From teacher to teacher educator: Supporting the development of schools-based physics coaches

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A Research & Development Project

Submitted for the MSc in Teacher Education 2020

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From teacher to teacher educator: Supporting the development of schools-based physics coaches

ABSTRACT

The Institute of Physics (IOP) employ, on a secondment basis, teachers (school-based coaches or SPCs) for half a day or a day each week to work with science departments in other local schools.

The aims of this investigation are to explore:

1. What knowledge the SPC comes to the role with and what knowledge they have to develop during the first year in role.
2. a) How they develop that knowledge, and b) to what extent, mentoring and community interventions facilitate the development of that knowledge

I have followed four coaches over the course of their first year in the role, collecting data on their views on their developing knowledge bases through interviews and through reflective diaries as well as recording field notes on their interactions with their mentors and their community of practice.

Different areas of knowledge, discussed in interviews and reflective diaries, have been categorized and ordered to show their connections to one another, resulting in a framework (shown below in figure 1) that highlights the typical knowledge base of a coach (aim 1). I have then re-analyzed the interview data, using this framework, to highlight how coaches currently develop this knowledge (aim 2a) and the extent to which mentoring and community interventions, which I put in place, support that development (aim 2b). Analysis of the data shows SPCs typically come with a well-developed knowledge for teaching, and this is further developed through peer networking within the community, comparing approaches with other teachers and gaining new ideas.

Knowledge around coaching pedagogy, teacher learners and engagement is typically less developed, and SPCs develop this through both experience and discussing specific problems with their mentors. Case studies are used to illuminate specific examples of how mentoring and community interventions have supported knowledge development.

The investigation has hopefully provided a useful tool in terms of a framework that will help conversations around the knowledge and development of coaches. It has also highlighted the need to discuss coaching pedagogy more explicitly in the coaches' development programme and the need to make some aspects of the programme compulsory (e.g. regular mentor meetings).

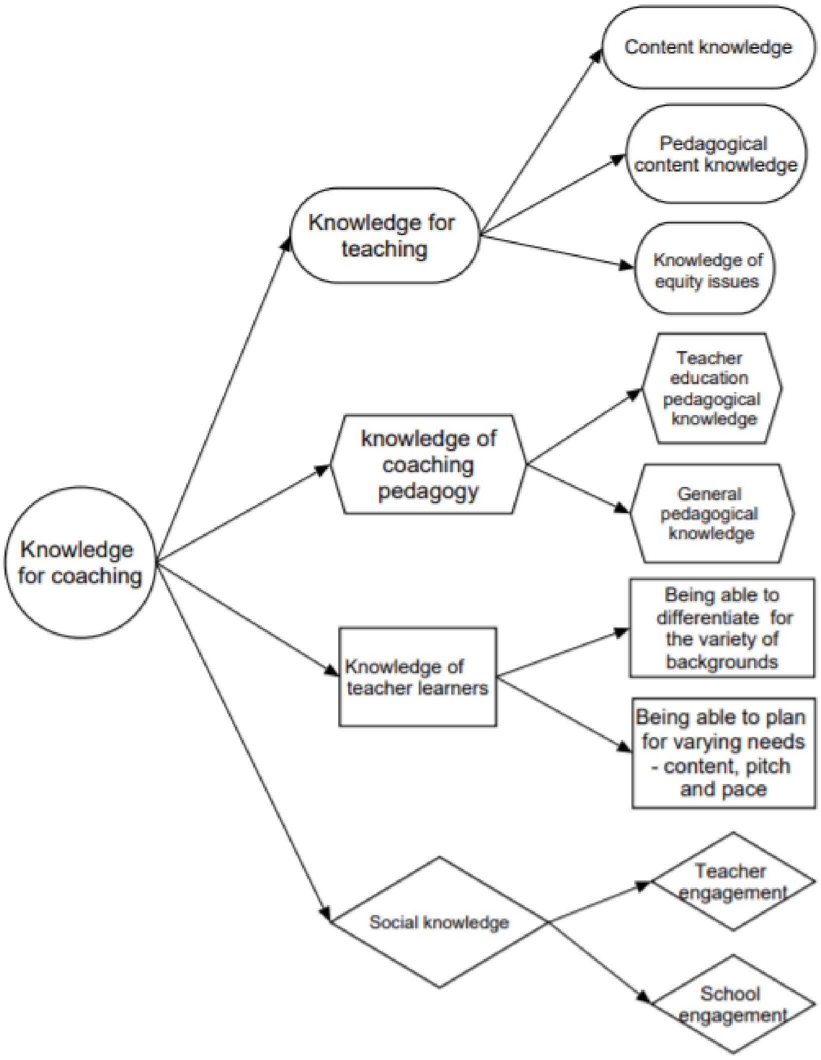
Content knowledge
Pedagogical content knowledge
Knowledge for teaching
Knowledge of equity issues
Teacher education pedagogical knowledge
knowledge of coaching pedagogy
General pedagogical knowledge
Knowledge for coaching
Being able to differentiate for the variety of backgrounds
Knowledge of teacher learners
Being able to plan for varying needs - content, pitch and pace
Teacher engagement
Social knowledge
School engagement

Fig 1: A framework for coaching knowledge

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1 Introduction

There is a well-documented shortage of physics teachers in England (Smith, 2010; Smith and Gorard, 2011; Migration Advisory Committee, 2017; Allen and Sims, 2017). As a result, pre-16 physics is often taught by chemistry and biology teachers in UK state schools, (referred to in this assignment as (physics) non-specialists, as they do not have a degree in physics or a physics related subject like engineering). The Institute of Physics (IOP) over the last ten years has run a programme to support these non-specialists with physics pedagogy. From 2016, the IOP has employed, on a secondment basis, around 50 teachers (known as schools-based physics coaches or SPCs) for half a day or a day each week to work with non-specialists in other local schools. I currently manage the team of 14 SPCs based in the south east England area.

When the IOP started doing this in 2016, there was an assumption that if the application process was robust enough, a good teacher would make a good coach and little thought was given to the additional knowledge/skills needed or support they may need to transition to working with teachers. As manager of a team of SPCs, from my experience, I know that some teachers struggle with the transition, and so I am keen to investigate the transition process, understand the challenges new SPCs face and what I can do to support them to be successful. While there is some research around the experiences of teachers starting to work in initial teacher education (Fuller et al., 2014), there is little research about my context, teachers starting to coach in-service teachers.

I have chosen to focus on knowledge in this investigation, and my definition of knowledge is inclusive of understanding and skills. I am interested in both what SPCs need to understand to be successful in their role and the skills required to put that understanding successfully into practice. Therefore, I intend to investigate their existing and developing knowledge and by knowledge I mean ‘facts, information, and skills acquired through experience or education; the theoretical or practical understanding of a subject’ (Oxford University Press, 2020).

My first aim in this investigation is to consider what knowledge the SPC comes to the role with and what knowledge they have to develop during the course of the first year in the role. My literature review firstly looks at the debates in the literature about the different types of knowledge that both teachers and teacher educators have, to give an understanding grounded in the literature about what the knowledge base of a developing and established teacher educator might look like. I will compare this with the knowledge base that the SPCs perceive they are developing later in the investigation.

The literature review will consider the difficulties that have been reported by teacher educators when they first started in teacher education. It will be useful to consider whether the SPCs face similar difficulties and the role of knowledge (or lack of) in these difficulties.

As manager of the SPCs, I am responsible for the development of the SPCs. My second aim considers a) how they develop that knowledge highlighted by my first aim, and b) to what extent, interventions I put in place can facilitate the development of that knowledge. In my literature review, I look at what the literature says about how teacher educators learn, to inform the interventions chosen to support the SPCs. The investigation then goes on to follow four coaches as they start working with other schools, starting from September 2019 – July 2020 and investigate how they respond to interventions put in place to support their development. After exploring the knowledge perceived to be developed by the SPCs, and how they currently develop it, I will be able to consider whether there are areas of knowledge that need further development by SPCs and which ways knowledge development of the SPCs can be supported, and potential improvements to the interventions.

The investigation takes an overarching view of the development of a teacher in their first year supporting other teachers. Current governmental policy in England is advocating teachers taking on more of the leadership of professional development (Husbands, 2015; Boylan, 2016) and initial teacher training (Department for Education, 2016).   The investigation may well raise some issues common to any teacher taking on a teacher educator role for the first time.

2 Literature review

This literature review will firstly, linked to aim 1, look at what knowledge teachers have or need for teaching physics (section 2.1), as this is what the SPCs are assumed to have and the non-specialists that they work with are assumed to lack. It will then look at what the research says around the knowledge base for teacher educators (section 2.2) – the role they are taking on as SPCs. Common difficulties experienced by beginning teacher educators will be discussed (section 2.3), and the role of knowledge bases in these difficulties. Finally, linked to aim 2, I look at what the literature says about how teacher educators learn (section 2.4), to inform the interventions chosen to support the development of the SPCs.

2.1 What do teachers need to know to teach physics?

There have been many attempts to categorize all that teachers need to know to teach. Shulman (1987) initially suggested a minimum of 7 categories of teacher knowledge, which included things from general pedagogical knowledge to knowledge of educational contexts (dept, school, area), and knowledge of educational purpose. In this section we are looking at subject specific teaching knowledge, what we need to teach physics, as this is what SPCs are assumed to have, and non-specialists are assumed to lack.

The importance of subject specific teaching knowledge was raised by Shulman (1986), when he proposed the term ‘pedagogical content knowledge’ (PCK), meaning knowledge of powerful analogies, explanations and demos, and an understanding of what areas the students might find easy and hard. He was highlighting the wealth of teacher knowledge that is additional to and exists between knowledge of one’s subject and knowledge of how to teach. Keller, Neuman and Fischer (2017) define PCK as the dimension that only teachers of the subject have and need; content knowledge (CK) comprises professionals content knowledge (e.g. that of a physicist); and pedagogical knowledge (PK) is shared by teachers of every subject.

Some argue that PCK is a dynamic body of knowledge, built on the profession's collective wisdom (Schneider and Plasman, 2011), which teachers draw on and apply to their context (students, school, environment) to create context specific PCK (Grossman, 1990; Barnett and Hodson, 2001). Others say that PCK is a personal thing, generated through experience and different for different contexts (National Research Council, 1996; van Driel et al., 2001) and continually created in practice, as teachers pull simultaneously from separate knowledge domains of SMK, pedagogy and context (Cochran, DeRuiter and King, 1993).

This separation of collective and personal PCK was included in the consensus model of teacher education, a model reached after much discussion at a summit which gathered 24 researchers from 7 different contexts. The model identifies that PCK (for example, instructional strategies, student misconceptions, content representations) is agreed collectively and accessed by teachers, who then transform it into their personal PCK (filtered by context and beliefs) (Gess-Newsome, 2015), which resonates with my experience. When working with teachers, the SPCs offer suggestions from collective PCK which has been discussed by the community of physics teachers and coaches. An example of this collective PCK is the general consensus around approaches to teaching energy through stores and pathways, which has been reached through (continuing) discussion, (Tracy, 2014). How the teacher then applies it to their classroom is up to them, as they have specific learner and context knowledge. When they try it out and reflect on it, they create their personal PCK.

An alternative breakdown of PCK is provided by Veal and MaKinster (1999) who describe PCK as domain specific (for example, strategies for equation manipulation in physics), topic specific (models for electricity) or general PCK (purposes for practical science). Teachers at different levels of experience, or teaching out of specialism, may have different levels of topic specific PCK (Veal and Kubasko, 2003).

Subject knowledge is also needed to teach physics, and specifically a good knowledge of what is on the curriculum. Curriculum is sometimes included within PCK (Lee and Luft, 2008) and is a term worth defining more closely, as the recent focus by Ofsted on curriculum planning and sequencing (Ofsted, 2019) has stimulated a lot of debate and writing on the topic (Boxer et al., 2018; Myatt, 2018), with multiple meanings given to the word. Curriculum is commonly held to be the 'subjects comprising a course of study' (Oxford University Press, 2020). However, knowledge of how the subjects (or topics) are connected are also important when considering the knowledge base of a teacher (e.g. making the connection between gamma waves when teaching radioactivity and when teaching the electromagnetic spectrum). Connections should be considered within the curriculum (Myatt,2018), particularly as research shows effective teachers typically have good connection knowledge (Rowland et al., 2005, 2013).

Research shows that a lack of PCK causes an issue for those teaching out of specialism; research shows that they tend to struggle with knowing student misconceptions, developing good explanations, knowing what practical to use, what key concepts to emphasise – all aspects that could be bracketed under PCK (Childs and McNicholl, 2007). In addition, subject knowledge including understanding how lessons and topics connect is also important (Rowland et al., 2005, 2013).

2.2 What do teacher educators need to know?

In this literature review, I will be referring to teacher educators. However, my context is around a specific type of teacher educator, the SPCs, who are still teaching children and in their additional roles for the IOP, facilitating professional development of other in-service teachers – a hybrid teacher leader (Margolis, 2012). There is, so far, a relatively small number of studies on those that lead professional development (Perry and Boylan, 2018) and hybrid teacher leaders (Margolis, 2012). Therefore, I will also be pulling on the wider research of teacher educators working in initial teacher education institutions (who normally have left teaching), and school-based mentors, where appropriate, in this literature review. There will be wider issues that affect initial teacher educators (e.g. pressure to undertake research) (Murray, 2006) that I will not be including in this literature review, as they do not apply to SPCs.

The literature reviewed below shows that there seems to be no consensus on a structure of a knowledge base for teacher educators, and different categories have been stressed by different researchers. Below is an overview of the different categories highlighted by different academics.

2.2.1 KNOWLEDGE FOR TEACHING

The majority of writing on the knowledge base of teacher educators assume that teacher educators start with the knowledge base of the teacher and the knowledge of a teacher educator is additional (see for example, Field, 2012; Selmer et al., 2016; Goodwin and Kosnick, 2013). Not all teacher educators start as teachers (Newberry, 2014) but the teacher educators in this study, SPCs, are all teachers. The previous section, 2.1, talks about this knowledge base in greater detail.

This knowledge could be seen as the 'content', what the teacher educators are teaching the leaner teachers (Field, 2012). However the skills picked up teaching at school can also be utilised in the teacher education setting. What is considered good practice for school students can also work for adult learners and thus teachers who are starting in teacher education could 'transfer' some of their existing knowledge to their new role. For example, there some consensus around the benefits for students of active learning (where students are not just passively listening) (e.g. Freeman et al., 2014) and contextual teaching (Sevian et al, 2018). Active, highly contextualised learning has also been found to be an effective strategy for teacher learning (Cordingley et al., 2015; Darling-Hammond et al., 2017) so knowledge of these strategies can work for both settings.

The ease with which new teacher educators can apply their existing knowledge may depend on their type of expertise as well as their level of expertise, according to Berliner (2001, 2004). He refers to fluid expertise, where the experts have skills and knowledge that can be transferred across from other contexts to help work on a new problem. This is opposed to crystallized expertise which consists of intact procedures that have been thoroughly learned and can only be used in relatively familiar tasks. Aim 1 for this investigation is to look at what knowledge teachers bring to the role and I am interested to see how this knowledge can then be applied.

In order to know which of their skills are transferable, it could be useful for a teacher educator to know to what extent teaching adults and teaching school students are similar and to what extent they are different. Much of the research in the field of andragogy or adult learning is founded on the work of Knowles (1984) who claims:

- Adults need to be involved in the planning and evaluation of their instruction
- Experience provides the basis for learning activities
- Adults are most interested in learning subjects that have immediate relevance and impact for their job or personal life
- Adult learning is problem centred rather than content orientated

In addition, Borthwick et al. (2020) points out that an adult audience could be more critical and they may become anxious if they perceive their time isn't being used well. However, adult learning theory, in particular the work by Knowles (1984), has attracted some criticism in that some of the assumptions made by Knowles could also be said to apply to some children. The claims could be said to be more in line with an independent learner rather than an adult learner (Merriam, 2001). Therefore, it could be said that there are some pedagogical similarities in the pedagogical knowledge for teaching children and for teaching adults.

2.2.2 KNOWLEDGE OF CONTEXT

There is general consensus that teacher knowledge includes knowledge of context: teachers needs to understand their learners and the context in which they are situated (for example, Lee and Luft, 2008; Cochran, DeRuiter and King, 1993). However, for the teacher educator, knowledge of context becomes more complex. For example, Goodwin and Kosnick (2013) discuss the context of different classrooms, of student teachers, the system within which the teachers reside and the context of the teacher educator i.e. their training institute.

