Developing the mathematics teacher workforce in England's FE colleges: towards a 'communities of practice' strategy

Diane Dalby* and Andrew Noyes

University of Nottingham, Nottingham, UK.

Diane Dalby (corresponding author)
School of Education
University of Nottingham
Jubilee Campus
Wollaton Road
Nottingham
NG8 1BB
0115 7484392
diane.dalby@nottingham.ac.uk

Andrew Noyes
School of Education
University of Nottingham
Jubilee Campus
Wollaton Road
Nottingham
NG8 1BB
0115 9514470
andrew.noyes@nottingham.ac.uk

Diane had extensive experience of managing and teaching mathematics in the Further Education sector before undertaking a doctoral study of the experiences of vocational students learning mathematics. She now works as a Senior Research Fellow in the Centre for Research in Mathematics Education at the University of Nottingham.

Andrew taught mathematics at secondary school before joining the University of Nottingham. He is Professor of Education and with wide research interests in 14-19 education. He has been heavily involved in qualifications reform and is engaged in national policy advisory work.

Developing the mathematics teacher workforce in England's FE colleges: towards a 'communities of practice' strategy

Since policy changes in 2014 about who studies mathematics post-16 in England, the mathematics teaching workforce in further education (FE) colleges has grown and diversified. The question of how best to develop the professional practice of this changing workforce is however unresolved. Teachers in a recent national study report the benefits of non-formal learning but the diverse organisational structures of colleges impact on the size and focus of teacher communities and thereby the nature of professional learning. Where mathematics teachers are enabled to meet regularly or work in close proximity, teacher learning communities emerge but their development is constrained by a lack of consensus on the professional identities and competencies of mathematics teachers in FE colleges. Despite these obstacles, we argue that there is considerable potential to enhance professional learning for mathematics teachers in FE through a *communities of practice* approach and that such a strategy for professional development is a key component of a self-improving further education system.

Keywords: community of practice; mathematics; professional learning.

Introduction

The importance of mathematics for the economy (BEIS, 2017), as evidenced in calls for improved skills from stakeholders (e.g. British Academy, 2015; Confederation of British Industry, 2015) and through international comparisons (Kankaraš, Montt, Paccagnella, Quintini, & Thorn, 2016; Wheater et al., 2013), makes mathematics education a key area of government policy in many countries. In England, the most recent substantial changes have been in the further education (FE) sector which has experienced major policy interventions aimed at improving mathematics (and English) outcomes for the lowest attaining third of students.

Since 2014, all 16-18 year old students who have not achieved a particular standard in GCSE Mathematics at age 16 (grade 4, previously grade C) have been required to continue studying the subject until they achieve this grade. The introduction of the Condition of Funding policy (CoF) produced a sharp rise in the number of students studying mathematics in FE colleges, but student attainment and progress have remained disappointingly low (DfE, 2019; Noyes, Dalby, & Smith, 2020). In 2019, the Centres for Excellence in Maths programme was established by the Department for Education to help tackle stubbornly low measures of student progress in the FE sector by focusing on the quality of teaching.

Improving teacher practice is commonly viewed as a key to raising standards (Day & Sachs, 2004) and professional development (PD) as a vital part of the improvement process (Guskey, 1994; Villegas-Reimers, 2003) so establishing sustainable PD models for this distinctive FE mathematics workforce is a pressing concern. Despite structural and operational changes in colleges (Noyes & Dalby, 2020a) resulting from the CoF, the systemic development of professional practice has been largely overlooked. Professional learning is a socially-situated practice of 'learning by participation' (Sfard, 1998) in activity that leads to a change in practice (Timperley, Wilson, Barrar, & Fung, 2008) so the diverse structural arrangements in large general FE colleges (GFECs) that divide the mathematics workforce into social groups have considerable impact on mathematics teacher professional development.

In addition to considering the effects of policy and institutional arrangements, any discussion of the professional development of mathematics teachers in FE needs to be located in the wider historical and cultural context of professional practice in the sector. The idea that technical or trade skills were more important than pedagogy (Fletcher, Lucas, Crowther, & Taubman, 2015) and views of dual professionalism (Orr

& Simmons, 2010) that prioritise occupational expertise have been pervasive. Notions of teacher professionalism have been unclear and contested (Gleeson, Hughes, O'Leary, & Smith, 2015) whilst attempts at regulation have proved controversial (Lucas, 2007; Lucas, Nasta, & Rogers, 2012). The introduction of occupational standards (1999) and compulsory initial teacher training (2001), followed by revised standards (2005) and a compulsory CPD requirement were important steps towards better definition of professionalism in England's FE sector. However, the Lingfield Report (BIS, 2012) heralded a revocation of regulation and a return to uncertainty, variation and contestation. Although the re-introduction of professional standards (See Education and Training Foundation, 2014) may have had some consolidating effect, practices still broadly reflect Lingfield's (2011) view that colleges themselves are best placed to decide what constitutes good professional practice.

This paper considers mathematics professional development in FE by drawing on a recent national study funded by the Nuffield Foundation (2017-2020). The Mathematics in Further Education Colleges project (MiFEC) investigated policy enactment and practice in England's FE colleges using a mixed methods, multi-scale design. The findings highlighted the complexity and interconnectedness of mathematics provision, an important element of which was workforce professional development. In this paper we consider 1) how organisational structures in FE colleges affect the professional learning of mathematics teachers, and 2) how mathematics-focused communities of practice are formed within different structures and settings.

