to work with Pat on developing it, and we could both support each other. Maths is something I enjoy, not something I find easy - as an adult - but through the MKN I've personally learned a lot, as well as seeing the children grow miraculously - their grades have soared, their levels and their confidence in numeracy - it's had such a big impact - that's been lovely to see. And then being part of a group and discussing ideas and finding out we have the same problems, and then what works well in one group, trying it in your own school. […] At this age [Year 2] their minds are opened and they can look at a problem now and have lots of angles to come at it… it has given them skills and confidence to tackle any problem and not give up (Lisa, KS2 teacher).*

and also her sense of self as a teacher:

> *Going into this made me realise there is a lot more to teaching than just working in the classroom, that you can go off and run projects, working across the group… it made me feel more like a professional teacher rather than just someone who goes into school every day and teaches - does that make any sense? (Lisa, KS2 teacher).*

Pat was able to note changes to, and influences on, the LA as a result of these networked projects:

> *[The network within which the MKN was located] was set up partly because of the LA not providing what CPD we wanted - and now were working with NCETM on another little project with the LA, but only as a result of the two projects, to invite the LA adviser on board. So a 2 way relationship is building with the LA now.*

> *[I] heard about an LA maths talk course across the county, and I thought 'we are doing this stuff!', so I said 'can we help you do this since we are doing the MKN on this?'. The person moved from being defensive to saying, oh can we meet up and have a talk, so I thought, this is really nice, because- there was a dialogue going in with the authority, whereas before it was all a bit us and them, [our network] doing their own thing. (Pat AST).*

Finally, there were influences on school:

> *The empowerment of staff is what we really take away from NCETM work (Richard, headteacher).*

Although the headteacher was unsure where the impetus to change had actually come from:

> *We had a top down approach [to CPD] over 10 years - we were afraid to do things differently, but had to make changes. Now, I'm more inclined to give teachers more freedom to do what is right for the children and how they learn best and can be better learners, I take a back seat on it. … maybe it was a fortuitous liaison [with the NCETM] or maybe they helped it, but we have latched onto their approach - and maybe if they weren't working in the way the way they do we wouldn't have latched on to it (Richard, headteacher).*
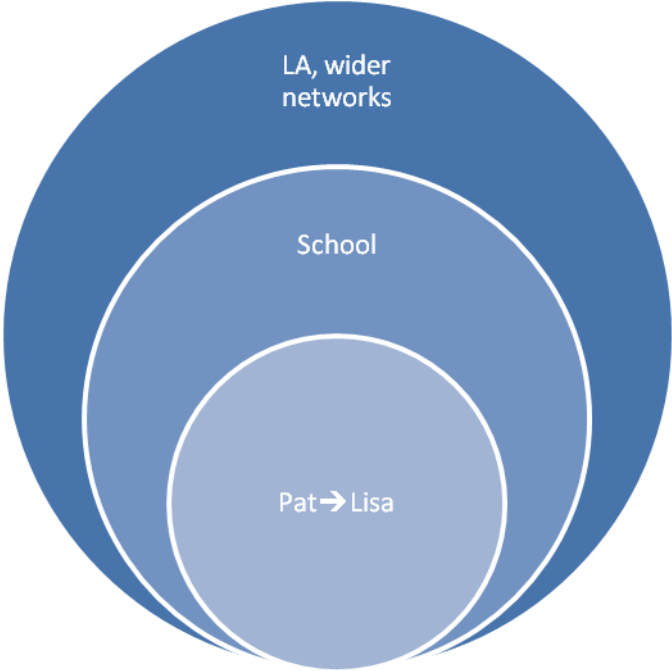
Fig 2. Pat's arenas of leadership