A helpful simplification is provided by the findings from a study looking at four teacher educators working with in-service teachers, which conceptualises the knowledge base of teacher educators as layered, with one layer referring to students (how students learn, the context of students, what students need to learn) and one layer referring to teachers (how teachers learn, the context of teachers, what teachers need to learn) (Selmer, Bernstein and Bolyard, 2016).

The importance of knowledge of teacher learners has been highlighted by a review into effective CPD. In particular recognising the different starting points of teacher learners was found to be important in supporting improved outcomes (Cordingley et al., 2015).

2.2.3 SOCIAL KNOWLEDGE

Knowledge of how to interact with and relate to learner teachers in order to effectively teach, has been identified by researchers as a critical knowledge base for teacher educators (Smith,2005; Koster and Dengerink, 2008; Goodwin and Kosnick, 2013; Davey,2013). Loughran (2006) highlights the importance of many aspects of social knowledge in his reflections on his principles of practice, including listening (both for clues that learning is happening and to learners concerns), balancing sensitivity with honesty and the importance of establishing a safe learning environment to encourage trust. His account and the others referenced above emphasize the importance of relationships, understanding the needs and concerns of both the individual learner, the group and the interplay between individuals within the group.

2.2.4 KNOWLEDGE OF TEACHERS' BELIEFS AND BIASES

The consensus model of PCK, mentioned in section 2.1, describes how beliefs and biases can affect a teachers ability to learn (Gess-Newsome 2015). It shows collective knowledge being passed through the amplifier or filter of teacher beliefs before being 'converted' into personal PCK. Hence if there is collective PCK that a teacher doesn't believe in, it will be filtered out and not used in their classroom and so understanding where there may be a conflict is important for a teacher educator.

Literature shows teachers come to teaching with beliefs and biases based on their past experience and these beliefs are persistent and resistant to change if they are not challenged (Goodwin and Kosnick, 2013). Providing opportunities for teachers to surface their beliefs was shown to be a helpful pedagogical method (Cordingley et al., 2015).

A knowledge of the psychology behind why some teachers may be resistant to change could be useful for teacher educators. For example, there is confirmation bias (where unfamiliar ideas are forgotten), sunk-cost bias (where we hold onto hard-won ideas) and fundamental attribution error (where we resist criticism). In addition, the halo effect (where we may assign positive characteristics like being knowledgeable to someone we like) and the Dunning Kruger effect (where we confuse enthusiasm for expertise) can come into play and affect the learning of teachers (Weston and Clay, 2018).

2.2.5 KNOWLEDGE OF ISSUES OF EQUITY

Knowledge around social justice, issues of race, class and inequity and the ethical/moral purpose of teaching is discussed by a number of teacher educators (Davey, 2013; Goodwin and Kosnik, 2013; McIntyre, 1990) as an important part of a teacher educator's knowledge base. However, while the importance of these matters is often articulated, John (2002) found limited evidence of the content of strategies that could be used to explore issues of social justice and no discussion of any framework that might help tutors and students investigate these realms, in his case studies across six teacher educators.

This category of teacher educator knowledge is of particular interest to the IOP, as the IOP has been working on why the same proportion of girls as boys do not take physics post-16, (Institute of Physics, 2017, 2018). We are also interested in the wider work by Louise Archer et al. (2015) on science capital, as it considers science engagement and why some students may 'opt out' of physics. There is a central desire is for our coaches to feel confident in their knowledge around these issues and as comfortable raising these issues with teachers as they do physics.

2.2.6 KNOWLEDGE OF TEACHER EDUCATION PEDAGOGY

Field (2012), in her study of 6 teacher educator colleagues, highlighted that it was this aspect, teacher education pedagogy, that beginning teacher educators most struggle with, as oppose to her other two knowledge categories; subject knowledge and knowing how to teach one's subject. By the term teacher education pedagogy, I mean the methods employed to support teacher learning, or the knowledge of how to teach others how to teach (your subject).

Some researchers say that a pedagogy of teacher education is yet to be agreed (Loughran, 2006) and teacher education is complex as we are teaching about teaching. However, there are common elements of teaching practice that repeat in both the literature on initial teacher education and continuing professional development (CPD). Much of the evidence about effective CPD comes from two recent meta-reviews (Cordingley et al 2015, Darling-Hammond et al., 2017), which considered 46 and 35 studies respectively. Meta-reviews, where experts identify and read relevant studies before summarising the main findings, are subjective in nature (Wiliam, 2016, p73). However, the process is transparent, and they can provide a useful overview and identify important features to consider. I will highlight the elements below as I am interested if the SPCs encounter and use these elements during their first year.

2.2.6.1 Exemplification

Exemplification (how teaching is learned e.g. by co-teaching, modelling effective practice) is one of three categories in Philpott's 2014 framework for teacher education pedagogy. Exemplification mentioned in the CPD literature include observing others (peers, mentors) and example materials (e.g. lesson plans or curriculum materials) and trying out teaching strategies so teachers can engage in the same style learning as their students (Darling- Hammond et al., 2017).

Modelling best practice is a common theme in the literature emerging from ITE (Smith, 2005), but an additional layer is discussed – the ability to explain what you're doing and why you're doing it (Davey, 2013; Korthagen and Kessels, 1999; Loughran, 1995). By articulating thinking processes, one can make tacit knowledge explicit. One can also model reflective practice; a skill emphasised during ITE. By explaining why the teacher educator is doing what they are doing, teacher educators are both reflecting about what they are doing and modelling that reflection (Dinkelman, 2003; Loughran,1995).

2.2.6.2 Theoretical perspectives

The introduction of theoretical perspectives to teachers is a key part of teacher education pedagogy (Hayward, 1997; Korthagen and Kessels, 1999) and information on the underpinning rationale and theory is often an element in successful CPD (Cordingley et al., 2015).

Research has highlighted that theory is easier to understand when one can compare it to one's own experience and knowledge in that field (Korthagen and Kessels, 1999). Pre-service teachers often have very little day-to-day experience about what it is actually like to teach when they first start on their training course and many studies show pre-service teachers' preoccupation with behaviour management, (see, for example, Furlong and Maynard, 1996). Therefore introducing theory to pre-service teachers (because they lack knowledge/experience and are focused on behaviour management) is challenging (see, for example, Korthagen and Kessels 1999, Korthagen and Lagerwerf, 1996).

Experienced teachers, who have extensive day-to-day experiences, may find it easier to absorb theory, as they have more case study knowledge to test theory against (Berliner, 2004). The ITE literature suggests that theory transfer is more successful when teacher educators introduce integrated theory and practice knowledge at the point of usefulness (Korthagen and Kessels,1999; Burn and Mutton, 2015), make helpful ideas from theory available as suggestions for practice, and encourage teachers to critique those ideas (McIntyre, 1993).

2.2.6.3 Collaborative learning

The literature shows fostering collaboration and peer learning is a key teacher education pedagogy that supports teacher learning. Research has shown that learning from other teachers is a valuable source of development (Williams, 2010; Rhodes and Beneicke, 2002) and schools with a collaborative culture provide a supportive environment for development (Williams, Prestage and Bedward, 2001). As Vescio, Ross, and Adams (2008, p. 81) put it, such groups and networks constitute a ready source of "knowledge [that] is situated in the day-to-day lived experiences of teachers", relating back to another feature of good CPD – that it need to be situated in the lives of teachers (Cordingley et al., 2015). A 2012 study of two UK science departments (McNicholl, Childs and Burn, 2013) showed how collaboration between teachers allowed detailed context-sensitive knowledge, relevant to the level of expertise and resources to be exchanged in a quick and effective way, when teachers needed it. Particular subject specialists were often relied on as 'resource people', from whom teachers would seek help.

Collaborative CPD, with emphasis on peer support was found to develop enthusiasm for collaborative working (Cordingley, Bell, Rundell and Evans, 2003; Stoll, Bolam, McMahon, Wallace and Thomas, 2006) and promoting change that extended beyond the classroom (Darling-Hammond et al., 2017). However, while most effective CPD includes an element of collaboration, it is not sufficient in its own right (Cordingley et al., 2015; Timperley, 2008). Expert knowledge input is useful (Stoll, et al., 2006; Cordingley et al. 2015, Darling-Hammond et al., 2017; Timperley 2008) and is needed to stop the 'recycling of inadequacies' (Alexander, Rose and Woodhead, 1992).

Overall, the evidence suggests that pedagogically teacher educators should be encouraging collaboration between teachers whilst aware of the limitations outlined by Cordingley et al. (2015).

2.2.6.4 Providing space to reflect

Many writers in teacher education emphasise, as part of their pedagogy, the importance for teacher educators to provide a space for their learner teachers to reflect. For example, professional development models frequently provide built-in time for teachers to think about and make changes to their practice (Darling- Hammond et al., 2017) and this reflection is important for bringing about and embedding changes in practice (Cordingley et al., 2015). The importance of reflection in teacher learning is illustrated by the interconnected model of teacher growth from Clarke and Hollingsworth (2002), where four potential domains are identified where change can take place. Reflecting on one of these domains can cause a change(learning) in another domain or encourage action, which can lead to further reflection and change/learning and the four domains are: an external source of information or stimulus (like a CPD session – external domain), trying things out in the classroom (domain of practice), noticing improvements in the classroom (student engagement or results –domain of consequence)) and revisiting your knowledge/beliefs (personal domain).

Providing the space to reflect is also a key issue in ITE and in the literature in ITE there is a focus on how a reflective mindset can be encouraged. McIntyre (1993, p.43) defines reflection 'as a systematic enquiry into one's own practice to improve that practice and to deepen one's understanding of it' – a central tool for lifelong learning. Importantly, reflection needs to be done by the teacher; it cannot be done for them by the teacher educator (Loughran, 2002). There are a number of ways in which ITE encourage reflective practice in student teachers (seminar, group discussions, journals, videotaped lessons – Loughran, 1996), but there is limited evidence as to their efficacy (Zeichner, 1987). A small-scale action research project showed that reflection in action can be demonstrated by the teacher educator through articulation of pedagogical decisions during the course of the session, and this modelling was valued by the students (Loughran, 1995; also see section 2.2.6.1 on exemplification).

2.3 Common difficulties of early career teacher educators

There is some literature about the difficulties of teachers who are just starting to work in teacher education with in-service teachers. The majority of references in this section is taken from ITE. It will be useful to consider whether SPCs face similar difficulties.

2.3.1 LACK OF KNOWLEDGE ABOUT META- TEACHING (TEACHING ABOUT TEACHING)

Typically, teacher educators have had previous successful careers as teachers (Bullough,2005; Murray and Male, 2005; Zeichner, 2005) or are practicing schools teachers (Cope and Stephen, 2001) and thus have amassed a knowledge base that allowed them to operate successfully as teachers. However, little support is given to them about the differences between classroom teaching and teacher education (Murray and Male, 2005; Zeichner, 2005). To start, they may see their role primarily as passing along knowledge about good teaching practice and their practice may be transmission orientated, despite having strong constructivist teaching principles when in the classroom (Murray and Male, 2005; Dinkelman et al., 2006; Field, 2012). Zeichner (2005) in his description of his own development explained that initially he was at a loss as to what to do, other than show them how he handled certain situations. Few realise that there is a body of literature on teacher education (Zeichner, 2005). The literature often mentions that there should be a training for those that are supporting teachers in the classroom. However, it rarely says what should be in it (Clarke, 1997) and much of the literature says that there is no agreed pedagogy of teacher education (Loughran,2006).

2.3.2 EXPOSING VULNERABILITY IN ORDER FOR TEACHERS TO LEARN

As highlighted in section 2.2.6.1, articulation of teaching decisions by the teacher educator can help make explicit the modelling of good practice (Loughran, 1995; Dinkelman, 2003). Teacher education literature also encourages the critical analysis and questioning of the teacher educator’s practice by the student teachers, so they can dissect prevailing assumptions (Loughran, 2006). This entails teacher educators laying their own practice open to criticism, exposing their own vulnerability as learners (Russell and Loughran, 2007). While this can provide a good learning opportunity for both teacher and teacher educator, Berry and Loughran (2002) reflects on the high emotional cost, particularly for early career teacher educators, who may not be so proficient at acting on feedback in-the-moment and who can be left feeling vulnerable and exposed.

2.3.3 MANAGING RELATIONSHIPS

Managing relationships at many levels was identified as a common difficulty for early career teacher educators. Early career teacher educators are having to learn to manage effective relationships with their learner teachers and this includes, for example giving feedback effectively (Bullough, 2005) and adjusting to the pedagogical skills needed to work with adult learners (Kremer- Hayon and Zuzovsky, 1995; Murray and Male, 2005). In addition, managing a mentoring relationship that also contains an element of judgement (Allsop, 1997) and the interpersonal skills needed to nurture the relationship between the schools and the university can also be challenging for early career teacher educators (Bullough, 2005; Dinkelman et al., 2008). One could say improving social knowledge could perhaps help with this difficulty.

2.3.4 IDENTITY

Early career teacher educators have reported challenges with their identities as they make the transition for teacher to teacher educator. For example, much of the issue around identity is centred around the lack of acknowledgement in the differences between the role they had as teachers and the new teacher educator role, and the corresponding dip in their expertise. They are learning about teaching (teachers) but are seen as experts in teaching (Loughran, 2006). They are both experts in teaching, but novices in teaching about teaching. The feeling of 'novice', while being perceived as an expert and having been an expert can challenge their identity (Murray, 2006, p.3). They need to be learners and teachers simultaneously.

As a result early career teacher educators have expressed negative self-views of being vulnerable, exposed, marginalised, disempowered and de-skilled which has been reported to slow down the formation of a teacher educator identity (Field, 2012; Murray and Male, 2005) and can lead to them clinging to their identity as a teacher, and emphasizing this experience (Bullough, 2005; Dinkelman et al., 2006). In turn this emphasis on their teaching experience can then affect their pedagogical choices, as discussed in section 2.3.1.

While a teacher educator shouldn't cling to their teacher identity, they should acknowledge it and include it as an important part of their new teacher educator identity (Swennen et al., 2010) and their knowledge base. Improving knowledge around teacher education pedagogy and the knowledge they bring with them from their previous teaching role could perhaps help with this difficulty.

2.4 Learning to become a teacher educator

In this section, we review reports from literature of how teacher educators typically learn and interventions that support learning.

2.4.1 LEARNING ‘ON THE JOB’ AND THE ROLE OF REFLECTION

Much of the literature on the development of early career teacher educators indicates that they predominantly learn on the job (Zeichner, 2005; Murray and Male, 2005). For example, in a study of 293 teacher educators by Goodwin et al. (2014, pp291), participants spoke of picking up teaching skills “by osmosis”; adapting practices and techniques from their own university experience and lecturing, facilitating discussions, and assigning work that emulated the practices of past professors whom they perceived as effective. Goodwin et al. (2014, p.291.) reports that these teacher educators stated that their own practices were “invented out of desperation,” without any induction, mentoring, or systematic support, with a lack of induction being a common theme throughout the literature in this area.

A key part of developing during this experience is being able to be reflective, to listen and learn (Guilfoyle, Hamilton, Pinnegar and Placier, 1995; Dinkelman, 2003; Clarke and Hollingsworth, 2002). For example, reflecting on interactions with those that they are teaching give teacher educators a greater understanding of context and learners (Zeichner, 2005; Dinkelman et al., 2006). Appendix D shows how Clarke and Hollingsworth’s model of professional growth (as explained in section 2.2.6.4) could also be applied to coaches.

In addition, there are pedagogical skills, developed through teaching students, that could be useful in the role. The knowledge of the applicability of these skills to this role is likely to be developed through reflection and experience. This is discussed further in section 2.2.1.

2.4.2 MENTORING

Studies into the impact of mentors on beginning teacher educators have shown that mentors can be useful to help orient mentees, direct them towards opportunities and keep them from making mistakes (McEvoy et al., 2019). Mentees also learnt a great deal from working alongside their mentors and achieved best when given support appropriate to their level of development (i.e. as they progress from dependency to greater autonomy (Griffiths et al., 2010).

Mentors also gain pleasure from the relationship (Griffiths et al., 2010) and a study into expert teacher educators (Hashim and Ahmad, 2013) showed how both being well mentored and then becoming a good mentor can contribute to the development of an expert teacher educator.

However, formal mentoring schemes have been shown to be less effective when there is no clear direction about the purpose of the mentoring relationship, resulting in sporadic, agenda-less meetings and missed opportunities for in-depth, reflective, learning conversations (Harrison and McKeon, 2008). Mentors are typically used as support for someone undergoing a career transition and should be experienced colleagues with knowledge of the requirements of the role and able to broker access to a range of increasingly self-directed learning opportunities to support the development of the whole person, according to Centre for the Use of Research and Evidence in Education (CUREE, 2005).