Conceptual framework

In the absence of a substantial body of relevant research in the FE mathematics context, our conceptual framework draws together key ideas from across the PD literature. This includes consideration of professional *development* and *learning*, which might be

formal or non-formal, individual or collective. We focus on the notion of a *community of practice* (Lave & Wenger, 1991; Wenger, 1999) and, in the diverse and complex structural arrangements of FE colleges, the meaning of *apprenticeship* in an FE workforce devoid of agreed professional standards.

Professional development and professional learning are sometimes viewed as synonymous but both are weakly defined in the FE sector. Much *professional development* in colleges comprises formal sessions of Continuing Professional Development (CPD) that are more about knowledge transfer than knowledge creation (Wiliam, 2002) or 'knowing that' but not necessarily 'knowing how' (Winch, 2013). Such knowledge without application falls short of a key goal of professional development, of changing professional practice in workplaces (Timperley et al., 2008). Professional development may involve professional learning that is related to the craft of teaching but is unlikely to have the desired effect unless this focuses on developing a 'knowledge of practice' (Cochran-Smith and Lytle, 1999, Dana and Yendol-Hoppey, 2008) that leads to changes in the classroom. Learning *in*, and *from*, practice is also important (Matos et al., 2009) and the typical FE CPD session, which focuses on instruction *about* how to teach, needs to be accompanied by exploration *in* the classroom and reflection *on* practice in a process of inquiry (Dana & Yendol-Hoppey, 2008).

We conceptualise professional development more broadly than the traditional CPD model suggests, to incorporate learning that occurs in both planned and unplanned ways, including what Eraut (2000) calls *non-formal* learning. Teachers develop tacit knowledge of organisational culture over time through immersion in a particular environment, its practices and relationships. Such non-formal learning is largely hidden (Hodkinson & Colley, 2005) and generally goes unrecognised. Eraut (2000) makes a

useful distinction between non-formal learning that is *reactive*, involving the noting of ideas stimulated by current experience, and *deliberative* learning that has planned goals and systematic reflection. In a situation where mathematics teachers may interact closely with colleagues who teach the same subject and/or with vocational teachers, the opportunities for non-formal learning are wide-ranging but largely reactive, unless guided by college leaders.

Both individual and collective aspects of professional learning are of interest herein. A key concept is that of a *community of practice* (Lave & Wenger, 1991; Wenger, 1999; Wenger & Snyder, 2000) in which social interaction is the medium for a blend of objective and cultural learning (Eraut, 2000). Such communities are united by a shared aim of improving their professional expertise as members follow negotiated learning journeys of sense-making and identity development towards the goal of achieving professional competence (Wenger, 1999, 2011; Wenger & Snyder, 2000). Experience and competence for Wenger (1999) are interlinked, captured in the broader notion of *knowing in practice* which is manifest and experienced by members of the community in their enactment of practice.

A community of practice is based on a model of apprenticeship, in which the novice works closely with an expert (Lave & Wenger, 1991). The learning journey of each individual member involves a development of practice that Wenger (1999) views as a mirror image of their identity within the community. Applying this idea in the FE context is hampered by a lack of consensus about what being an expert looks like for FE mathematics teachers. Despite the introduction of general professional standards for FE in 2014, local college conceptualisations of ‘expert’ practice still hold sway and PD goals are locally-determined. Whilst Wenger (1999) accepts that local communities of practice construct their own understandings, he balances that localisation with the need

for dialogue between the *local* and the *global* in the construction of meaning and identity. The absence of national consensus on mathematics teacher professionalism produces weak connections to the *global* and the risk of isolation for local communities of practice.

Studies of learning communities suggest several core characteristics. Although some of these focus on the development of organisation-wide professional learning communities rather than smaller sub-communities, there are similarities. Establishing a shared vision and aims is a common theme (Bolam et al., 2005; Hord, 2009; Stoll, Bolam, McMahon, Wallace, & Thomas, 2006), as is collaboration that is focused on professional practice (Little, 2002; Stoll et al., 2006). This facilitates individual and collective learning but is contingent on the development of a culture of openness, trust and mutual support (Bolam et al., 2005; Stoll et al., 2006). Inquiry into practice is also seen as fundamental to an effective community of practice (Dimmock, 2016; Hord, 2009; Lieberman & Pointer Mace, 2009) and a key person is the apprenticeship model is the "accomplished teacher" who is prepared to make the complexity of their practice transparent so others engage in inquiry and critical dialogue about teaching and learning (Lieberman & Pointer Mace, 2009).

Changes in teachers' behaviours are commonly considered as evidence of professional learning (Timperley et al., 2008) but any widespread, sustainable change in behaviour within an organisation involves complex socio-technical systems (Stacey, 2007) in which beliefs, social interactions and organisational cultures all play a part. Colleges are 'living systems' where change creates disturbances that ripple through a complex array of interlinked sub systems. Cause and effect are distanced (Senge, 2006), with non-linear connections between input and output (Fullan, 1993, 2001). Changes in teacher practice might result from disturbances in college systems such as a

restructuring, which in turn creates a disjuncture and a re-culturing (Fullan, 1993) as established communities are split and reform into new communities (Handy & Aitken, 1986). Such processes bring opportunities for the development of new norms and shared beliefs that in turn affect teachers' professional practice.

Organisational structures place constraints on teachers but they can also become empowered to develop their own working practices within them (Gleeson & James, 2007) and, in a complex interlinked system, these can have a wider effect. Rather than a *community of practice* being isolated in a large organisation, Wenger (1999) considers it active at both its core and boundaries. Although core members identify closely with the community, there is a position of legitimate peripheral participation (Lave & Wenger, 1991) where others are influenced without being core members. In FE colleges, this may be a vocational teacher who interacts with mathematics teachers based in their department and gains useful understanding of their professional practice. The distribution of mathematics and vocational teachers therefore has implications for the professional learning of both communities.