2.4.3 COMMUNITIES OF PRACTICE

A community of practice (CoP) may be of use in helping a teacher educator become more connected as well as giving them a space in which they can discuss their practice. Beginning teacher educators can feel lonely when they are unable to make professional connections with other teacher educators (Williams and Ritter, 2010). To counter this, communities of practice formed within induction programmes offer an opportunity specially for beginning teacher educators to share new knowledge, methods, tools, activities and materials (Poyas and Smith, 2007), do team planning, teaching and supervision (Murray, 2008) and develop social interaction with other members of the community (Kwan and Lopez-Real, 2010). Technology can support interaction and Margolin (2011) discusses how a group of teacher educators use a messaging service to continue conversations and enrich collaborative capacity.

Wherever a teacher educator enters the CoP, there will be a common set of understanding and assumptions held collectively, which they will need to negotiate and can contribute to (Field, 2012; Fuller et al., 2005). Hökkä, Eteläpelto, and Rasku-Puttonen (2012, pp84) claim the CoP can support identity formation as identity is partially formed by the teacher educators' 'participation in the practice and discourses of work organization'.

Some of the challenges to supporting peer networking in CoPs, which have been reported in the teacher education literature and which also may prove challenging in CoPs involving teacher educators, include buy in from all the participants to the CoP (Higgins and Leat, 1997) and time constraints (Rhodes and Houghton-Hill, 2000).

2.5 Summary

The research seems to show that teacher educators both need to know how to teach and how to teach someone to teach. How to teach someone to teach, or teacher education pedagogy is an area that the research shows that initial teacher educators often struggle with. This indicates that there is often a lack of guidance about teacher education pedagogy when they start, and many teacher educators learn how to teach others to teach by trial and error. Other knowledge bases discussed in the literature include knowledge about learner-teachers (which teacher educators often learn through experience), knowledge around equity issues and social knowledge (around relationships). Research shows mentoring and becoming involved in a community can help support a teacher educator transition into the role. It reports mentoring can help provide opportunities for early career teacher educators and help prevent mistakes being made, whereas communities of practice can support beginning teacher educators sharing ideas and making social connections with one another.

3 Methodology

3.1 Rationale for Study

I am responsible for managing a team of coaches including teachers who are seconded as schools-based coaches or SPCs to work with science departments in other local schools for between half a day and a day a week. When the IOP started working with schools based coaches in 2016, there was an assumption that if the application process was robust enough, a good teacher would make a good coach and little thought was given to the additional knowledge/skills needed or support they may need to transition.

The preceding literature review highlights some of the issues that teacher educators have when starting to work with teachers (Fuller et al., 2005). Much of it is based on the new knowledge and skills that they need to acquire (Field, 2012) and the lack of support they are given in the development of this knowledge (Murray and Male, 2005; Zeichner, 2005). Most of the research is set in the context of ITE.

There has been little research on the development of teacher coaches, or SPCs. Bearing in mind what we learnt from the literature review about the knowledge and development of teacher educators in ITE, and the benefits of mentoring and communities I plan to investigate the following:

1. What knowledge the SPC comes to the role with and what knowledge they have to develop during the first year in the role.
2. a) How they develop that knowledge, and b) to what extent, mentoring and community interventions facilitate the development of that knowledge

I have proposed the second question in two parts, as SPCs come to the role with a wide variety in experience and from different backgrounds, and only spend a small proportion of their working life on the coaching role therefore I recognise that over the year they will develop their knowledge in response to demands and exposure to ideas from a variety of places. As part of this holistic investigation, I want to understand all the ways in which the coach develops (as it may give me ideas for developing the coaching development programme) as well as focusing in on the effectiveness of the current mentoring and community intervention. This will hopefully help to ascertain the needs of SPCs and help map out a curriculum for a better induction programme in the future.

3.2 Methodological approach

I am taking a case study approach, and I have chosen the case of four beginning coaches in their first year in the role, from when they start working with other schools in September 2019 to the end of the school year in July 2020. A case study provides an in-depth analysis of a situation bounded by time and activity, using a variety of data collection methods over a sustained period of time (Cresswell, 2014). I have chosen this approach to systematically gather evidence to investigate the interaction of factors and events affecting the development of these SPCs during that first year. While the findings are unlikely to be easily generalizable, it may provide suggestions for intelligent interpretation for other similar cases, for example, SPCs starting in future years or working in other geographical regions (Nisbet and Watt, 1984).

I took a qualitative, exploratory approach, as there is currently a lack of research around the development of SPCs and therefore many unknowns (Cresswell, 2014). A small sample has been chosen, to allow more (and more detailed) data to be collected (Open University, 2003).

3.3 Sampling

I aimed to recruit four coaches. I wanted to be able to collect detailed data of what had impacted on the coaches' development. Therefore, I needed to keep the group quite small, so I could cover enough detail, in the time allocated. However I needed a group big enough that might allow for coaches having to drop out – it was ethically important to me that no coach felt like they were letting me down if they had to drop out due to other pressures.

There were 6 teachers starting as SPCs in September 2019 in my team. SPC applicants typically have a varying amount of teaching experience and this has been replicated in my participant pool. All potential participants identified as male and while ideally I would like a sample across genders, I am not able to in this case, and acknowledge that someone of a different gender might have different experiences not covered in this investigation.

I eliminated two coaches from the initial recruitment round, who were job sharing, as they would have less time to dedicate to the role. I invited the remaining four to take part in the study, firstly with an informal conversation, followed up with an email containing research information, (aims and potential demands on time) and the consent form. Further questions were answered by telephone, after which consent forms were returned by interested participants. I stressed the voluntary nature of participation throughout the process to potential participants and made sure that they had adequate information to give informed consent (British Education Research Association [BERA], 2018). This was particularly important as I have managerial responsibility for them, and I did not want anyone to think that this was something that they were expected to do. All seemed positively inclined towards research and happy to take part. Pseudonyms for the coaches and their mentors have been used throughout and care has been taken to avoid the identification of individual schools, while also giving enough information so that the reader can understand the context that the coach is working in. Pseudonymisation occurred directly after consent forms had been collected.

3.3.1 PARTICIPANTS

- Adam is an experienced teacher (20+years) and head of department in a small 11-16 inner city comprehensive.
- Barry is an experienced teacher of 20+ years and head of physics in a large 11-18 comprehensive in a large town.
- Colin worked in engineering previously and has been teaching for 3 years in a large 11-18 village school.
- Derek has been teaching for around 3 years (after graduating) and has just moved to a small academy school in a market town.

3.4 Interventions

In the literature review, I looked at the role that reflection, support from a mentor, and a community of practice plays in development. As IOP area manager, I am responsible for the development of these coaches and so, informed by the literature discussed above, I have provided the following opportunities/interventions for these coaches over the course of a year.

Mentor: Each SPC had access to a mentor, who was an experienced physics teacher educator. The mentor is available to discuss session plans, co-deliver a session, or observe/give feedback on a session.

Community: The SPC is part of a larger team and I was keen to provide the right conditions for the coaches to learn from one another, as a professional learning community. I put the following interventions in place:

- Each SPC was added to a messaging group (using WhatsApp software). In total there, are around 20 physics teacher educators on the messaging group, all working in a similar region (East/South East England). The messaging group enabled rapid peer to peer communication.
- Opportunity to attend ‘regional physics days’ on Saturday, where they could observe other physics teacher educators run sessions, and network with peers.
- Access to regular team meetings and coaching seminars, with opportunity to network with peers and participate in workshops run by more experienced coaches, about developing coaching practice. Ideally there would be a team meeting and a coaching seminar each term.

Please refer to table 1 on page 28 for approximate timings of the interventions.

In March 2020, a global pandemic broke out, shutting schools and stopping face to face meetings, which meant that the coaches only had access to two team meetings and 2 coaching seminars in this period. The pandemic also meant that plans to observe the coaches working with teachers in the spring and summer term and to jointly plan a session with them using the ‘Japanese Lesson study’ method were cancelled.

It should be noted that each coach was offered the same opportunities, but it was not compulsory for the coach to take advantage of any opportunities. This programme decision was based on the assumption that SPCs, as adults and ‘experts’ are responsible for their own development and would be aware of their own development needs. On reflection, this assumption resonates with assumptions made by Knowles’ adult learning theory in 1967 (see section 2.2.1), which have since been criticised and found to be unreliable (Merriam, 2001).

3.5 Data collection methods

In this section I review and justify my chosen data collection methods. All data through this investigation was kept securely on a password protected laptop, encrypted using MacAfee endpoint encryption complaint with FIPS 140-2 standards.

Phase and dates	Autumn term Sept – Dec 2019	Spring term Jan – May 2020	Summer term May - July
Intervention	Setting up of WhatsApp group, national coaching meeting, 2 x regional days, 2 x meetings, interviews (round1), ongoing WhatsApp conversations	1 regional day, 1 meeting, (interventions suspended due to Covid), interviews (round 2), ongoing WhatsApp conversations	Interviews (round 3), ongoing WhatsApp conversations
Data collection	Audio recorded initial interviews (round 1) to gather coaches' perceptions on what knowledge they perceive they have at this point, contextual data about schools from DfE website (https://get-information-schools.service.gov.uk/) and Ofsted reports, field notes from meetings and mentor conversations.	Audio recorded interviews (round 2) and reflective diaries to gather coaches' reflections on what knowledge they perceive they are developing at this point and what they have learnt from running sessions, field notes of meetings and mentor conversations.	Video recorded interviews (round 3) and reflective diaries to gather coaches perceptions how they feel they developed their knowledge. Field notes from meetings and WhatsApp data to analysis engagement with the interventions. Coaching output data from sessions used to triangulate data around knowledge development
Research questions	What knowledge do the coaches come to the role with? What knowledge do they expect to need to develop?	What knowledge are the coaches developing over the year and how are they developing it? Are all coaches engaged?	What knowledge have the coaches developed over the year and how have they developed it? Why might an SPC not engage with mentoring and/or community interventions?

Table 1: Timeline of interventions and data collection

3.5.1 INTERVIEWS

I decided that my main data set would be based on semi-structured interviews, as I was interested in what the SPCs perceived their own knowledge base to be and its growth over the year (aim 1) and the extent to which they perceived that mentoring and community interventions supported their development (aim 2). Semi-structured interviews allow respondents to express themselves at length, but offer enough shape to prevent aimless rambling (Wragg, 1984). I used an interview guide (Patton, 1980, p.206), which can be seen in appendix A, where topics and issues to be covered are decided in advance, but there is flexibility in sequence and working as oppose to a standardized open-ended interviews. This gave me flexibility to adapt to a particular individuals circumstances, increasing comprehensiveness, while still maintaining systematic data collection (Patton, 1980). This naturalistic, inductive and open-ended approach (Lofland, 1971; Patton 1980) allowed me to have a grounded perspective, giving participants the opportunity to expand on the points of their development that they found to be most relevant, while allowing me to give prompts to the approximate areas that I would like them to reflect on, and ask further questions when they brought up areas of particular interest. I took care to make sure that the questions did not bias a response.

Interviews were held in neutral environments, either on the phone, by video call, in the participants school or at the IOP offices. Permission was asked to record all interviews and permissions was granted, so all interviews were audio recorded. Dates of interviews are recorded in table 2 in appendix A.

Interview round 1 helped to establish what knowledge the coaches perceived that they brought with them, and what knowledge they thought might need to develop, (aim 1). I asked general questions about how long they had been in teaching, how they would describe their teaching style, their coaching style and what they saw as the key differences between teaching (working with children) and coaching (working with adults) to explore their initial thoughts around coaching. I then explored the teacher educator knowledge domains with them as set out by Goodwin (2010) and Goodwin and Kosnik (2013) and I asked them to rate themselves on a scale of 1-5 in a) how important they thought that knowledge was for teaching and b) how much they felt they knew in that area. Refer to appendix A for further details on the questions asked during each interview round.

Interview round 2 was seeking reflections about how their first sessions with school had been and any lessons learnt. Reflections on issues or problems encountered could indicate developing knowledge.

Interview round 3 towards the end of the school year was asking them to reflect on the year, to ascertain their perceptions on how their knowledge had developed (aims 1 and 2a) and to what extent the mentoring and community interventions helped (aim 2b). We revisited the domains of knowledge that we had discussed in the preliminary interviews. Initially I had asked them to score themselves 1-5 in these areas. I was hoping to be able to see areas where they thought they had improved by a difference in ranking. However, it was clear that the SPCs felt uncomfortable with ranking themselves, and so the dialogue around to what extent and in which areas they had developed was much more interesting. There were a number of areas in which the coaches didn’t know what they didn’t know at the beginning, so even though they may have ranked themselves highly in that area at the beginning, they were happy to discuss how much they had developed through the year.

Colin, who had been identified as not engaging with the interventions to the same extent as the others, was also asked why he had not engaged and what should be changed to make the intervention more effective.

3.5.2 REFLECTIVE DIARIES

SPCs were asked to keep a reflective diary, detailing how their first sessions had gone and what they would change next time. Diarists need to be given a series of instructions (Burgess, 1984), so I asked them to write reflections after sessions (how did you plan, how did the sessions go, what will you do the same/differently next time) and to note any particular points they felt helped their development as a coach (or was meant to help but didn't) e.g. meeting with a fellow coach, joint planning of a session, watching someone else's session, ideas from Twitter etc.

3.5.3 EXISTING DATA ON SCHOOLS

I looked at Ofsted reports and Department for Education data (https://get-information-schools.service.gov.uk/) to write the description of the SPCs' school and context in section 3.3.1. Understanding the SPCs' context helped me to interpret some of the examples and answers they gave in interview.

3.5.4 FIELD NOTES

I was able to keep field notes of interactions with the interventions over the year. I chaired the coaches' meetings, so I was able to track attendance. I had monthly catch up calls with the mentors, so I was able to get the perspective from the mentors about whether the SPC was in contact with them or not and kept field notes of these conversations. I also had access to the WhatsApp messaging group, so I could also record the extent to which it was used as a community intervention (aim 2b) and the amount each SPC contributed to the group. Appendix B shows this data, which was useful to determine the extent of engagement by a coach. This helped triangulate the data from the interviews around the extent to which the coaches perceived they were involved in the interventions.

3.5.5 FEEDBACK DATA FROM SESSIONS

I had access to the records from the sessions run by the SPCs in their first year. This enabled me to look at their coaching output, as recorded by attendance and feedback from their sessions, which can be seen in appendix C. In terms of coaching output indicators, teacher hours are an indicator of how active the coach has been (for example, working with 3 teachers for 2 hours is equal to 6 teacher hours) and NPS (net promoter score) is an indicator of how well regarded the session has been by the participants on a scale of -100 to 100 (Reichheld, 2003). This data was used to triangulate the data from the interviews around perceived knowledge and was used as a crude indicator as to whether a coach might have had a particular difficulty or lack of knowledge at a certain point. If an SPC had a lower than expected coaching output, it could indicate a lack of knowledge in a certain area.

3.5.6 OBSERVATIONS

Observations would have given me an idea of the knowledge of a coach, based on my observations on how they put that knowledge into practice. However I discounted doing initial observations, as I felt the process of observation at that point might bias my dataset (due to my position, I would have wanted to give feedback to the coach, which would have been an additional intervention and so might have changed the ‘normal’ development path of the coach). My role as researcher/observer vs colleague/manager would have been put into conflict. In addition, it would have put additional stress on the SPC at a point where they were just finding their feet.

I had planned to do observations with the SPCs towards the end of the year, when I would have already collected data around their initial development path. I had planned to do a Japanese Lesson Study style (Doig and Groves, 2011; Seleznyov, 2019) where we would have jointly planned a session, which the SPC would have led, while I observed. This would have generated data about the development of the SPC at this point, as well effectiveness of the Japanese lesson study as a development tool. Unfortunately, schools closed in March due to the Corona virus outbreak, and I was unable to complete this stage of the investigation

3.6 Collaboration and associated ethical issues

Collaboration with participants was integral to this investigation. Each interview was not just an information seeking exercise but was also a discussion about how the SPCs were doing and next steps. I tried to limit my input into the conversations, but occasionally had to react to the subject matter, (e.g., to reassure the SPC that their approach was ok, or to provide a suggestion to an issue) due to my dual role as researcher and manager. I recognise that my conception of the interview process is that of the everyday encounter, as oppose to the information transfer or transactional concept as defined by Cohen, Manion and Morrison (2007). As such, I take on board the weaknesses of that approach; that there will be differing relationships with each interviewee, there will be misunderstandings and I may not have access to all the information (due to some being withheld). However, the view of Kvale (1996) of knowledge being generated between humans, often through conversation resonates with me, and I believe that free conversation helps information generation. Coaches commented during the interviews that they had gained from having the space in the interviews in which to reflect.

My position as researcher in this investigation is of an insider, which has a number of advantages namely; I have existing relationships with the SPCs, so I understand the context and the issues for SPCs well and have access to investigate them further. However, there are challenges. I know how busy SPCs are as both teachers and coaches, which limits the demands I feel I can place. At the start I outlined to the participants the potential time involved. During the interview process, I was careful to not let any interviews go over an hour, as I felt that this would be breaking our initial agreement. I was always aware of the time pressures on teachers, and so took care that anything I asked them to do (reflective diaries, interviews) were effective and efficient. The teachers who were involved took part on an informed voluntary basis (BERA, 2018).

I was aware of the potential conflict of interest due to me being responsible for the performance of these coaches in my role as regional education manager for the Institute of Physics. I chose to avoid any judgement of their performance (i.e. by session observations) as felt that this would put them under a higher role of scrutiny than others, and it might interfere with other performance management processes at the IOP, including contract renewals (which happens in March). Also judgement might affect their ability to open up during interview.

Collaboration also happens within the team of coaches in the area. Part of the interventions are community based; WhatsApp groups, regional days, coaching seminars and team meetings. I organise these community activities, and develop them in a collaborative manner, listening to feedback and monitoring activity.

I have alerted my line manager at the IOP and the professional practice group at the IOP of the research project, in case they had any concerns, as the research interacts with my job at the IOP. They have not raised any concerns.

3.7 Limitations of the approach

The investigation relies heavily on the coaches' perceptions in relation to my two aims/questions, as ascertained through interviews. As said, data around coaches' engagement with the interventions (appendix B) and coaching output (appendix C) were used to triangulate the data, to check that they supported the picture of development built up by the interviews. However, no observations were made of the SPCs working with teachers (due to the March 2020 epidemic closing schools), so no first-hand observations could be made.

This study is a small sample of the coaches working for the IOP. While some patterns and themes may emerge, each coach is an individual and extrapolation to all coaches should be avoided– not every SPC will be affected by these issues in the same way, and there will be SPCs for which different issues are more important.

3.8 Data analysis

I chose to look for themes in my data, as I wanted to see what patterns in the data emerged across the SPCs, in terms of what knowledge bases the SPCs perceived were of importance, and how they developed that knowledge. Thematic analysis is a suitable qualitative approach to penetrate a situation not susceptible to numerical analysis, due to the complex dynamics involved (Cohen, Manion and Morrison, 2007).

I transcribed all interviews. I then took all the answers from the interview questions and the reflective diaries and using the constant comparative method (Thomas, 2017), I coded passages depending on what knowledge the SPC was talking about, related to aim 1. The passages were of variable lengths and one passage could contain multiple sentences if they were all on the same code. I then reread the data, checking it against the list of codes I had produced. Once I had refined my codes, it was evident that I had a list of codes pertaining to the knowledge that the coaches had perceived were important and/or that they had developed. Some codes had been discussed in direct response to a question (e.g. I had asked about their knowledge of resources) and others had emerged out of discussion following a question (e.g. differentiating for a variety of teachers). My next step was to then recognise the associations between the codes – some codes were of a similar nature and could be grouped together and considered as one category (e.g., I put session focus and session pitch/pace together). This produced nine categories. The connections between these categories were then considered and this inductive process generated four broad themes or knowledge bases (e.g. knowledge for teaching), under which the categories sat (e.g. PCK)

I was aiming for an interpretive, grounded approach, where the themes emerge from the data and participants. However, I acknowledge that it was not a fully grounded approach (Glaser and Strauss, 1967) as

1. My questions (based on the framework from Goodwin and Kosnick, 2013) are likely to have biased the data.
2. Codes that chime with my experience learning to coach and the readings that I have done are likely to jump out more at me (confirmation bias).

While the list of codes was useful for starting to look at knowledge that the coach came with and what they developed, the hierarchical ordering of the codes was central for helping to establish patterns, particularly when it came to the next stage of looking for patterns in how coaches developed their knowledge. Once I had established the network of knowledge bases from the interview and diary set, I revisited the interview and diary data with my second aim in mind, how did they develop their knowledge? For each category, I looked for evidence of how SPCs typically developed that knowledge base and I describe these findings in section 4.2.

The final stage of the analysis involved analysing field notes from meetings, mentors and the chat on WhatsApp to ascertain whether a coach had engaged with the mentoring and community interventions (appendix B). Using this data, I chose to describe two examples in more detail; Barry, who was identified as having engaged well with the interventions and Colin had made minimal use of his mentor and had not been able to come to many meetings (attending 1 out of 7 opportunities). By looking at these two examples in section 4.3, and returning to the interview and diary data set, I was able to highlight how mentoring and community had helped those that had engaged and if they hadn't engaged, why that might be. The coaching output data (appendix

C) was used as a crude indicator to highlight if the coach might have had particular issues, for example, if the metrics were much lower or higher than the other coaches.

4 Findings and discussion

In section 4.1, I suggest a knowledge framework based on the categories emerging from the data from this investigation following four SPCs over their first year in role from September until March (when the coronavirus epidemic halted work in schools), to answer aim 1; What knowledge the SPC comes to the role with and what knowledge they have to develop during the course of the first year in the role. In section 4.2, I then use this framework and revisit the interview and diary data to try to ascertain aim 2a; how they develop that knowledge. In section 4.3, I then tackle aim 2b; to what extent mentoring and community interventions supported them; looking at an example of an SPC that engaged with the interventions and an example of an SPC that did not engage to the same extent.

4.1 What knowledge do SPCs have and what knowledge do they develop?

From coding the interviews and reflective diaries, a number of categories emerged, that could be grouped under four core themes or knowledge bases that the coaches perceived they needed; knowledge for teaching, knowledge of coaching pedagogy (as in methods used to support the learning of teachers), knowledge of teacher learners and social knowledge (in terms of engagement). Each of the knowledge bases is comprised of categories as shown in the network analysis in figure 1. In the following section, we will explore these themes and comprising categories in the context of the interview data and compare how they relate to other writing in the field.

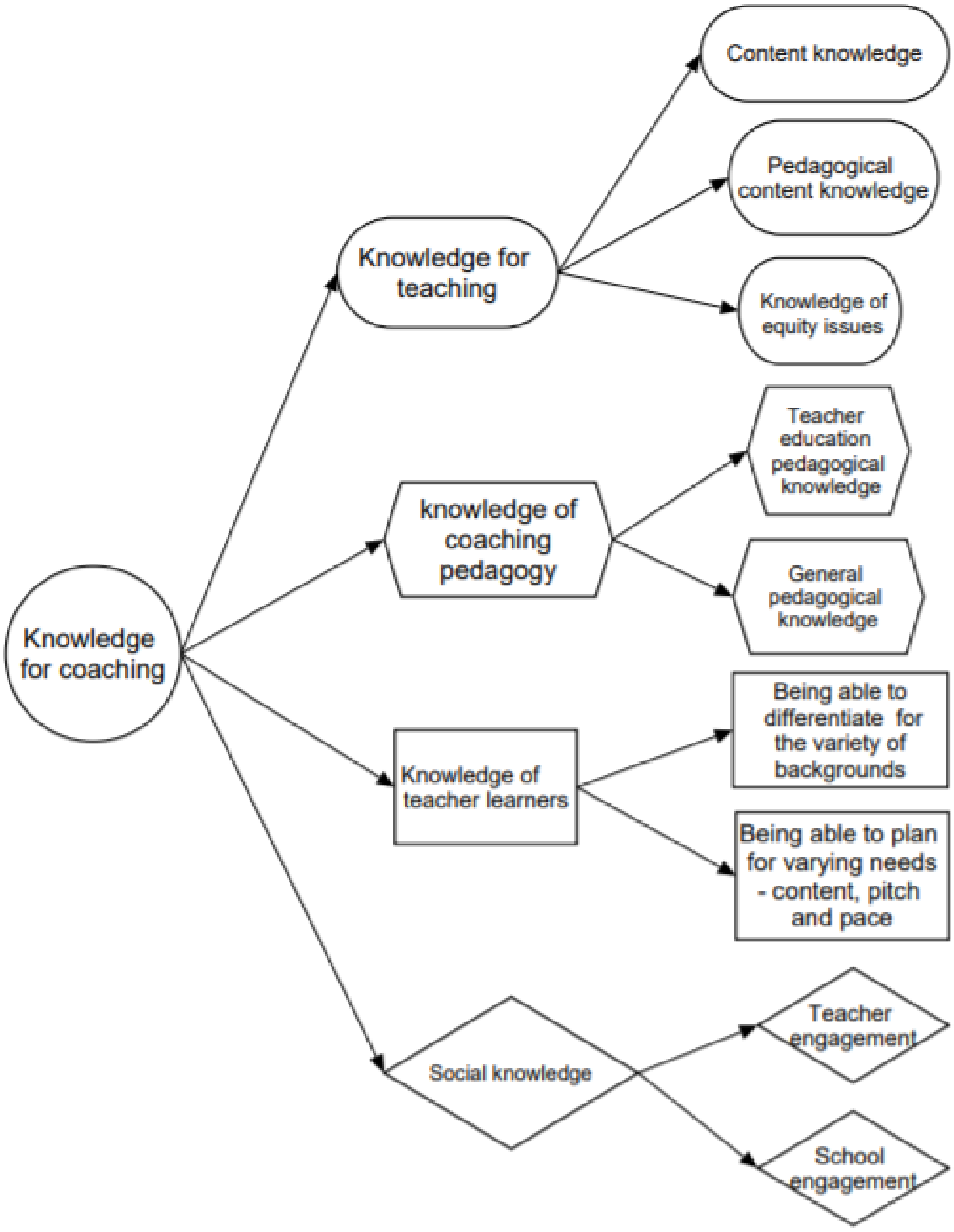

Knowledge for coaching
Knowledge for teaching
Content knowledge
Pedagogical content knowledge
Knowledge of equity issues
knowledge of coaching pedagogy
Teacher education pedagogical knowledge
General pedagogical knowledge
Knowledge of teacher learners
Being able to differentiate for the variety of backgrounds
Being able to plan for varying needds - content, pitch and pace
Social knowledge
Teacher engagement
School engagement

Fig 1: A framework for coaching knowledge

4.1.1 KNOWLEDGE FOR TEACHING

This analysis found that the SPCs perceived that knowledge of how to teach physics was central for the role, similar to the analyses of knowledge for teacher education by Field (2012), Selmer et al., (2016) and Goodwin and Kosnick (2013). The knowledge for teaching theme comprises three categories: Content Knowledge (CK), Pedagogical content knowledge (PCK) and equity. We will explore these in more detail below.

4.1.1.1 Content knowledge

Although all SPCs had a degree in physics, engineering, or a related subject there was some nervousness around the level of content knowledge needed. There were some concerns around being 'exposed' and not being able to answer questions posed by the teachers (Russell and Loughran, 2007; Berry and Loughran, 2002). While the SPCs had been teaching for a number of years, they acknowledged that the questions from teachers were likely to be more demanding, as the teachers wanted to get to the point where they could answer the questions that children would ask. The coaches had to think about how to explain something to someone, who then had to explain it to someone else.

> *It's more intimidating. They are engaging with it much more so that their questions are much more challenging. And the explanations you need to give them are much more in depth. They're not as willing often to say "Oh, I don't get that so I'll just pretend I did" and they ask questions which students don't ask. (Adam)*

Coaches seemed to develop their understanding of the division between the knowledge of what was on the curriculum (the 'core' knowledge or what the teachers they were educating wanted to focus on) and the more broader knowledge that they had access to, of the interesting snippets of physics that went beyond the curriculum, but served to illuminate it. The coaches were typically deeply fascinated by physics, and enjoyed the opportunity to go off and explore additional physics during their personal practice, for example, in his initial interview, Colin described his love of ‘going down rabbit-holes’. However, while working with teachers, they realised that they had to focus in on the core knowledge and what the teachers needed to know for teaching:

> *They’re not that interested in going beyond the specification, they just want to teach what the kids need to know to get through it, - it made me more aware of what that is. . . . I think if I put the shoe on the other foot, that then, if I was teaching Biology to year 11, and I didn't know something, I think I'd probably want to focus on just what's coming up in the specification. (Derek)*

4.1.1.2 Pedagogical content knowledge

Coaches perceived this area of knowledge to be their strongest initially, however they also felt that this was an area of continuing growth during their first year. They discussed how talking about PCK with colleagues helped them reflect on what they did as well as providing new ideas.

> *It's . . increased the number of demonstrations and practicals and resources that I can use with teachers, . . . things. I've seen tried by other people that I haven't tried myself. You get stuck, you use certain resources and certain things over and over again, and you're happy with them. You don't try other things out. This has made me try [other things] out a lot more. (Adam)*

In agreement with Shulman (1987), knowledge around resources was acknowledged as being important. Coaches were happy to acknowledge that while they may not know about all resources available, it was important to know some good reliable sources for resources, for example one SPC mentioned www.iop.spark.org and Best Evidence Science Teaching (accessible at https://www.stem.org.uk/best-evidence-science-teaching). They discussed how non-specialists might find it difficult to assess the quality of a resource, so it was important that they were able to recommend good sources for resources:

> *Knowing where good resources are and helping non specialists find them [is important]. They might not be able to recognise them. If it was biology, and someone said find a resource, from a quick glance, I would not know what is good and what’s bad. And everyone’s pushed for time. (Derek)*

4.1.1.3 Knowledge of equity issues

In initial interviews, while most of the coaches acknowledged that being able to support students from minority backgrounds in physics was important, they also acknowledged that this was an area that they felt less confident in, they perceived that they knew less about and that they spend less time developing, as they have a lot of other competing demands on their time.

> *The science capital thing interests me, I should be doing more, I need to do more, put more into my lessons, but with everything else going on, it's taken a back seat. (Derek)*

However, over the year, the coaches engaged more with the research in this area as it was a recurring theme in meetups with 'science capital' (a concept around supporting students who don't see science for them) being a central topic at two meetings and the IOP research on girls in physics being a topic at another. In the interviews, most coaches expressed their intent to use it more in both their personal and coaching practice, and highlighted it as an area they would like to develop more in.

4.1.2 KNOWLEDGE OF COACHING PEDAGOGY

The knowledge of how to teach other how to teach (your subject) (Field, 2012) emerged as a knowledge base through this analysis, as coaches reflected on sessions that they had run, and how they could improve. Initially the coaches perceived that they knew very little about it and felt a degree of 'imposter syndrome'. They had seen it done badly and did not want to replicate that.

> *I've been in situations where I've had more experience than the person talking. They talk as if they are right. It very quickly rubs people up the wrong way. (Derek)*

This theme is divided into two categories– pedagogical knowledge specific to teacher education, and existing pedagogical knowledge that the SPCs brought across from their teaching role.

4.1.2.1 Pedagogical knowledge specific to teacher education

While the coaches were aware that teachers would be bringing their own ideas and suggestions to suggestions and were happy to include them, concerns of being 'sage on stage' and misconceptions around transferring their teacher knowledge to the teacher learners still pervaded initially (similar to accounts from other teacher educators for example; Murray and Male, 2005; Zeichner, 2005; Dinkelman et al., 2006). A lack of knowledge around the role of teacher educator contributed to some 'imposter' feelings, as they did not feel the 'expert' that they perceived this role required, or that they had any right to be telling teachers how to teach. As the year progressed, their knowledge of their role became more nuanced, as they embraced the idea of professional sharing, and 'guiding from the side'. They learnt how to introduce ideas for discussion rather than holding forth as the expert:

> *And I was thinking well, You know, I mean, who am I to stand in front of a bunch of colleagues and say hey, This is, this is kind of how you teach, except that's not what we do. . . SPN is much more of a collaborative process. So, yeah, that fear of the of the whole pedestal thing, you know, of having to deliver a session, right? You know, you are setting the agenda and directing people in certain ways. But I think the really nice thing the way in which one can arrive at a kind of constant dialog throughout our session is the key thing. That makes this so much more pleasant than any other. . . .standing at the front and delivering to people. (Barry)*

They discovered some pedagogical strategies discussed in section 2.2.6 through experience. Both Derek and Adam discussed the use of exemplification and explicitly explain pedagogical decisions as an important teaching strategy, which is also picked up by the literature on teacher education pedagogy (Davey, 2013; Korthagen and Kessels, 1999; Loughran, 1995).