Methodology

The case study data that informs this paper are part of a much wider study of Mathematics in FE Colleges (MiFEC) which is reported in full elsewhere (Noyes & Dalby, 2020a, 2020b). A structured sample of 32 General FE colleges was selected from the 187 general further education colleges (GFECs) at the commencement of the project (Sept 2017). Data were generated from visits to each college during which interviews were held with individual mathematics teachers, vocational teachers, managers and the college principal or another designated senior leader. Student focus groups were also conducted. The combined data from the cases amounted to 238 interviews, 62 student focus groups and, a large volume of documentary evidence (e.g.

Ofsted reports). All of the interviews were combined in a large NVivo project and analysis was carried out using a grounded coding approach from which a two-tier framework was developed.

Mathematics teachers from the case studies also participated in a national survey about their backgrounds, qualifications and experience, which included questions about their professional development. The response rate is estimated to be just over 60%, with a total of 480 respondents (Noyes, Dalby, & Lavis, 2018).

Findings

This section presents a focused analysis of the MiFEC data concerned with the professional learning of mathematics teachers. The 32 case studies showed that staffing structures for mathematics can be categorised broadly into centralised or dispersed strategies. In practice, the majority are hybrids of these two approaches, with multiple teams in which mathematics teachers are grouped together either on different sites, or by vocational area, or by the mathematics qualifications they teach (see Table 1).

[Insert Table 1 here]

Table 1: Structural models for staffing and management and number of sample colleges.

These organisational strategies have clear influences on the professional learning

These organisational strategies have clear influences on the professional learning of mathematics teachers. In order to explore the affordances and constraints of these varied contexts, we first present a case portrait of ‘Alderton College’ as an initial point of comparison, which has a fairly typical hybrid staffing and management structure for mathematics. This case illustrates the ways in which communities of practice can be formed under particular circumstances. We then use this as a reference point to highlight points of similarity and difference across the full set of cases.

Alderton College has a full range of vocational provision and a sixth form. The provision is dispersed across several sites, with a dedicated sixth form centre in the heart of the city, a large technical skills site and smaller sites some distance away for land-based and local communities.

A Head of English and Mathematics has strategic responsibility for mathematics provision and manages a team who teach GCSE and functional mathematics to 16-18 year olds on vocational study programmes. These teachers are in site-based sub-teams, each one teaching students from a small group of vocational areas. They explain that this works well when there are several mathematics staff together on one site because they can liaise about their teaching and support each other whilst keeping in close contact with vocational staff. The arrangement is less satisfactory for those in very small site teams since they feel isolated from other colleagues.

A weekly cross-college team meeting is highly valued. This is part of a wider culture change for those teaching mathematics, initiated by a new manager for mathematics and English. The meetings are intended to provide regular CPD opportunities and other discussions about teaching and learning. Teachers report a greatly increased emphasis on sharing between colleagues and feel the diversity of the team is an asset since they benefit from the varied expertise of their colleagues.

Some departments have their own mathematics teams though because their work is seen as specialized (e.g. LDD, ESOL) or focuses on adults. Although there is some sharing of mathematics teachers across areas for practical reasons and other liaison, contact is limited. Those outside the 16-18 team are sometimes invited to participate in centralised meetings but this often conflicts with other priorities determined by their line managers and they rarely attend.

The college has recently revised its approach to improving teaching and learning and has abandoned systems that involved formal graded classroom observations. Professional development now focuses on the work of Teaching and Learning Coaches (TLCs). They observe lessons and identify professional development needs in what is considered to be a supportive manner, which aims to encourage openness and sharing between teachers. Identified needs are then addressed by the TLCs, who also deliver some targeted CPD sessions. Greater transparency of classroom practice is developing and has contributed to culture change within the mathematics team. The HoEM feels the team are becoming more responsive to new ideas and are accepting on 'open door' policy. There is a sense of tackling problems together and using inquiry approaches to find what works.

At Alderton College, teachers and managers identified benefits for professional learning from structures that brought them together with other mathematics teachers, even if only in small groups. Centralisation was generally popular across the case studies, with both mathematics teachers and Heads of Mathematics, since opportunities for non-formal professional learning occurred during the working day when teachers worked in close proximity (e.g. shared staff rooms). However, structural arrangements often involved some dispersion of teachers across sites. This decreased opportunities for non-formal learning from mathematics colleagues but increased liaison with vocational staff. Potential benefits from both *centralised* and *dispersed* staffing structures were evidenced but mathematics teachers with experiences of centralised arrangements were particularly enthusiastic about the benefits of that model:

> Why I'm finding this better is because we get to share good practice. We get to plan together. We get to share ideas, raise questions, discuss problems. It feels better because it feels more as being part of a team as opposed to … although the departments are very supportive, it wasn't the subject specialism. So you were

> the maths person in say Childcare and everyone else was doing Childcare. (Mathematics teacher, Case study X)

This teacher perceived clear benefits from opportunities for informal sharing of ideas but felt more comfortable in a community of mathematics teachers where professional identities were similar, and 'practice' was understood as teaching mathematics. Teachers at Alderton also valued opportunities for collaboration and sharing of practice and reported that dispersion across sites led to feelings of isolation. Those who were site-based or placed in a vocational area at Alderton did however develop a better understanding of those vocational areas and a closer identity with them. This raises a question about the nature of 'practice' in these different communities: mathematics as stand-alone subject versus mathematics connected to a study programme. Across the cases, some teachers referred to developing vocational relevance in their teaching and a few suggested that a vocational specialism was part of their professional identity (e.g. I am a GCSE mathematics teacher for Sport). The nature of the small social communities formed within the structures at Alderton College clearly had an effect on non-formal learning for mathematics teachers and contrasting professional learning opportunities for teachers in dispersed and centralised structures were evident across the case studies.

In colleges with dispersed staffing, a common approach was to coordinate regular meetings of mathematics teachers. Although the frequency, focus and attendance varied between colleges these meetings provided opportunities for professional development and the building of a mathematics-focused, cross-college community of practice. At Alderton, it was not just the frequency of these meetings that teachers felt was important but the emphasis on 1) sharing practice and 2) discussions about teaching and learning. The first encouraged a culture of increasing openness between teachers and appreciation of the diversity of experience within the team, whilst

the second helped establish a focus on the development of professional practice. In other case studies, conversations about classroom practice only took place informally and professional learning lacked any clear sense of purpose or direction.

> There are lots of resources that we share across and I can ping something across to someone and say, 'Have you got something to cover this?' and that's really nice and everybody shares which I think is good because even though you'll never follow what somebody else does, you might steal a few bits of what they do and put it into your own thing because it's very personal teaching. (Mathematics teacher, case study 1)

For this teacher, mathematics teaching was very individual and any collaboration was self-directed. In contrast, the mathematics teachers who met together weekly at Alderton engaged in dialogue about their professional practice, through which they developed a better understanding of one another and the collective benefits of sharing expertise. This formed part of a planned strategy led by the Head of English and Maths involving a deliberate shift of focus in their weekly meetings towards teaching and learning.

Alderton's mathematics teachers developed a sense of being part of a larger community with a common mission to improve teaching. They recognised that they were all trying to solve the same problems and could do this collectively despite being dispersed. However, the approach relied heavily on individuals sharing their 'good practice'. This strategy, which was evidenced in other case studies, encouraged transparency and discussion about classroom practice but often without clear direction and overall purpose. Teachers shared their ideas and others reported that this was useful to their professional learning but there was less evidence of how this contributed to a planned pathway towards collective or individual goals.

The Head of English and Maths at Alderton explained how mathematics teachers had become more open about their classroom practice and more prepared to try new approaches as a result of regular meetings. In addition, the college as a whole had adopted an approach to improving teaching and learning that involved frequent but supportive observations of classroom practice. Other colleges had similar policies and encouraged peer observations but some encountered resistance.

> Some welcome [*classroom observations*] and some don't. They just find it intrusive and possibly a bit challenging to their experience as a teacher. So it's not always welcomed. I think they feel as though it doesn't come across to them as being supportive and it doesn't matter what you say and how you word it. They'll always feel that little bit threatened, but it's not meant to be like that. (Maths teacher, Case 1)

Changing teachers' perceptions of observations and developing more transparency of practice involved a cultural change and disruption of established norms. The introduction of a new Head of English and Mathematics acted as a catalyst for cultural change in conjunction with a new college-wide approach to classroom observation which reinforced the planned culture change.

At Alderton and elsewhere, there were tensions between managers about line management and 'ownership' of mathematics teachers. This led to some fragmentation since a few curriculum managers retained their own specialist mathematics teams. Such issues arose because responsibility for mathematics provision was 'shared' to some extent between mathematics and vocational managers but the boundaries were difficult to negotiate.

> They [*maths teachers*] don't have to be media practitioners, but they need to be linked to the area. So they need to have a close relationship with all the other teachers and be able to be in contact with them and understand what they're

> learning and what they're doing, because if that communication's there, then the students know that you're one team. (Vocational manager, Case 3)

Both vocational and mathematics managers saw advantages in having greater contact with, and 'ownership' of, mathematics teachers so arriving at agreement was difficult.

In summary, the Alderton College case illustrates five key points that were evidenced in other case studies.

- *Structural arrangements affected the professional learning that mathematics teachers experienced.* Teachers reported benefits from the non-formal learning that happened when working in close proximity to others teaching the same subject. Working in a small group, or as the sole mathematics teacher in a department, limited learning from other mathematics teachers but enabled better understanding of vocational practices.
- *Diversity in the mathematics teaching workforce presents opportunities for professional learning, especially when mathematics teachers form collaborative communities but these often need further development to become effective communities of practice.* Many colleges had a large, diverse mathematics teaching workforce with a variety of expertise. Some colleges tried to unlock this potential by encouraging teachers to 'share good practice' and develop collaborative communities, across or within structural arrangements. These resembled communities of practice but needed further development to become effective as a means of ongoing professional learning.
- *The development of effective communities of practice in FE colleges for mathematics teachers is constrained by a national lack of consensus about their professional identity.* The sharing of good practice often amounted to a sharing of self-identified good ideas, with variations between and within colleges about

the competencies of an expert FE mathematics teacher. Without a shared vision of what expert practice looks like, there was a lack of clarity about professional learning goals.

- *The establishment of a community of practice is often constrained by fragmented structures and tensions between managers about the ownership of mathematics teachers.* The communities of mathematics teachers in the study rarely involved all those teaching mathematics, especially in large multi-site colleges. Hybrid structures were common which resulted in some fragmentation of the workforce. In some dispersed staffing arrangements, dual priorities and expectations of allegiance to the vocational area prevented mathematics teachers from engaging with a college-wide mathematics-focused community.
- *Valuable opportunities for change occur in FE colleges that could be harnessed to develop more effective communities of practice for mathematics teachers.* Where structural or leadership changes occurred, these opened up opportunities to change social communities of mathematics teachers and their cultures. A connected approach between these communities and college improvement systems brought opportunities for synergy that supported the development of effective communities of practice.