> *Modelling that in a session for other teachers, and being able to say I did this in a particular way and this is why I did it this way and this is why you should do it that way, that's something beyond just physics, it's about a way of delivering things. (Adam)*

4.1.2.2 Existing pedagogical knowledge brought from teaching

The coaches initially perceived the knowledge they needed for coaching as being different from their teaching role. However, with experience they started to see how the two roles overlapped. There were elements that the SPCs identified as being different, i.e. a higher level of explanations was needed for the learner to be able to then explain it to someone else (see section 4.1.1.1). However, when they were able to see the similarities, they reported being able to apply their existing expertise rapidly, similar to how Berliner (2001, 2004) describes in his work on expert teachers and fluid expertise.

> *As a teacher, I know exactly what I'm doing . . I know what the students will say . . .I know what the misconceptions are. I said it's going to be quite different with teachers, but what I've realized is it isn't that different with teachers, I can use those same skills that I've got from teaching students with teachers and it works. (Adam)*

Initially, SPCs sometimes (wrongly) assumed that teacher learners would be more motivated and more able to learn independently, compared to the students that they work with. These are similar to the assumptions made by Knowles (1987) in his adult learning theories which were criticised for having an idealised view of the teacher learner (Merriam, 2001). SPCs improved this knowledge with experience. Initial experiences showed them that teacher learners might need a similar level of structure, as demonstrated by a recap from Derek on his initial attempts at encouraging discussion:

> *I thought I'd planned a good session, ... but then it was really hard work getting them to discuss . . . . I was expecting them to be able to discuss things better than students, but they were a lot worse, considerably worse. . . . If I was to do something like that again, I would pre-empt those bits, which I hadn't necessarily thought about, ... I think maybe providing them with an example (Derek)*

4.1.3 KNOWLEDGE OF TEACHER LEARNERS

SPCs perceived that they developed in their knowledge of teacher learners over the year. I have broken this into two categories: knowledge of the variety of backgrounds and how to respond to this variety within the same session, and knowledge of the needs of teacher learners and how to plan effective sessions to meet those needs.

4.1.3.1 Differentiating for the variety of backgrounds

One of the most difficult things that several of the coaches found was how to work with the physics specialists from the department in the room. They worried about both making sure that the specialists gained something from the session and also about the potential 'challenge' by the specialist – that the specialist might ask a question that could expose a lack of knowledge in the SPC. In section 4.1.1.1, we discussed the anxiety caused by questions from (typically non-specialist) teachers, seeking thorough explanations. Questions from specialists tended to be even more challenging, as the specialist might be asking the SPC to justify one approach over another.

> *it's the confidence of delivering that spectrum of specialists and non specialists, and the confidence of delivering to specialists and feel like I'm adding something for them. they do ask me questions, and I think oh yeah, I've never really thought about that before. (Adam)*

However, by the end of the year, they were realising that they could use specialists, technicians and more experienced staff, to feed into the discussions. By acknowledging and valuing the experience of the teachers they perceived that they were more likely to get the teachers onside, more likely to have constructive conversations and more likely to be able to set up a 'resource person' for the department, who could continue to discuss physics practice when support from the IOP stopped:

> *. . . . . if, very early on, you acknowledge the fact that, hey, we're all in different places, and then actually really rely on those people who are your experts, as it were to, to keep that dialog happening. And then, hopefully, you get all, your really anxious non-specialists getting involved in the dialog, as well, and it's not just a couple of physicists talking to each other, but it's everyone talking about teaching and learning.(Barry)*

Adam, as well as working with teachers, also worked a lot with technicians, as he recognised that they could be a 'resource' person, a source of ongoing physics information (as mentioned in research by McNicholl, Childs and Burn, 2013):

> *One of the things I have tried to do is meet with technicians and skill them up. They can then promote it to teachers. Technicians can suggest practicals and teachers know that they can be set up. I thought that quite important to do. . you tend to find technicians often last at schools longer than some teachers. (Adam)*

4.1.3.2 Planning for needs; content, pitch and pace

Knowledge of teachers and their needs was identified as being important when it came to planning and running effective sessions, by both SPCs and the literature (Cordingley et al., 2015). Understanding teacher needs helped coaches select appropriate content, and adapt the pitch of the session and the pace.

In terms of content, coaches reported that working with teachers helped them develop an understanding of which areas teachers struggle with, and therefore what to focus on their sessions. For example; they identified student misconceptions for the topic (which teachers can often share), associated practical work, and domain specific pedagogy (e.g. use of models, or application of Maths skills) (Veal and Makinster, 1999) as areas to focus on:

> *The reason I started stressing the importance of models is realizing that some non-specialist teachers were getting hung up on them . . . so I'm starting to see the sticking points that non-specialists have coming into the subject. (Colin)*

Knowledge of practical work was a recurring topic in interviews. The SPCs knew from their experience of teaching physics that it was important to get equipment out and do practical work as the subject was otherwise sometimes intangible. They identified that the teachers needed to know how to use the equipment they have, feel confident enough to get the equipment out and know how to relate that equipment back to the theory.

> *In electromagnetism, the diagrams are very abstract. The circuit is floating in mid-air, with the cells in mid-air, with the piece of cardboard which doesn't look like cardboard. You know what you're looking at as a physicist, but as a non-physicist you'll never know what it is, and then we're expecting students to. So saying to teachers, the reason you need to demo this and not show them a video, is because they need something concrete to be seen. (Adam)*

In terms of pitch, initially some SPCs struggled, as they lacked knowledge and understanding of the teachers' needs. For example, in interviews Barry discussed his surprise at the level at which some teachers were starting from. However he learnt from experience and talked at length about how his knowledge about teacher learners had developed over the year and how he felt more able to listen to the participants and adapt the session to their starting points:

> *it's interesting how the audience start in so many different places. I think that vital thing, when you first meet a new school for the first time, it's really, it's having your antenna out and really listening and working out where are they at? And actually not assuming. . . . .* So, that's to say, that actually, you can't make assumptions, and it's interesting that how, during the course of the session, time, and again, . . .you start out thinking: Hey, we're going to begin here, and you know, we might get up to that, but actually they were beginning here and we can get up to that.*(Barry)*

In terms of pace, SPCs discussed the difficulty of knowing how much to fit in one session. Sessions are typically booked in for between 45 minutes and 1 hour and SPCs are asked to cover a whole topic. They have to make decisions about what to focus on. Derek below discusses how initially he tried to fit too much in, but, learnt from experience:

> *I overestimated how much I could get done in that 40 minutes, by the time everyone had turned up, the time just went, if I was to do it again, I would be more aware of what I can get done in that time. (Derek)*

4.1.4 SOCIAL KNOWLEDGE

All SPCs need to sign schools up to receive the training they are offering, negotiate dates for sessions with the head of the department and capture and maintain the attention of teacher when they are there, all of which were highlighted as stress points within the interview. I have identified this knowledge base as social knowledge, chiming with literature mentioned in section 2.2.3, which identifies social knowledge as a knowledge base. This links with section 2.3.3, which discusses the difficulties that early career teacher educators can have in managing relationships. In my context, this theme is split into two categories around engaging schools and engaging teachers.

4.1.4.1 School engagement

Coaches talked about the difficulty of signing up schools to the programme and of getting into schools, often due to the lack of response of their contact person within the department. Ascertaining who to contact and what to say was part of their developing social knowledge:

> *I meant to go before Christmas, but they didn't respond. Apparently, they had email issues. I was emailing the head, but prob not as good as emailing the second in science, she seems a bit more on the ball. (Derek)*

4.1.4.2 Teacher engagement

Most SPCs discussed the difficulty of attracting and maintaining the attention of the teachers during sessions. Teachers might arrive late to the session, might leave early or might be checking their email during the session, as they juggled the different demands on their time.

> *At the start of the, I didn't really know what to expect. I appreciate now, that those in front of me might not necessarily want to be in front of me. (Derek)*

The SPCs tried different engagement techniques. For example, Barry used his knowledge of the daily life of a teacher to develop an empathetical relationship. He knew that the teachers would need some time to relax after the day, before they would be able to learn:

> *. . . . , you have to remember that, they've just come out of the classroom 10 minutes before, . . And now they've got to go to that meeting, too, because that blokes coming from the IOP again . . . . . that first bit of the meeting is very much about cake and biscuits and coffee. . . . . .They'll often be someone who comes in and goes, Ah, you know, period 4, I can't believe. . . . . they need to decompress, and they need to talk about stuff. . . .. No matter how much you think, we've only got an hour. . . . . I think you have to give them 5 to 10 minutes of decompression getting into the into the zone otherwise. They're just going to be a bit like, Oh, God, when is this going to end? (Barry)*

Most SPCs discussed using engaging 'hooks' or 'can-openers' to attract attention and build relationships - cheap and cheerful fun demos, using a variety of everyday items like balloons, sweets and children's toys, that showed physics phenomena and provoked discussion. Derek discusses below how he saw this in practice while observing another coach running a session:

> *Like teaching children, is there a hook that would interest them? . . . Ally, he showed some really good examples like the ball bearings hitting them together and burning a hole in the paper. I hadn't seen that before. Once the teacher saw that, that was them hooked for the rest of the session. . . .. Something like that would definitely. get their interests. So a thing having something almost gimmicky just to get them on board would be good. . . .. The hooks are probably more necessary when there's a whole department of people who might not want to be there on a Friday afternoon, and if it's a 1 to 1 meeting with someone who's requesting this probably don't need those*

hooks. You probably don't need the gimmicks because they would be more engaged because they've asked for it. (Derek)

4.2 How do the SPCs develop their knowledge?

Having established a theoretical framework which sets out the knowledge base for a coach, in this section, I revisit my data set with my framework in mind to look at how the coaches develop these knowledge bases (aim 2a)

4.2.1 KNOWLEDGE FOR TEACHING

4.2.1.1 Content knowledge

Above, in section 4.1.1.1, we discussed how coaches were initially concerned that their content knowledge would be challenged by the more difficult questions by teachers. They improved their content knowledge by reflecting on experience; listening to the questions by teachers, attempting explanations, and reflecting on how that question could be better answered next time, with each question improving their case knowledge. In a diary entry from Dec, Adam explains his next step after reflecting on a session

> *There were a few questions where my nerves got the better of me and I stumbled over the explanations. I need to think through, plan for these questions, particularly from physics specialists. (Adam)*

Their awareness of curriculum knowledge improved as they worked with and received feedback from teachers about what they wanted to focus on (which often tended to be curriculum specific). Barry below reflects on a session, where he tried to introduce some extracurricular information:

> *First session at [this school], I spent the first two minute stalking about [the scientist that the school was named after]. Someone put on the evaluation form don't know why he bothered with all that history (Barry)*

4.2.1.2 Pedagogical content knowledge

Barry and Adam both came to the role with over 20 years of teaching, but still perceived that they learnt a great deal in collaborative conversation with colleagues, as it encouraged them to revisit how they taught and the models, explanations and demos that they used.

> *I'd have said that's my strong suite, but at the same time, how little you know. . . . . . this is a great opportunity to really examine everything from the start again. . . . the more that you have these discussions, these conversations, these dialogues with colleagues . . . with everyone on the WhatsApp group, everyone I bump into, and even colleagues at school . . it's nice to be forced to keep rethinking this sort of thing (Barry)*

The WhatsApp group helped conversations continue outside of meetings, and even if a coach wasn't actively involved, they gained from having sight of the conversations that were happening.

> *" for the WhatsApp group, I'm a bit of a lurker in the background reading through the message and getting all the ideas and tips of what to do and how to, and it's not. I don't think it's necessarily about using all of it, all the time, it's just about the building of the arsenal, and building the toolkit, isn't it? (Derek)*

Mentors were a great source of information, particularly when it came to planning specific sessions.

> *I said, look, I'm delivering this session on waves. I have never done that before, what do you think are the key things, I could do, In one hour, we sat down, and we went through particular demonstrations in particular, things that I could do, so, [my mentor] was able to support me, in, in that. (Adam)*

In addition, mentors could be invited to sit in on a session or co-lead a session with the mentee. Barry gives an example below of how feedback from his mentor helped him reflect and improve on his explanations:

> *he was able to sort of just highlight a couple of ways in which, you know, you might explain something slightly differently. . . . there was one example, where I'd done an explanation and he just tweaked the language while we were doing it very slightly. And I thought that was nice, just a general sort of sense of the greater team, as it were. (Barry)*

4.2.1.3 Knowledge of equity issues

Development of knowledge of equity issues required input from an expert (Stoll et al., 2006; Cordingley et al., 2015, Darling-Hammond et al., 2017; Timperley, 2008), as well as community discussion. This expert input often came from either an expert leading the conversation at meetings or further reading. The messages were reinforced through repetition – if coaches were introduced to an idea which then recurred in further discussions later on, they reported of it becoming more prominent in their thinking.

> *I first came across [Science Capital] at the Ogden Trust Conference last June where Louise Archer, she delivered a big presentation on it and I went away. But then it also was reinforced very strongly by the the IOP thing in June or July whenever it was and suddenly you get two presentations in the course of one. month it's actually got through my thick skull, suddenly. I was going, Yeah, this actually is really important (Barry)*

4.2.2 KNOWLEDGE OF COACHING PEDAGOGY

In the literature teacher education pedagogy is identified as an important knowledge base, which is which teacher educators are left to develop (Field, 2012; Goodwin et al., 2014). This resonates with the SPC context, where much of this knowledge was developed through experience, as discussed below.

Initially SPCs were concerned that they had to be the ‘expert’, but they developed their understanding of the role through experience. Through running sessions and reflecting on what made a session work well, they gained knowledge in guiding learning and suggesting pedagogical approaches for discussion, as oppose to passing on knowledge. This is similar to the findings by Goodwin et al. (2014).

> *At the start of the year, I didn't really know what was expected of me, and I think I was thinking that I needed to be font of all knowledge. Where as, I think I realized over the year that it's not necessarily about . .know[ing] things, because it's more important thing to . . . suggest methods of getting . . knowledge across. (Derek)*

Some pedagogical approaches were developed ‘on the job’ (Goodwin et al., 2014). Both Derek and Adam discussed in interview about modelling and explaining aloud to the teacher learners so they could understand what the SPC is doing. This particular process also made them reflect and think on what they could improve (Dinkelman, 2003; Loughran,1995).

> *If I’m helping adults to improve their teaching, then I need to vocalize why I'm doing it that way. It has made me reflect on why I'm teaching it that way And also . . .Is it worth doing it that way? How can I do better? (Derek)*

Through reflecting on their experiences and comparing their experiences of coaching to their experiences of teaching, the SPCs were able to see where their pedagogical knowledge from teaching usefully transferred over to their coaching role. Derek reflects on a session below, where he had perhaps assumed that the teachers would be more independent (Merriam, 2001) but on reflection was able to apply his existing knowledge (Berliner, 2001, 2004).

> *“I think maybe providing them with an example, . . . Maybe provide more structure and more prompts for a discussion, like I would do in a lesson, rather than having it too open, I would try and focus it a lot more. . . . but I'd certainly have some examples in my back pocket. (Derek)*

4.2.3 KNOWLEDGE OF TEACHER LEARNERS

As can be seen in section 4.1.3 most coaches seem to develop their knowledge of teacher learners through working with them. Like Zeichner (2005) and Dinkelman et al. (2006), reflections on interactions with those that they are teaching give a greater understanding of their context and learners.

All SPCs talked about the value of small group sessions in developing their knowledge of their learner teachers. Some SPCs were able to plan additional smaller sessions with specific groups (e.g. NQTs or technicians) and found that engagement in these sessions were better, and that they were able to find out and address needs more easily. Alternatively, by setting group work within a session allowed the SPC to circulate and talk to those having difficulty.

> *I've found a very useful thing, has been to have a lot of the session where they're breaking out and trying stuff for themselves. And then, you can circulate around. . . , you can go work with those people who are obviously saying, Hang around, I'm not sure about this. . . (Barry)*

Both Barry and Derek talked about a moment when they realised they needed to change their approach, to ensure that they were really catering to their teachers' needs. They were both taking along equipment from their schools, as they could be confident that it worked, and they knew how to operate that version and they were keen to explain the theory using the equipment. However, they realized in practice that it was much more useful to spend the time learning how to use the equipment that was actually available at that school, and then making sure that the teachers knew how to use their own school's equipment. As Derek said:

> *I took a fair bit of stuff from school, but I realised . . . . if they don't have access to it, I don't know how much use it is, ... so it must have been in December some time, I went back to that school to work with the head of science and another teacher there, again doing magnetism and electromagnetism, but I didn't take anything, and I thought that was a lot more useful because then we could go into the prep room, and see what they've got and work with that so I did pretty much the same session, but with their stuff, which was a lot more useful . . . I could have probably been told that, but I think, by doing it myself and finding out that way, probably more useful. (Derek)*

Both Adam and Derek discussed how their knowledge of teacher learners improved from watching other coaches run sessions, in terms of how teachers behave, what the coach decided to focus on and how the teachers responded.