Discussion

We now reconsider each of the key points above and explore the implications for colleges using the theoretical framework presented earlier.

Structural arrangements affected the professional learning that mathematics teachers experienced.

A variety of staffing structures were used by colleges. Teachers valued non-formal

opportunities to learn from colleagues but different structural arrangements affected the type of community that they were in and the professional learning opportunities available. *Table 2* summarises how different structural arrangements affected the professional learning of mathematics teachers.

[Insert Table 2 here]

Table 2: Connections between structures and professional learning for mathematics teachers.

FE colleges develop site-based communities with very different cultures (Hodkinson et al., 2007) and these shape the professional learning of mathematics teachers who work within these social groups. Given that these structures are instrumental in the development of communities then, as Fullan (1993) explained, these need to be suitably focused, with an culture appropriate for the intended professional learning.

It is however not just the potential focus of professional learning and possible variations that need consideration but also the learning process. Wenger (1999) explains this as a negotiated experience involving membership of a community and a learning pathway with a strong connection between identity and practice, depicting these as "mirror images of each other" (p.149). Mathematics teachers in dispersed arrangements are likely to be in small groups (or alone) within a vocational environment yet the evidence suggests that their professional identity remains primarily that of a mathematics teacher. Although a small minority refer to a vocational specialism (e.g. a mathematics teacher in Sport), professional identities with respect to the vocational community are generally weak. Despite sharing the broader professional occupation of teaching FE students, mathematics teachers are positioned on the periphery of vocational communities and unlikely to move to a more central position as their expertise increases (Lave & Wenger, 1991) since their professional goals are not the

same. They retain a distinctive identity that forms a barrier to full membership of a vocational community of practice but remain isolated from colleagues with whom they identify more closely. A strategic approach to developing a cross-structural community of mathematics teachers, as evidenced at Alderton College, is needed to support professional learning in these situations.

Nevertheless, mathematics teachers in vocational communities do have opportunities to widen their *knowledge about* vocational practices and the mathematics embedded within them which can lead to stronger connections between mathematics and vocational studies. This knowledge does not necessarily result in increased *knowledge of* practice or changes in the classroom without further steps of reflection and inquiry (Cochran-Smith & Lytle, 1999; Dana & Yendol-Hoppey, 2008; Dimmock, 2016). The structural positioning of mathematics teachers within vocational areas is likely to have a limited effect on their teaching without a *deliberative* approach (Eraut, 2000) with planned goals and systematic reflection on activities that develop *knowledge of* vocational practice into pedagogical changes in mathematics classrooms.

Diversity in the mathematics teaching workforce presents opportunities for professional learning, especially when mathematics teachers form collaborative communities but these often need further development to become effective communities of practice.

Robson (2006) identifies that teacher communities with a specific vocational or academic interest are a distinctive feature of colleges but views these as "diverse and disparate" (p. 10), reflecting the state of the FE workforce more generally (Gleeson & James, 2007). The mathematics teaching workforce in FE colleges is similarly diverse but this does provide a range of specialist expertise that can be utilised for professional learning (Noyes & Dalby, 2020a; Noyes et al., 2018). The potential is sometimes

harnessed by encouraging collaboration and the sharing of ‘good practice’, either between members of a centralised team or across a dispersed structure through regular cross-college meetings of mathematics teachers.

A group of collaborating teachers is not necessarily a *community of practice* though, in Wenger and Snyder’s terms (2000). In the context of large organisations, Wenger and Snyder (2000) see a team and a community of practice as two different groups, with communities of practice often cutting across structures as a temporary arrangement for a specific purpose. In FE colleges, structures and communities of practice seem more closely linked, with the structure providing opportunities for communities with different shared aims and values to form. In some cases, cutting across existing structures is the only way to develop a mathematics-focused community of practice but this still needed to be sustainable and not temporary.

The social groups formed across or within structures in the case studies often exhibited some characteristics of a community of practice, such as a shared focus of activity, commitment to one other, transparency of practice and a culture of collaboration. However, other characteristics were often lacking and we now explore these briefly.

One of the key areas concerns the role of the ‘accomplished teacher’ (Lieberman & Pointer Mace, 2009), who facilitates inquiry by opening up their own practice to others. The range of expertise within a diverse mathematics teacher workforce presents opportunities for a range of expertise to be explored but also complicates the development of a community of practice. Rather than having one or more professional experts who support those less experienced, as would happen in a traditional apprenticeship model, individuals each bring expertise that is valuable and opportunities to learn from a large number of members with diverse competencies are the norm.

Furthermore, although sharing 'good practice' in these teacher communities encourages a culture of openness and transparency, which is a key aspect of a community of practice (Bolam et al., 2005; Lieberman & Pointer Mace, 2009; Stoll et al., 2006), the impact on professional learning is variable. The criteria used to define 'good practice' are often unclear, leading to highly subjective and contextualised interpretations of the term. The sharing of 'good practice' has the potential to add value to collective and personal learning when used appropriately but without a clear understanding of what this looks like, the community lacks a common goal and learning trajectories are uncertain.

The communities in the case study colleges might therefore be more appropriately termed *communities of practices* rather than communities of practice, to signify the range of expertise brought to the community and the different notions of professional competency. This is not an insurmountable problem but increased clarity about the shared aims is needed so the learning trajectories of its members become more consistently oriented towards an agreed professional identity and set of competencies.

The development of effective communities of practice in FE colleges for mathematics teachers is constrained by a national lack of consensus about their professional identity.

The development of clear aims for these communities is also adversely affected by the national context. The historical background summarised earlier shows how developments of professional standards for FE teachers have been fraught with difficulties. Despite the recent development of non-mandatory professional standards, FE teacher professionalism remains a contested concept in FE colleges (Gleeson et al., 2015). Evidence that adjustments are needed for mathematics teachers transitioning from school to FE (Noyes & Dalby, 2020a) suggests that professional standards are not

transferable across educational contexts and FE mathematics teaching needs its own competency framework. This ongoing uncertainty about the expected professional competencies of FE mathematics teachers does not help communities of practice develop a collective goal or shared understanding of suitable professional learning trajectories.

The lack of sector-level clarity adds uncertainty to what is already a variable and ill-defined notion of professional identity at college level. Although the renewed commitment from the government to training and professional development in the FE sector is welcome (DfE, 2021), the focus on teaching vocational and technical skills overlooks the particular needs of those teaching subjects such as mathematics.

The establishment of a community of practice is often constrained by fragmented structures and tensions between managers about the ownership of mathematics teachers.

Management structures for mathematics in large organisations differ from typical hierarchical structures for vocational provision in FE or the departmental approaches found in schools. Shared-responsibility arrangements and distributed management for mathematics are common features (Noyes & Dalby, 2020a). In these large and complex management structures, people and the power relationships between them become important.

In many colleges, attempts were made to bring mathematics teachers together but these did not involve all the workforce since some departments were considered niche areas (e.g. sixth form centres, foundation learning) and had their own mathematics teachers. Teachers in these areas generally remained disconnected from other mathematics-focussed communities and rarely attended meetings with other mathematics teachers. Distinctions between their role and that of other mathematics

teachers appeared more important than the pedagogical similarities but more significantly, there were issues about the 'ownership' of these mathematics teachers. Despite strongly identifying themselves as mathematics teachers, their managers saw them as 'belonging' in their niche areas and collaboration with other mathematics teachers was not a priority. Similarly, in a fully-dispersed structure, mathematics teachers sometimes reported difficulties attending meetings of mathematics teachers due to the priorities of their vocational line managers. The social domains formed within structural frameworks are an important consideration (Stacey, 2007). Power differentials within the informal network of liaisons and affiliations that accompany the formal structures can lead to tensions over the 'ownership' and control of mathematics teachers but these need to be resolved if college-wide mathematics-focused communities of practice are to thrive.

Wenger (2014) argues that a community of practice needs to be active in complementary ways at its core and at its boundaries. If mathematics-focussed communities are developed within colleges, the potential benefits to mathematics teachers in terms of subject-specific professional learning are clear but there is a danger of exclusivity if the boundaries are too tight, which poses a threat to wider organisational understanding of mathematics teaching. A decision for centralisation rather than dispersion of mathematics teachers may be made for various reasons by managers, some of which are pragmatic, but the boundary activity of mathematics-focused communities needs to be considered since this has a wider impact on the college, e.g. on embedded teaching of mathematics within vocational programmes. Such communities might be well advised to retain some openness rather than developing into closed exclusive groups.

Valuable opportunities for change occur in FE colleges that could be harnessed to develop more effective communities of practice for mathematics teachers.

Most colleges in our sample had restructured their mathematics staffing since the Condition of Funding in response to the increased numbers of students studying GCSE or functional skills mathematics. A disjuncture such as this often provokes innovation and creative thinking (Handy, 1993) and this was evidenced in colleges' attempts to find solutions to other problems associated with mathematics provision. Structural changes also affect social interactions and behaviours (Stacey, 2007) but it is important that the social changes are desirable ones and lead to a positive re-culturing (Fullan, 1993). The difficulty encountered by colleges has been to create a disturbance in their systems that relates to the desired outcomes and contributes to improvement by making effective use of the principle of "splitting and bonding" (Handy & Aitken, 1986, p.27) to build new liaisons, affiliations and communities.

In many cases, considerations of the desired outcomes were limited, especially with respect to professional learning, and more *reactive* rather than *deliberative* (Eraut, 2000). Although a structural change can create a useful disturbance, the frequency of changes between different structural models in some colleges gave little opportunity to reap the benefits before another change was instigated. Such approaches seem unlikely to result in any effective learning trajectory for mathematics teachers since the splitting of teams, without adequate time for new bonding, does not facilitate the development of communities where mutual aims, trust and collaboration can be easily established. Wenger and Snyder (2000) refer to successful managers being able to draw the right staff together in an infrastructure where learning communities can then prosper. This was evidenced at Alderton College, where a change of leadership caused a disjuncture that became an opportunity for change and a new manager was able to initiate the

development of a mathematics-focused community with a collaborative approach to improving the quality of teaching.

At Alderton College, there was also a synergy between the development of this community and a revised college system for improving the quality of teaching. The emphasis on a supportive approach, involving frequent classroom visits without grading lessons, helped develop a transparency of practice within a safe culture. This encouraged teachers to explore, take risks and inquire into their practice, thereby developing further key elements of an effective learning community (Dana & Yendol-Hoppey, 2008; Dimmock, 2016). In many colleges though, the professional learning activities of a mathematics-focussed community of practice were unconnected to college systems for improving teaching. These two areas, each with the potential to support professional development, often worked in different ways, with tensions between measuring performance and developing a culture in which activities essential to professional learning could take place.