> *going in and watching the lessons that [coach x] delivered, [coach y] delivered, to see what I could do. And pretty much every single time they started, with the right-lines/wrong-tracks misconceptions idea. So, I thought it'd be really good to start that way, because knowing that, as much as students have these misconceptions, teachers can have them, and then reinforce them with students. (Adam)*

4.2.4 SOCIAL KNOWLEDGE

SPCs were initially surprised that teachers might not want to engage, and sometimes talked to their mentor about this issue. As seen in the section 4.1.4, they tended to use their knowledge from teaching around forming relationships and providing interesting hooks.

Knowledge around school engagement was often discussed with the mentor; what schools they should approach, what needed discussing at the initial meeting, how to establish a good relationship and plan and so on. Adam below talks about how he learnt more about school engagement and the first meeting with a school by going along to one that his mentor was leading:

> *I went to one session where she was doing the school partnership agreement. . . , that was useful to be in a meeting for the first time, I learned to do that then. (Adam)*

4.2.5 SUMMARY OF DEVELOPMENT

It could be claimed that the majority of knowledge development happened through the coach experience and reflecting. However, mentoring seemed to be useful to support the coach in dealing with specific problems. Observing other sessions helped SPCs understand teacher learners. Rapid fire PCK exchange of knowledge happened through community interaction at meetings and through WhatsApp. The next section will look more specifically at mentoring and community intervention.

4.3 To what extent can mentoring and community support development

In section 4.1 I proposed a framework of coaching knowledge and in section 4.2 I discussed in general terms how coaches developed their knowledge in these areas. In this section, we will be looking at aim 2b; to what extent do mentoring and community support development and looking at two examples; Barry and Colin.

To assess the extent to which the interventions help, I firstly analysed the data from my field notes with regards to the extent that the coaches engaged with the intervention. As can be seen from the table in appendix B, Colin had minimal engagement with the intervention, whereas Adam, Barry and Derek all had good engagement. To highlight the impact of mentoring and community, I consider two examples; Barry, who did engage and Colin, who did not engage to the same extent.

4.3.1 HOW DID MENTORING AND COMMUNITY SUPPORT BARRY?

Barry is an example of a coach throughout the year engaged well in the programme, reported enjoying the exchange of PCK ideas within the team, was able to get into schools, and through activity in schools, could reflect, learn and develop in a variety of ways. In this section I look at how mentoring and community interventions helped him.

Barry had a strong relationship with his mentor. As well as regularly catching up with his mentor, Barry also reported that his mentor came along to a session and provided useful feedback.

> *he came along to [a session], and we sat in the car afterwards and chatted for good, oh, probably an hour and a half, about all sorts of things. It's really great to have that sort of instant feedback on all the things that you've just done . . . A lot of it is reassurance and positive stuff . . . But also, he was able to sort of just highlight a couple of ways in which, you know, you might explain something slightly differently (Barry)*

Barry picked up ideas for solving specific problems after discussing them with his mentor, for example the lack of equipment in some schools.

> *Many schools haven't got fancy ripple tanks and haven't got all of this stuff. . . . getting around that has been really interesting. [mentor]'s little mini ripple tank with the lego bricks is the greatest. I don't know whether [mentor] came up with it, but certainly I first saw it from him (Barry)*

In terms of the community interventions, Barry reported that meetings gave him a sense of the 'bigger picture' and a feeling of 'camaraderie'. This sense of community might help with some of the isolation issues reported in the literature (Williams and Ritter, 2010) and reflects other research about social networks in communities of practice (Kwan and Lopez-Real, 2010).

> *a real sort of camaraderie has begun and the first time when I got to chat with lots of people back June time when you invited me to a thing back at HQ, that was marvellous, to see people from all over the country and you know to really just get that sense of yeah, we're all in the same boat together. And actually we've all got the same kind of challenges, but at the same time, it's all very doable, you know . . . it's nice to see that big picture (Barry)*

Meetings allowed the input of 'expert' ideas, as well as providing a feeling of community. These expert ideas were typically ideas from research that had been distilled and contextualised to help integration of theory (Korthagen and Kessels,1999; Burn and Mutton, 2015; McIntyre, 1993). This was appreciated by Barry.

> *People like me, we need it boiled down, so we need experts like you as the intermediary, so, yeah, that kind of stuff is good. (Barry)*

Regional physics days allowed continuation of this networking as well as the opportunity to observe other coaches running sessions.

> *the more informal stuff like speed [REGIONAL TEACHER DAY], you know, that was great, to be honest, I did far more networking there, then I did in terms of helping out. But nevertheless, it was great to talk to people in the local area. (Barry)*

The messaging group in particular was reported to be a very easy and effective way for coaches to access help and easily share PCK ideas that they have just seen or discuss educational matters more generally (i.e. how their schools were responding to COVID), which resonates with research by Margolin (2011) on use of technology in communities.

> The WhatApp is brilliant, don't you think? I mean, I think the fact that it's an informal mix of great questions, and certainly that would be my first point, if I had some query about something, I'd instantly go there. Be it a query about some physics point or just a general administrative question or anything like that, so that's great. (Barry*)*

In summary, Barry came to the role with many years of teaching experience. As can be seen in section (4.1.2.1) he initially felt like an imposter when it came to supporting other teachers. Community interventions like meetings helped him feel supported and connected to other coaches. He was able to draw on support through the community network and through his mentoring relationship when he felt he needed it. In particular, he perceived his knowledge for teaching developed through mentoring and community interventions, as he revisited his existing knowledge base with new ideas.

4.3.2 COLIN – WHAT CAN WE LEARN?

In Colin's initial interview, Colin expressed confidence in his knowledge for physics teaching and also discussed his coaching experience in his prior career. He looked in a good position to make a strong start as a coach. However, shortly afterwards, communication channels broke down. According to my field notes, he struggled to reply to emails to his mentor or engage with the coaching programme outside the WhatsApp group, between November and the following April. He struggled in engaging schools with only one school recruited and delivered 12 teacher hours delivered over the year, which is low compared to other SPCs (see appendix C).

The next time contact was re-established in April. The focus was on what we could do to help increase Colin's activity with schools, as the low activity was bringing Colin's continuing involvement with the coaching programme into question. A concerted effort was made by the mentor to get in touch with Colin by phone, to establish an action plan and by the end of the summer term, things were in place to support more coaching activity by Colin in the following academic year.

A summer term interview helped establish some of the issues that resulted in a low engagement with the coaching programme. Firstly, in terms of the coaching input, Colin initially was unaware that engaging schools was his responsibility. He thought that engagement of further schools for him was something that was 'going on in the background'. He lacked knowledge around school engagement. This is something that could have been resolved if we had made mentor meeting more compulsory.

Secondly, in terms of engagement with the coaching programme, he simply felt that he didn't need the support.

> *If I need help, I'll come and ask for help, but I've not found anything that really strikes me to that extent. There's a couple of things that I've thought I've got to think about that, but I thought about it, read a bit, and thought ok, I can do it. I've come in with a lot of transferable experience and skills. (Colin)*

Colin received excellent feedback for the sessions that did run. He reported a strong knowledge base in coaching pedagogy as he had extensive experience of coaching in his previous career and he was able to translate his previous knowledge across and apply his knowledge of different coaching models to the variety of learner before him (Berliner, 2001,2004), which contributed to him receiving excellent feedback for the sessions he ran (see appendix C).

> *For each individual there, they tend to have slightly different need, and so if the ones who are out of specialization, mostly, it's just. best practice and also highlighting where they have their own misconceptions. So self realisation with Alexia, who's actually a physics teacher herself, it's more coaching in terms of support. Also giving her space where she can talk about her approaches, allow her to explore her own ideas and bounce back, to help her develop. So it's coaching an elite, rather than coaching. (Colin)*

While Colin was perceived as not engaging with the programme, he still benefited to a certain degree by operating at the periphery of it and occasionally engaging with peer networking. This is demonstrated by the following quote, where he discusses hearing about science capital:

> *I've not used science capital at all yet. I want to do that. Because everyone keeps on mentioning it, clearly it works. That's something I'm getting, where something has been mentioned multiple times, like, Well, OK, I need to look at that. Because that must be important. (Colin)*

In summary, Colin came to the programme with a perceived high level of knowledge of teaching physics and a high level of coaching pedagogy, which resulted in some well-regarded sessions being run. However, his lack of knowledge of the process around engaging with schools meant that his coaching output was limited, and as there was limited contact with the mentor, the problem wasn't identified until later in the year. This highlights that all the knowledge bases identified in the first section are important in order to be a successful coach and that the mentor plays an important role in helping mentees avoid mistakes (McEvoy et al., 2019).

5 Conclusions and implications

During this investigation, we have followed the progress of four coaches over the year, and interviewed them about their experiences to try and answer the questions

1. What knowledge the SPC comes to the role with and what knowledge they have to develop during the course of the first year in the role.
2. a) How they develop that knowledge, and b) to what extent, mentoring and community interventions facilitate the development of that knowledge

In this section I draw together the main findings from the previous section to answer the above questions. As I look at the extent to which mentoring and community interventions help, I highlight potential changes that might improve the mentoring and community interventions as well as suggesting other potential improvements to the coaching programme. I highlight wider implications of my investigation, including some potential areas for collaboration and propose some areas for further research.

5.1 The knowledge base for coaching; what is it and how do coaches develop it?

The findings show that coaches perceive that they need a knowledge base that extends across four main themes: knowledge for teaching, knowledge of coaching pedagogy, knowledge about teacher learners and social knowledge around engagement. Fig 1 on page 39 shows how these themes can be broken down into further categories.

Knowledge for teaching can be broken down into subject knowledge, PCK and knowledge around equity issues. In terms of subject knowledge, the SPCs show some concerns about having to step up their level of explanation to suit a teacher audience. They improve this through experience, practicing their explanation and reflecting on how it could be improved. Their knowledge around curriculum becomes more defined, as during their work with teachers, they listen to the feedback about concentrating on the core curriculum.

The SPCs identify as having well developed PCK. However, their PCK continues to develop throughout the year and through working collaboratively and sharing practice with others, whether through WhatsApp or other coach meetups. One could say that they arrived with their personal PCK (Van Driel et al., 2001), but then added to it by discussing ideas with peers (Poyas and Smith, 2007). Negotiating and contributing to collective understandings and assumptions around PCK could be said to help build the community and collective PCK (Field, 2012; Fuller et al., 2005; Schneider and Plasman, 2011; Gess-Newsome, 2015).

Knowledge around equity (e.g. what to do to encourage groups not currently represented in the physics community) is typically perceived as being lower than knowledge around physics. Expert input at meetings introduced knowledge on this topic throughout the year. Coaches mentioned how repeated messaging around this topic at meetings and during conversations reminded them to engage and develop this knowledge base. However, similar to John (2002), interviews indicated an interest in this area, but little activity in terms of coaching practice.

The second theme was knowledge of coaching pedagogy. SPCs were able to apply some of their existing pedagogical knowledge to their coaching role, but they needed some experience and reflection to ascertain which aspects were useful (e.g. how to organise class discussions, guiding from the side) and so they typically started the year feeling that they knew very little in this area, in a similar way to accounts of other early career teacher educators (Murray and Male, 2005; Zeichner, 2005). Other aspects of coaching pedagogy were developed by experience, reflecting on their sessions and thinking about what needed in their sessions (e.g. modelling effective practice and articulating pedagogical decisions).

The third theme, knowledge of teacher learners, is an area that develops predominantly through experience and through interactions with the teacher learners themselves, which you can see also occurring in other accounts in this field (Zeichner, 2005; Dinkelman et al., 2006). In appendix D, you can see a diagram of how this learning might be happening based on Clarke and Hollingsworth's theory of change in appendix D. As the SPCs got a better idea of what the teacher learners needed, the planning, in terms of the pitch pace and content of the session, improved.

Initially some SPCs felt vulnerable when there were physics specialists in the session, as they felt that they may be exposed as 'imposters' (Berry and Loughran, 2002). With practice, and as their knowledge in coaching pedagogy also developed, coaches became better at getting all teachers to contribute at the relevant level.

Similar to other writings in this area (Smith,2005; Loughran, 2006; Koster and Dengerink, 2008; Goodwin and Kosnick, 2013; Davey, 2013), social knowledge was identified as the fourth theme in the knowledge base of a teacher educator in this investigation. In particular, SPCs identified the need for this knowledge base to both engage schools with the programme and engage teachers with the session. They developed in this area through talking through issues with their mentor and then trying different ideas.

The findings show that a lot of this development happens through a reflection/action cycle, possibly in a similar way to that described by Clarke and Hollingsworth. Mentoring and community also played a role in development, which we will discuss further in section 5.1.1.

5.1.1 HOW DID MENTORING AND COMMUNITY INTERVENTIONS HELP?

Adam, Barry and Derek all worked with their mentors to different extents. All found it useful to discuss issues or problems with their mentor and to exchange ideas with their mentor, whether around teacher engagement or ideas for PCK. Barry working alongside his mentor and found receiving feedback especially useful in developing his knowledge around teacher learners and PCK (Griffiths et al., 2010). Colin did not engage with his mentor, and as a result, struggled to improve his knowledge around school engagement and did not engage as many schools or run as many sessions as other SPCs. Towards the end of the year, contact between Colin and his mentor had been re-established and school recruitment had been improved. This indicates the role the mentor plays in helping the mentee avoid mistakes (McEvoy et al., 2019).

In terms of community, the networking through the messaging group, regional days and meetings enabled coaches to exchange ideas, particularly around PCK and establish relationships with each other (Poyas and Smith, 2007; Kwan and Lopez-Real, 2010). Opportunities to observe colleagues at regional days were useful to improve knowledge of teacher learners and planning sessions for their needs. Meetings were a good opportunity to introduce ‘expert’ input (Stoll, et al., 2006; Cordingley et al., 2015, Darling-Hammond et al., 2017; Timperley 2008). Knowledge introduced in these meetings was further developed through conversations about that input in the community.

5.2 Implications with regards to my practice

I have proposed a framework of knowledge bases needed for coaching, based on the perceptions of early career coaches of what they need. I have used this framework to review what coaches learn and how they learn it. I hope that this framework might prove useful when talking to new SPCs about their development and talking to mentors about what knowledge development they may be supporting in their mentees.

My literature review established that there is a literature base on coaching pedagogy. While a teacher education pedagogy has not been universally agreed, there are useful aspects for coaching written in the literature (Cordingley et al., 2015; Darling-Hammond et al., 2017 Smith , 2005; Korthagen and Kessels, 1999; McIntyre, 1993). The findings show the coaches are not currently exposed to this body of research (Zeichner, 2005). It will be worth considering how to explicitly include elements of coaching pedagogy as 'expert' input into meetings, in the same way that equity issues have been introduced. At the moment, there is a lot of knowledge that coaches have to 'discover' through experience (Goodwin et al., 2014). By providing some theory basis in which to ground that experience might support their transition and knowledge growth (Korthagen and Kessels,1999; Burn and Mutton, 2015), particulary if we encourage SPCs to critique those ideas from theory against their experience (McIntyre, 1993).

The other way of introducing new ideas and particular knowledge to the coaches is the mentoring relationship. If the mentors were introduced to some of the ideas from literature around teacher education or coaching pedagogy, they could then introduce that knowledge to their SPCs. More systematic development for the mentors who are working with the coaches could include guidance on what elements of teacher education literature might be useful (Clarke, 1997).

Engagement with the coaching programme this year has essentially been voluntary, with the idea that a coach would engage with which aspects they could. I have shied away from making it compulsory, as I am aware that coaches find it difficult to get out of school or have caring commitments after school. However, Colin is an example who opted out of it, as he didn't feel he needed it. For the following academic year, I will consider what aspects of the programme to make compulsory and having clear expectations about how one should be working with the mentor (e.g. half-termly catch-ups). This resonates with the work from Harrison and McKeon (2008), which discusses how mentoring relationships needs a clear framework to work within. This might help all get the maximum benefit from their mentor and reasons for low coaching activity to be picked up sooner.

It was clear from the findings that the coaches valued the peer to peer interaction during meetings. However, meetings were sometimes difficult to access due to geographical and time issues. As can be seen by appendix B, the messaging group was consistently used by everyone, presumably because it is easier to access. During lockdown, I have been running meetings online, which has been more accessible for everyone and increased engagement throughout the team. This is an aspect I will continue with in my practice.

The case study of Colin revealed that his minimal engagement with the interventions were tied in with his perception that he was an experienced coach and he didn't need support. This gives me pause for thought in terms of how I communicate the benefits of the mentoring relationship and community interventions to the coaches and how I can encourage an atmosphere of continual improvement in my team.

5.3 Wider implications and potential for collaboration

In section 5.2, I have suggested some changes to my personal practice and the management and development of my team. There are four other regional teams at the IOP who work in a similar manner to mine, and a group called the Professional Practice Group (PPG), who take an overview of improving coaching at the IOP. I plan to share the findings from this investigation with the other regional managers and the PPG, and should the findings chime with their experience in their team, I look forward to collaborating with them on an improved SPC induction (with clear expectations with regards to essential and non-essential engagement), ongoing mentor training, development of standards and further discussion around coaching pedagogy.

In terms of implications beyond my context, I would argue that this paper adds to the growing evidence that there is an additional coaching or teacher education pedagogy knowledge base that is required when one goes from teaching to teaching teachers, (Field, 2012; Philpott, 2014; Zeichner, 2005; Murray and Male, 2005) and that needs to be taken account of when supporting someone beginning work in teacher education. This is of particular importance as current governmental policy in England is advocating teacher taking on more leadership of professional development (Husbands, 2015; Boylan, 2016) and so we are likely to see the continued increase of practicing teachers leading CPD.

5.4 Future research

My investigation yielded a framework, which could be of use in discussing coach development. However, it was generated from data from just four participants. Further research work on its applicability to a wider subset would be useful.

My research also yielded a case of someone with low engagement with mentoring and community interventions and low coaching activity. Low coaching activity by an SPC is an issue for the IOP as it is judged on the extent of support we give to teachers. Further research across other low coaching activity cases would be useful, to build up a picture of what causes low coaching activity and what can be done to remedy it, with the aim of increasing consistency of coaching activity across SPCs.

My initial plans included the Japanese Lesson Study method, where the SPC and mentor jointly plan, the SPC is observed leading the session and both SPC and mentor jointly reflect post session. This aspect of the investigation was stopped due to the impact of the coronavirus epidemic. I still hope to trial this within the programme, when normal routines resume, as I believe it has the potential to encourage collaboration, which the coaches in this study reported they valued, and provide supportive feedback through non-judgemental observations.

6 References

Alexander, R., Rose, J., & Woodhead, C. (1992). *Curriculum Organisation and Classroom Practice in Primary Schools: A discussion paper*. London: Department of Education and Science

Allen, R., & Sims, S. (2017). Improving science teacher retention: do National STEM Learning Network professional development courses keep science teachers in the classroom? Retrieved from The Wellcome Trust website: https://wellcome.ac.uk/sites/default/files/scienceteacher-retention.pdf.

Allsop, T. (1997). Mentoring in action: 'difficult times'. In T. Allsop and A. Benson (eds.) *Mentoring for Science Teachers (pp 59-80).* Buckingham: Open University Press.

Archer, L., Dawson, E., DeWitt, J., Seakins, A., & Wong, B. (2015). "Science capital": A conceptual, methodological, and empirical argument for extending bourdieusian notions of capital beyond the arts. *Journal of Research in Science Teaching, 52*(7), 922-948.

Barnett, J., & Hodson, D. (2001). Pedagogical Context Knowledge: Toward a Fuller Understanding of What Good Science Teachers Know. *Science Teacher Education, 85,* 426–453.

British Educational Research Association [BERA]. (2018). Ethical Guidelines for Educational Research, fourth edition, London. Retrieved from https://www.bera.ac.uk/researchers-resources/publications/ethicalguidelines-for-educational-research-2018

Berry, A., & Loughran, J. (2002). Developing an understanding of learning to teach in teacher education. In J. Loughran and T. Russell (eds.) *Improving Teacher Education Through Self-Study (pp13-29).* London: RoutledgeFalmer.

Berliner, D. (2001). Learning about and learning from expert teachers. *International Journal of Educational Research,* 35, 463-482.

Berliner, D. (2004). Describing the Behavior and Documenting the Accomplishments of Expert Teachers. *Bulletin of Science, Technology & Society, 24*(3), 200-212.

Borthwick, A., Ellis, P., & Winterbottom, M. (2020). *The Trainer Toolkit.* Corwin: California

Boxer, A., Walker, R., Oates, T. Green, J. Raichura, P. Kaiser, N. Jones, G. Perks, M., Carroll, A., Passingham, A., & Counsell, C. (2018). Curriculum in Science: A symposium. Retrieved from: https://achemicalorthodoxy.wordpress.com/2018/12/02/curriculum-in-science-a-symposium/

Boylan, M. (2016). Deepening system leadership: teachers leading from below. *Educational management administration & leadership*, 1 (44), 57–72.

Bullough, R. (1997). Practicing theory and theorizing practice. In J. Loughran, & T. Russell (eds.) *Purpose, passion and pedagogy in teacher education (pp. 13–31).* London: Falmer Press.

Bullough, R. (2005). Being and becoming a mentor: school-based teacher educators and teacher educator identity. *Teaching and Teacher Education*, *21*, 143-145.

Burgess, R. (1984). Keeping a research diary. In J. Bell, T. Bush, A. Fox, J Goodey and S Goulding (eds.), *Conducting small scale investigations in education management* (pp.198-205). London: Harper and Row/The Open University.

Centre for the Use of Research and Evidence in Education [CUREE]. (2005). *National Framework for mentoring and coaching,* Cumbria, England. Retrieved from http://www.curee.co.uk/resources/publications/national-framework-mentoring-and-coaching

Childs, A., & McNicholl, J. (2007). Science teachers teaching outside of subject specialism: Challenges, strategies adopted and implications for initial teacher education. *Teacher Development, 11*(1), 1-20.

Clarke, D., & Hollingsworth, H. (2002). Elaborating a model of teacher professional growth. *Teaching and Teacher Education, 18, 947-967*

Clarke, A. (1997). Advisor as Coach. In J. Loughran & T. Russell (eds.), *Teaching about Teaching Purpose, Passion and Pedagogy in Teacher Education* (pp.164-180). London: Falmer.

Cochran, K., DeRuiter, J., & King, R. (1993). Pedagogical Content Knowing: An Integrative Model for Teacher Preparation. *Journal of Teacher Education, 44 (4)*

Cohen, L., Manion, L., & Morrison, K. (2017). *Research methods in education* (8th ed.). London: Routledge.

Cope, P., & Stephen, C. (2001). A role for practising teachers in initial teacher education. *Teaching and Teacher Education, 17*(8), 913-924.

Cordingley, P., Bell, M., Rundell, B., & Evans, D. (2003). *The impact of collaborative CPD on classroom teaching and learning. In: Research Evidence in Education Library.* Version 1.1. London: EPPI-Centre, Social Science Research Unit, Institute of Education. Retrieved from http://eppi.ioe.ac.uk/cms/Portals/0/PDF%20reviews%20and%20summaries/CPD_rv1.pdf

Cordingley, P., Higgins, S., Greany, T., Buckler, N., Coles-Jordan, D., Crisp, B., Saunders, L., & Coe, R. (2015). *Developing Great Teaching: Lessons from the international reviews into effective professional development*. London: Teacher Development Trust. Retrieved from https://tdtrust.org/wp-content/uploads/2015/10/DGT-Full-report.pdf

Cresswell, J. (2014) *Research Design: Qualitative, Quantitative and mixed methods approaches*. 4th edition. Sage: California.

Darling-Hammond, L., Hyler, M., & Gardner, M. (2017). *Effective teacher professional development.* Learning Policy Institute. California. Retrieved from: https://learningpolicyinstitute.org/sites/default/files/product-files/Effective_Teacher_Professional_Development_REPORT.pdf

Davey, R. (2013). *The Professional Identity of Teacher Educators: Career on the Cusp?* Abingdon: Routledge.

Department for Education. (2010). *The Importance of Teaching.* (CM 7980). Retrieved from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/175429/CM-7980.pdf

Department for Education. (2011). *Training our next generation of outstanding teachers – An improvement strategy for discussion.* (DfE-00038-2011). Retrieved from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/181154/DFE-00083-2011.pdf

Department for Education. (2016). *Educational Excellence Everywhere.* (CM 9230). p28. Retrieved from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/508550/Educational_excellence_everywhere__print_ready_.pdf

Dinkelman, T. (2003). Self-study in Teacher Education: A Means and Ends Tool for Promoting Reflective Teaching. *Journal of Teacher Education*, *54*(1), 6-18.

Dinkelman, T., Margolis, J., & Sikkenga, K. (2006). From Teacher to Teacher Educator: Reframing knowledge in practice. *Studying Teacher Education, 2*(2), 119-136. DOI: 10.1080/17425960600983155

Doig, B., & Groves, S. (2011). Japanese lesson study: teacher professional development through communities of inquiry. *Mathematics Teacher Education and Development,* 13. 77-93.

Farrow, R., Iniesto, F., Weller, M., & Pitt., R. (2020). *The GO-GN Research Methods Handbook.* Open Education Research Hub. The Open University, UK. CC-BY 4.0. Retrieved from http://go-gn.net/gogn_outputs/research-methods-handbook/

Field, S. (2012). The trials of transition, and the impact upon the pedagogy of new teacher educators. *Professional development in education,* 38 (5), 811–826.

Freeman, S., Eddy, S., McDonough, M., Smith, M., Okoroafor, N., Jordt, H., & Wenderoth, M. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences,* 111(23), 8410–8415. https://dx.doi.org/10.1073/pnas.1319030111

Fuller, A., Hodkinson, H., Hodkinson, P., & Unwin, L. (2005). Learning as peripheral participation in communities of practice: A reassessment of key concepts in workplace learning. *British Educational Research Journal, 31*(1), 49-68.

Gess-Newsome, J. (2015). A model of teacher professional knowledge and skill including PCK: Results of the thinking from the PCK summit. In A. Berry , P. J. Friedrichsen, & J. Loughran (eds.), *Teaching and learning in science series. Re-examining pedagogical content knowledge in science education* (1st ed., pp. 28–42). New York: Routledge.

Glaser, B., & Strauss, A. (1967). *The Discovery of Grounded Theory.* New Brunswick: Aldine Transaction.

Goodwin, A. (2010). Globalization and the preparation of quality teachers: Rethinking knowledge domains for teaching. *Teaching Education*, *21*(1), 19–32. https://doi.org/10.1080/10476210903466901

Goodwin, A., & Kosnik, C. (2013). Quality teacher educators = quality teachers? Conceptualizing essential domains of knowledge for those who teach teachers. *Teacher Development*, *17*(3), 334–346. https://doi.org/10.1080/13664530.2013.813766

Goodwin, A.L., Smith, L., Souto-Manning, M., Cheruvu, R., Yin Gang, M., Reed, R., Taveras, L. (2014) What should Teacher Educators Know and Be Able to Do? Perspectives from practicing teacher educators. *Journal of Teacher Education*, 65(4) 284-302

Griffiths, V., Thompson, S., & Hryniewicz, L. (2010). Developing a research profile: mentoring and support for teacher educators. *Professional Development in Education*, 36:1-2, 245-262, DOI: 10.1080/19415250903457166

Grossman, P. (1990). *The making of a teacher: Teacher knowledge and teacher education*. New York: Teachers College Press.

Harrison, J., & McKeon, F. (2008). The formal and situated learning of beginning teacher educators in England: identifying characteristics for successful induction in the transition from workplace in schools to workplace in higher education. *European Journal of Teacher Education,* 31(2), 151–168.

Hashim, H., & Ahmad, S (2013) Professional journey of the expert teacher educator. *Human Resource Development International,* 16:4, 471-479, DOI: 10.1080/13678868.2013.787266

Hayward, G. (1997). Principles for school focused initial teacher education: some lessons from the Oxford Internship Scheme. In T. Allsop and A. Benson (eds.) Mentoring for Science Teachers (pp.11-26) Buckingham: Open University Press.

Hökkä, P., Eteläpelto, A., & Rasku-Puttonen, H. (2012). The professional agency of teacher educators amid academic discourses. *Journal of Education for Teaching*, Vol. 38, Iss. 1, p. 83-102. DOI:10.1080/02607476.2012.643659

Husbands, C. (2015). What are teaching schools for? *Management in Education,* 29(1) 31-34 https://doi.org/10.1177/0892020614535798

Institute of Physics. (2017). *Improving Gender Balance: Reflections on the impact of interventions in schools.* Retrieved from https://www.iop.org/about/publications/improving-gender-balance

Institute of Physics. (2018). *Why not physics? A snapshot of girls' uptake at A-level*. Retrieved from https://www.iop.org/sites/default/files/2018-10/why-not-physics.pdf

Keller, M., Neumann, K., & Fischer, H. (2017). The impact of physics teachers' pedagogical content knowledge and motivation on students' achievement and interest. *Journal of Research in Science Teaching,* 54(5), 586-614 **https://doi.org/10.1002/tea.21378**

Korthagen, F., & Lagerwerf, B. (1996). Refraining the Relationship Between Teacher Thinking and Teacher Behaviour: levels in learning about teaching. *Teachers and Teaching,* 2(2), 161-190, DOI: 10.1080/1354060960020202

Korthagen, F., & Kessels, J. (1999). Linking Theory and practice: changing the pedagogy of teacher education. *Educational Researcher, 28*(4), 4-17.

Koster, B., & Dengerink, J. (2008). Professional standards for teacher educators: how to deal with complexity, ownership and function. Experiences from the Netherlands. *European Journal of Teacher Education, 31*(2), 135-149. DOI: 10.1080/02619760802000115

Kremer-Hayon, L., & Zuzovsky, R. (1995). Themes, Processes and Trends in the Professional Development of Teacher Educators. In T. Russell and F. Korthagen (eds.) *Teachers Who Teach Teachers: Reflections on Teacher Education* (pp.155-172). London: Falmer Press.

Kvale, S. (1996). *Interviews: an introduction to qualitative research interviewing.* London, Sage.

Kwan, T., & Lopez-Real, F. (2010). Indentity formation of teacher–mentors: An analysis of contrasting experiences using a Wengerian matrix framework. *Teaching and Teacher Education,* 26(3), 722-731.

Lee, E., & Luft, J. (2008). Experienced secondary science teachers' representation of pedagogical content knowledge. *International Journal of Science Education,* 30(10), 1343-1363.

Loughran, J. (1995). Practising what I preach: Modelling Reflective Practice to Student Teachers, *Research in Science Education*, 25 (4), 431-451.

Loughran, J. (2002). Effective Reflective Practice: In Search of Meaning in Learning about Teaching. *Journal of Teacher Education*, 53(1), 33-43.

Loughran, J. (2006). *Developing a pedagogy of teacher education: Understanding teaching and learning about teaching*. London: Routledge.

Loughran, J., & Russell, T. (2007). Looking into Teaching about Teaching. *Studying Teacher Education: A journal of self-study of teacher education practices*, 3:1, 1-3, DOI: 10.1080/17425960701279768

Margolin, I. (2011). Professional Development of Teacher Educators through a “Transitional Space”: A Surprising Outcome of a Teacher Education Program. *Teacher Education Quarterly,* 38 (3), 7-25.

Margolis, J. (2012). Hybrid teacher leaders and the new professional development ecology. *Professional Development in Education: Teacher Leadership and Professional Development: Perspectives, Connections and Prospects, 38*(2), 291-315.

McEvoy, E., Heikinaro-Johansson, P., & MacPhail, A. (2019). An exploration of the influence of professional relationships on the career pathways of physical education teacher educators. *European Physical Education Review,* 25(4), 913–928. DOI: 10.1177/1356336X18785106

McIntyre, D. (1990). Ideas and principles guiding the Internship scheme. In P. Benton (eds.), *The Oxford Internship Scheme: Integration and Partnership in Initial Teacher Education.* London: Calouste Gulbenkian Foundation.

McIntyre, D. (1993). Theory, Theorizing and Reflection. In J. Calderhead and P. Gates (eds.) *Conceptualizing Reflection in Teacher Development* (pp. 39-52). London:Falmer.

McNicholl, J., Childs, A., & Burn, K. (2013). School subject departments as sites for science teachers learning pedagogical content knowledge. *Teacher Development,* 17(2), 155-175. DOI: 10.1080/13664530.2012.753941

Merriam, S. (2001). Andragogy and Self-Directed Learning: Pillars of Adult Learning Theory. *New Directions for Adult and Continuing Education,* (89), 3.

Migration Advisory Committee. (2017). *Partial Review of the Shortage Occupation List: Review of Teachers.* Retrieved from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/585998/2017_01_26_MAC_report_teachers_SOL.pdf.