Conclusions

In a sector often constrained by funding and with disappointing outcomes for students retaking mathematics, establishing a cost-effective model for professional development with the potential for a wide-scale impact on classroom practice is an important element of any improvement strategy. The present situation of variability in the professional development opportunities for FE mathematics teachers needs the stability and coherence of an effective model. Achieving this is dependent on both the actions taken by colleges and a clearer articulation of the goals in government policy.

Within colleges, attempts are being made to build communities of mathematics teachers across different types of organisational structures. These structures facilitate and constrain the development of professional learning in different ways but if

communities of practice are to be constructed, then organisational structures need to support rather than impede their development (Wenger & Snyder, 2000). There is wide variation in the non-formal learning opportunities available and the functionality of groups of mathematics teachers within these structures as communities of practice but few exhibit all the characteristics expected. Colleges need to consider what they are intending to achieve through these communities, including how these will facilitate relevant *knowledge of practice* and ways in which this can be achieved without the exclusivity that affects valuable fringe benefits to other staff.

Structural, staffing and system changes occur frequently in FE colleges, resulting in disjunctures (Handy, 1993) that provide an opportunity to create new communities and reshape organisational culture. When harnessed appropriately, these changes can be used to support the development of mathematics-focussed communities of practice but this often requires a 'legitimization' by management through public recognition of the value of these communities and the provision of time for staff to participate (Lave & Wenger, 1991; Wenger & Snyder, 2000). Furthermore, colleges need to take a more holistic approach by resolving internal tensions and power struggles such as those concerning performance management and the 'ownership' of mathematics teachers. Aiming instead for synergy between different systems would have a beneficial effect on the formation of communities of practice and the professional learning of the mathematics teachers within them.

A major challenge to effective communities of practice for FE mathematics teachers is however the lack of consensus about what professionalism means in this context. Clearer sector guidance about professional standards for FE mathematics teachers and better understanding of best practice are needed to achieve a clear focus and learning trajectory for communities of practice for mathematics teachers in FE

colleges. Without a shared aim, professional development for FE mathematics teachers remains directionless and progression from the existing communities of *practices* to effective communities of *practice* will be unrealised. Variations between colleges are inevitable whilst these communities remain localised and even with a stronger 'global' (i.e. national/sectoral) connection, through for example the expanding Centres of Excellence in Maths networks, fragmentation and uncertainty will remain.

The development of professional learning through college-based communities of practice is a relatively low cost, sustainable model for effective professional learning that could support long-term improvement in the sector. With better national guidance on what it mean to be an expert FE mathematics teacher and increased understanding of how to build mathematics-focussed communities of practice within complex interconnected college structures and systems, this is a model that could lead to significant and sustainable changes in practice with potential for positive effects on student outcomes.

Acknowledgements

This work was supported by the Nuffield Foundation under Grant number EDO/42854.

References

BEIS. (2017). *Industrial Strategy: building a Britain fit for the future*. London: HMSO.

BIS. (2012). *Professionalism in further education: final report of the independent review panel*. Retrieved from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/422247/bis-12-1198-professionalism-in-further-education-review-final-report.pdf

Bolam, R., Mc Mahon, A., Stoll, L., Thomas, S., Wallace, M., Greenwood, A., & Smith, M. (2005). *Creating and sustaining effective professional learning communities.* London: DfES.

British Academy. (2015). *Count Us In*. London: British Academy.

Cochran-Smith, M., & Lytle, S. L. (1999). Relationships of knowledge and practice: Teacher learning in communities. *Review of research in education*, *24*(1), 249-305.

Confederation of British Industry. (2015). *Inspiring Growth: CBI/Pearson Education and Skills Survey*. Harlow: Pearson Education.

Dana, N. F., & Yendol-Hoppey, D. (2008). *The reflective educator's guide to professional development: Coaching inquiry-oriented learning communities.* Thousand Oaks, CA.: Corwin Press.

Day, C., & Sachs, J. (2004). Professionalism, performativity and empowerment: discourses in the politics, policies and purposes of continuing professional development. In C. Day & J. Sachs (Eds.), *International handbook on the continuing professional development of teachers* (pp. 3-32). Maidenhead: Open University Press.

DfE. (2019). *Revised A-level and other results in England 2017/18.* Retrieved from https://www.gov.uk/government/statistics/announcements/a-level-and-other-16-18-results-2018-to-2019-revised

DfE. (2021). *Skills for jobs: lifelong learning for opportunity and growth*. Retrieved from https://www.gov.uk/government/publications/skills-for-jobs-lifelong-learning-for-opportunity-and-growth

Dimmock, C. (2016). Conceptualising the research–practice–professional development nexus: mobilising schools as 'research-engaged'professional learning communities. *Professional Development in Education, 42*(1), 36-53.

Education and Training Foundation. (2014). *Achieving professional potential: professional standards framework for teachers and trainers in education and training*. Retrieved from https://www.et-foundation.co.uk/wp-content/uploads/2018/07/ETF_Professional_Standards_Framework_Spreads_Web.pdf

Eraut, M. (2000). Non-formal learning and tacit knowledge in professional work. *British journal of educational psychology, 70*(1), 113-136.

Fletcher, M., Lucas, N., Crowther, N., & Taubman, D. (2015). The further education workforce. In A. Hodgson (Ed.), *The coming of age for FE?* London: Institute of Education Press.

Fullan, M. (1993). *Change forces: Probing the depths of educational reform*. London: Falmer Press.

Fullan, M. (2001). *The new meaning of educational change*. London: Cassell.

Gleeson, D., Hughes, J., O'Leary, M., & Smith, R. (2015). The state of professional practice and policy in the English further education system: a view from below. *Research in post-compulsory education, 20*(1), 78-95.