Murray, J., & Male, T. (2005). Becoming a teacher educator: Evidence from the field. *Teaching and Teacher Education*, *21*(2), 125–142. https://doi.org/10.1016/j.tate.2004.12.006

Murray, J. (2006). Designing and implementing a mentoring scheme: University of Worcester SureStart recognized sector-endorsed foundation degree in early years. In A. Robins (Ed), Mentoring in the early years (pp.63–78). London: Paul Chapman

Myatt, M. (2018) The Curriculum. *Gallimaufry to coherence.* Suffolk: John Catt.

National Research Council. (1996). *National Science Education Standards.* Washington, DC: National Academy Press.

Newberry, M. (2014). Teacher Educator Identity Development of the Nontraditional Teacher Educator. *Studying Teacher Education, 10:2, 163-178.* DOI: 10.1080/17425964.2014.903834

Nisbet, J. and Watt, J. (1984). Case Study. In J. Bell, T. Bush, A. Fox, J Goodey and S Goulding (eds.), *Conducting small scale investigations in education management* (pp.72-92). London, Harper and Row/The Open University.

The Office for Standards in Education, Children's Services and Skills (Ofsted). (2019). *The education inspection framework* (No. 190015). Retrieved from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/801429/Education_inspection_framework.pdf

Oxford University Press. (2020). Knowledge. In: Lexico.com, Available at: https://www.lexico.com/definition/knowledge [Accessed 13/09/2020].

Oxford University Press. (2020). Curriculum. In: Lexico.com, Available https://www.lexico.com/definition/curriculum [Accessed 14/09/2020]

Open University (2003). *Research methods in education handbook*. The Open University: Milton Keynes.

Patton, M. (1990). *Qualitative evaluation and research methods.* 2nd edition. Newbury Park, London: Sage.

Perry, E., & Boylan, M. (2018). Developing the developers: supporting and researching the learning of professional development facilitators. *Professional Development in Education, 44:2, 254-271*. DOI: 10.1080/19415257.2017.1287767

Philpott, C. (2014). A pedagogy for initial teacher education in England. *Teacher Education Advancement Network Journal (TEAN), 6 (3). pp. 4-16.* Retrieved from: http://insight.cumbria.ac.uk/id/eprint/1589/

Poyas, Y., & Smith, K. (2007). Becoming a community of practice–the blurred identity of clinical faculty teacher educators. *Teacher Development, 11:3, 313-334.* DOI: 10.1080/13664530701644607

Reichheld, F. (2003). One Number You Need to Grow. *Harvard Business Review,* 81, 46-54, 124. Retrieved from *https://hbr.org/2003/12/the-one-number-you-need-to-grow*

Rhodes, C., & Beneicke, S. (2002). Challenges for managing teacher development in schools. *Journal of In-Service Education, 28(2), 297-310*

Rhodes, C., & Houghton-Hill, S. (2000). The Linkage of Continuing Professional Development and the Classroom Experience of Pupils: barriers perceived by senior managers in some secondary schools. *Journal of In-Service Education, 26(3), 423-435.*

Rowland, T., Huckstep, P. and Thwaites. A. (2005). Elementary teachers’ mathematics subject knowledge: The knowledge quartet and the case of Naomi. *Journal of Mathematics Teacher Education,* 8(3), 255-281

Rowland, T. (2013). The knowledge quartet: the genesis and application of a framework for analysing mathematics teaching and deepening teachers’ mathematics knowledge. *Journal of Education, 1*(3), 15-43

Schneider, R.M., & Plasman, K. (2011). Science Teacher Learning Progressions: A Review of Science Teachers' Pedagogical Content Knowledge Development. *Review of Educational Research*, *81 (4), 530-565.*

Seleznyov, S. (2019). Using Japanese lesson study in UK classrooms. *Journal of the chartered college of teaching, 5, 61-62*

Selmer, S., Bernstein, M., & Bolyard, J. (2016). Multilayered knowledge: Understanding the structure and enactment of teacher educators' specialized knowledge base. *Teacher Development,* 20(4), 437-457.

Sevian, H., Dori, Y., & Parchmann, I. (2018). How does STEM context-based learning work: what we know and what we still do not know. *International Journal of Science Education,* 40:10, 1095-1107, DOI: 10.1080/09500693.2018.1470346

Shulman, L. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15(2), 4-31.*

Shulman, L. (1987). Knowledge and Teaching: Foundations of the New Reform. *Harvard Educational Review, 57(1), 1-23.*

Smith, K. (2005). Teacher Educators' Expertise: What Do Novice Teachers and Teacher Educators Say? *Teaching and Teacher Education, 21, 177-92.*

Smith, E. (2010). Is there a crisis in school science education in the UK? *Educational Review, 62(2), 189–202.*

Smith, E., & Gorard, S. (2011). Is there a shortage of scientists? A re-analysis of supply for the UK, *British Journal of Educational Studies, 59(2), 159–77.*

Stoll, L., Bolam, R., McMahon, A., Wallace, M., & Thomas, S. (2006). Professional Learning Communities: A Review of the Literature. *Journal of Educational Change, 7, 221-258.* DOI 10.1007/s10833-006-0001-8

Swennen, A., Jones, K., & Volman, M. (2010). Teacher educators: their identities, sub-identities and implications for professional development. *Professional Development in Education, 36:1-2, 131-148*

Thomas, G. (2017). *How to do your research project.* 3rd edition. London: Sage.

The Open University. *(2001). Research methods in Education handbook.* (2001). Milton Keynes,UK: The Open University

Timperley, H. (2008) *Teacher professional learning and development.* The International Academy of Education: Switzerland. Retrieved from http://www.ibe.unesco.org/fileadmin/user_upload/Publications/Educational_Practices/EdPractices_18.pdf

Tracy, C., 2014. Energy in the New Curriculum: An Opportunity for Change. *School Science Review*, *96*(354), 51-61.

University of York Science Education Group. (2019). Best Evidence Science Teaching. Retrieved from https://www.stem.org.uk/best-evidence-science-teaching

Van Driel, J., Beijaard, D., & Verloop, N. (2001). Professional development and reform in science education: The role of teachers' practical knowledge. *Journal of Research in Science Teaching, 38(2), 137-158.*

Veal, W., & Kubasko, W. (2003). Biology and geology teachers' domain-specific pedagogical content knowledge of evolution. *Journal of Curriculum and Supervision, 18, 344–352.*

Veal, W., & MaKinster, J. (1999). Pedagogical Content Knowledge Taxonomies. *Electronic Journal of Science Education, 3(4).* Retrieved from http://ejse.southwestern.edu/article/view/7615

Vescio, V., Ross, D., & Adams, A. (2008). A review of research on the impact of professional learning communities on teaching practice and student learning. *Teaching and Teacher Education, 24, 80-91.*

Weston, D., & Clay, B. (2018). *Unleashing great teaching.* London and New York: Routledge

Wiliam, D. (2016). *Leadership for teacher learning: creating a culture where all teachers improve so that all students succeed.* West Palm Beach: Learning Sciences International.

Williams, A., Prestage, S., & Bedward, J. (2001). Individualism to Collaboration: the significance of teacher culture to the induction of new qualified teachers. *Journal of Education for Teaching, 27(3), 253-267.*

Williams, J., & Ritter, J. (2010) Constructing new professional identities through self-study: from teacher to teacher educator. *Professional Development in Education, 36(1-2), 77-92* https://doi.org/10.1080/19415250903454833

Wragg, E. (1984). Conducting and Analysing Interviews. In J. Bell, T. Bush, A. Fox, J Goodey and S Goulding (eds.), *Conducting small scale investigations in education management* (pp.156-197). London, Harper and Row/The Open University.

Zeichner, K. (1987). Preparing reflective teachers: an overview of instructional strategies which have been employed in preservice teacher education. *International Journal of Educational Research*, 11 (5), 565-575

Zeichner, K. (2005). Becoming a teacher educator: A personal perspective. *Teaching and Teacher Education, 21(2), 117-124.* https://doi.org/10.1016/j.tate.2004.12.001

7 Appendices

7.1 Appendix A: Interview dates and schedules

	Consent form returned	Interview 1	Interview 2	Interview 3	Written reflections submitted
Adam	23/09/19	27/09/19	03/03/20	15/06/20	13/03/20
Barry	19/09/19	23/09/19	16/03/20	10/06/20	16/12/19
Colin	15/09/19	1/11/19	7/02/20	3/08/20	
Derek	13/09/19	23/09/19	12/05/20	06/06/20	20/05/20

Table 2 Interview dates

Interview 1: Semi-structured interview schedule

1. How many years have you been teaching in school?
2. How would you describe your teaching style?
3. How do you envisage your coaching style?
4. What do you think that you bring to the role?
5. What are your biggest concerns taking on the role?
6. What do you think the similarities and difference are between teaching children and teaching adults?

In the following questions, we would tend to have a discussion about each domain of knowledge, how each coach interpreted the domain in their context.

7a. How important is it to have an understanding of pedagogical knowledge?

7b. How would you rate your understanding of physics pedagogy at this point in time (models, explanations, demos etc)?

8a. How important is Resources/curriculum material?

8b. How would you rate your understating of resources/curriculum?

9a. How important is it to have a good understanding of Physics knowledge?

9b. How would you rate your understanding of physics?

10a. How important do you think it is to have an understanding of your learners?

10b. How would you rate your understanding of your learners at this point in time?

11a. How important do you think it is to have an understanding of personal beliefs and philosophy of teaching?

11b. How would you rate your understanding of personal beliefs and philosophy of teaching?

12a How important do you think it is to have an understanding of sociological knowledge?

12b. How would you rate your understanding of sociological knowledge at this point in time?

13a. How important do you think it is to have an understanding of social knowledge?

13b. How would you rate your understanding of social knowledge at this point in time?

Interview 2: Semi-structured interview schedule

1. How did you go about planning the session? What were the important elements that you wanted to include?
2. What do you think went well in the session?
3. What do you think didn't go so well?
4. What will you do differently next time?
5. What were the key learning points?
6. Any particular points at which you feel helped your development as a coach (or was meant to help but didn't) e.g. meeting with a fellow coach, joint planning of a session, watching someone else's session, ideas from Twitter etc

Interview 3: Semi-structured interview schedule

1. How do you feel you've developed over the year?

2. How has mentoring helped that development?
3. How has working with and chatting with peers helped that development e.g. coaching day, WhatsApp, meetings?
4. Has there been any literature that you've engaged with over the year? Where did that come from?

In the following questions, we would tend to have a discussion about each domain of knowledge, how each coach interpreted the domain in their context.

5a. How important is it to have an understanding of pedagogical knowledge?

5b. How would you rate your understanding of physics pedagogy at this point in time (models, explanations, demos etc)?

6a. How important is Resources/curriculum material?

6b. How would you rate your understating of resources/curriculum?

7a. How important is it to have a good understanding of Physics knowledge?

7b. How would you rate your understanding of physics?

8a. How important do you think it is to have an understanding of your learners/context?

8b. How would you rate your understanding of your learners at this point in time?

9a. How important do you think it is to have an understanding of personal beliefs and philosophy of teaching?

9b. How would you rate your understanding of personal beliefs and philosophy of teaching?

10a How important do you think it is to have an understanding of sociological knowledge?

10b. How would you rate your understanding of sociological knowledge at this point in time?

11a. How important do you think it is to have an understanding of social knowledge?

11b. How would you rate your understanding of social knowledge at this point in time?

7.2 Appendix B: Coaches engagement

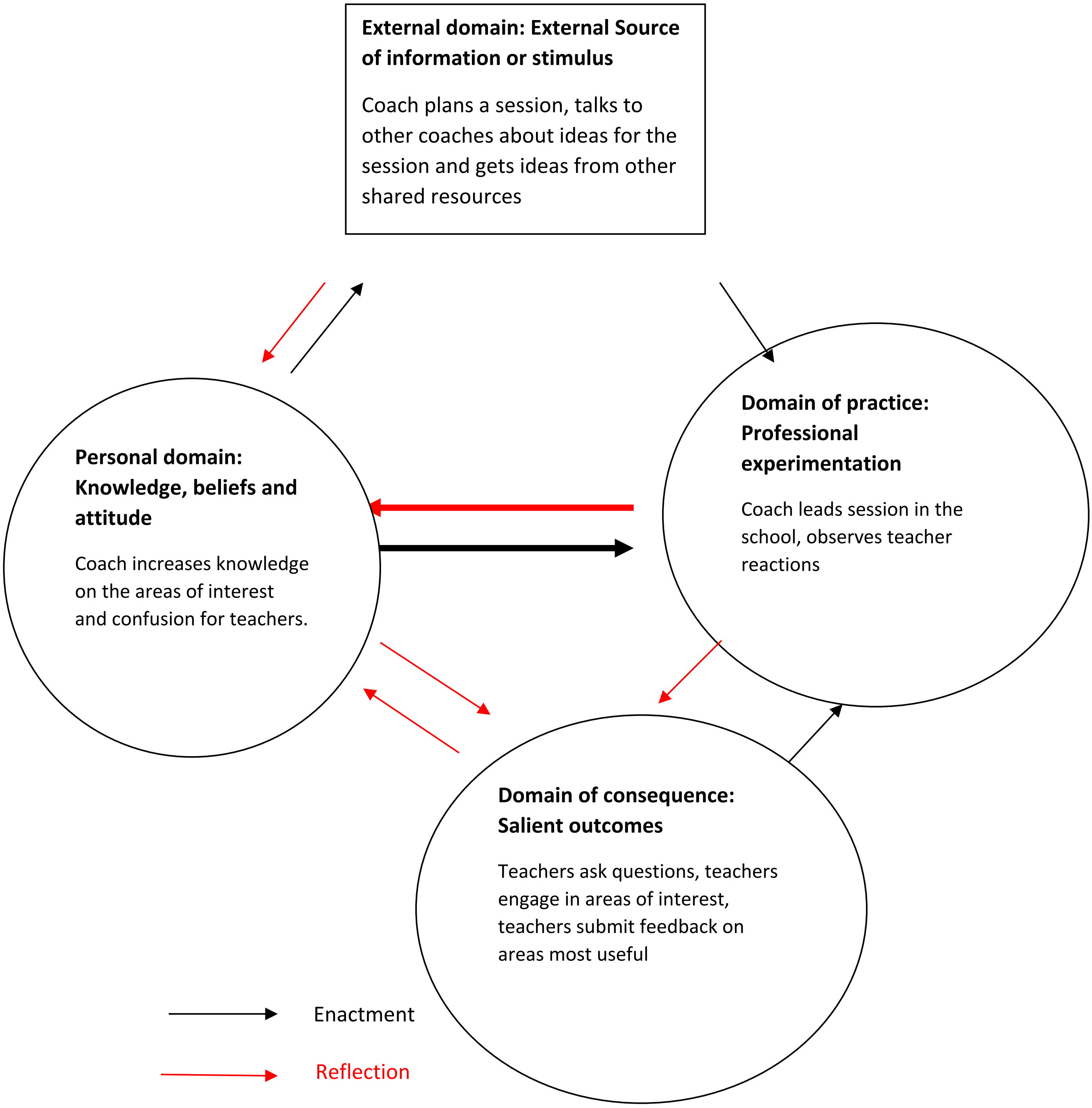
	Responsive to mentor	Meetings attended (max 6)	Regional days attended (max 2)	WhatsApp postings	My perception of the extent of engagement
Adam	Yes	5	2	23	good
Barry	Yes	2	1	33	good
Colin	No	1	0	26	Not engaged
Derek	Yes	3	1	21	good

7.3 Appendix C: Coaching output

Teacher hours and NPS are metrics used by the coaching programme administration. Teacher hours indicate the extent to which they have been able to engage teachers. NPS indicate (on a scale of -100 to 100) how well the session was received.

	Schools recruited	Teacher hours	NPS	Implications drawn
Adam	5	51	79	Good engagement, good feedback
Barry	3	69	44	Good engagement, medium feedback.
Colin	1	12	100	Low engagement, excellent feedback. Further investigation (by interview) shows a lack of knowledge around school engagement processes led to low teacher engagement.
Derek	3	20 (plus estimated 20 additional hours for SCITT)	88	Good engagement (when also considering SCITT work), good feedback

7.4 Appendix D: The change environment for coaches



External domain: External Source of information or stimulus

Coach plans a session, talks to other coaches about ideas for the session and gets ideas from other shared resources

Personal domain: Knowledge, beliefs and attitude

Coach increases knowledge on the areas of interest and confusion for teachers.

Domain of practice: Professional experimentation

Coach leads session in the school, observes teacher reactions

Domain of consequence: Salient outcomes

Teachers ask questions, teachers engage in areas of interest, teachers submit feedback on areas most useful

Adapted from Clarke, D. and Hollingsworth, H. (2002) Elaborating a model of teacher professional growth, *Teaching and Teacher Education*, 18, 947–967 (p. 951)