Gleeson, D., & James, D. (2007). The paradox of professionalism in English Further Education: a TLC project perspective. *Educational Review, 59*(4), 451-467.

Guskey, T. R. (1994). *Professional development in education: in search of the optimal mix*. Paper presented at the Annual Meeting of the American Educational Research Association, New Orleans, LA.

Handy, C. (1993). *Understanding Organizations* (4th ed.). London: Penguin Books.

Handy, C., & Aitken, R. (1986). *Understanding schools as organizations*. London: Penguin books.

Hodkinson, P., Anderson, G., Colley, H., Davies, J., Diment, K., Scaife, T., . . . Wheeler, E. (2007). Learning cultures in further education. *Educational Review, 59*(4), 399-413.

Hodkinson, P., & Colley, H. (2005). Formality and informality in college-based learning. *International yearbook of adult education, 31*, 165-182.

Hord, S. M. (2009). Professional learning communities. *Journal of Staff Development, 30*(1), 40-43.

Kankaraš, M., Montt, G., Paccagnella, M., Quintini, G., & Thorn, W. (2016). *Skills Matter: Further Results from the Survey of Adult Skills.* . Paris: OECD.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge: Cambridge University Press.

Lieberman, A., & Pointer Mace, D. H. (2009). The role of 'accomplished teachers' in professional learning communities: Uncovering practice and enabling leadership. *Teachers and Teaching: theory and practice, 15*(4), 459-470.

Little, J. W. (2002). Locating learning in teachers' communities of practice: Opening up problems of analysis in records of everyday work. *Teaching and Teacher Education, 18*(8), 917-946.

Lucas, N. (2007). Rethinking Initial Teacher Education for Further Education Teachers: From a standards-led to a knowledge-based approach. *Teaching Education, 18*(2), 93-106.

Lucas, N., Nasta, T., & Rogers, L. (2012). From fragmentation to chaos? The regulation of initial teacher training in further education. *British Educational Research Journal, 38*(4), 677-695.

Matos, J. F., Powell, A., Sztajn, P., Ejersbø, L., Hovermill, J., & Matos, J. F. (2009). Mathematics teachers' professional development: Processes of learning in and from practice. In R. Even & D. L. Ball (Eds.), *The professional education and development of teachers of mathematics* (pp. 167-183). US: Springer.

Noyes, A., & Dalby, D. (2020a). *Mathematics in England's Further Education Colleges: an analysis of policy enactment and practice*. Retrieved from https://www.nottingham.ac.uk/research/groups/crme/documents/mifec/interim-report-2.pdf

Noyes, A., & Dalby, D. (2020b). *Mathematics in Further Education colleges: final report. Retrieved from https://www.nottingham.ac.uk/research/groups/crme/documents/mifec/final-report.pdf*. Retrieved from https://www.nottingham.ac.uk/research/groups/crme/documents/mifec/final-report.pdf

Noyes, A., Dalby, D., & Lavis, Y. (2018). *A survey of teachers of mathematics in England's Further Education Colleges Retrieved from https://www.nottingham.ac.uk/research/groups/crme/documents/mifec/interim-report-1.pdf*.

Noyes, A., Dalby, D., & Smith, R. (2020). *Mathematics in further education: student progress over time*. Retrieved from https://www.nottingham.ac.uk/research/groups/crme/documents/mifec/interim-report-4.pdf

Orr, K., & Simmons, R. (2010). Dual identities: the in-service teacher trainee experience in the English further education sector. *Journal of Vocational Education & Training, 62*(1), 75-88.

Robson, J. (2006). *Teacher professionalism in further and higher education: challenges to culture and practice*. Abingdon: Routledge.

Senge, P. (2006). *The fifth discipline: The art and practice of the learning organization*. London: Random House Business.

Sfard, A. (1998). On two metaphors for learning and the dangers of choosing just one. *Educational researcher,, 27*(2), 4-13.

Stacey, R. D. (2007). *Strategic management and organisational dynamics: The challenge of complexity to ways of thinking about organisations*. Harlow: Pearson Education.

Stoll, L., Bolam, R., McMahon, A., Wallace, M., & Thomas, S. (2006). Professional learning communities: A review of the literature. *Journal of educational change, 7*(4), 221-258.

Timperley, H., Wilson, A., Barrar, H., & Fung, I. (2008). *Teacher professional learning and development.* Brussels: International Academy of Education.

Villegas-Reimers, E. (2003). *Teacher professional development: an international review of the literature.* Paris: International Institute for Educational Planning.

Wenger, E. C. (1999). *Communities of Practice: Learning , Meaning and Identity.* Cambridge: Cambridge University Press.

Wenger, E. C. (2011). Communities of practice: A brief introduction. Retrieved from https://scholarsbank.uoregon.edu/xmlui/bitstream/handle/1794/11736/A%20brief%20introduction%20to%20CoP.pdf?sequence=1&isAllowed=y

Wenger, E. C., & Snyder, W. M. (2000). Communities of practice: The organizational frontier. *Harvard business review, 78*(1), 139-146.

Wheater, R., Burge, B., Sewell, J., Sizmur, J., Worth, J., & Williams, J. (2013). The International Survey of Adult Skills 2012: Adult literacy, numeracy and problem solving skills in England. *BIS Research Paper 139*.

Wiliam, D. (2002). *Linking Research and Practice: Knowledge Transfer or Knowledge Creation?* Paper presented at the PME, Athens, GA.

Winch, C. (2013). Three Different Conceptions of Know-How and their Relevance to Professional and Vocational Education. *Journal of Philosophy of Education, 47*(2), 281-298.