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The role of mentors and the subject knowledge development of student mathematics teachers: developing an understanding of the influences on mentors' perceptions and practice.

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Abstract

School-based mentors play a central role in the subject knowledge development of student mathematics teachers, but their influence is not yet well understood. Whilst approaches to teaching and learning mathematics vary across schools in England, recent increases in the use of standardised resources have changed the nature of mentors' work as teachers in many schools and may affect the learning opportunities available for student mathematics teachers who spend the majority of their Initial Teacher Education (ITE) course on school placement.

Situated within a critical realist framework, this research draws on semi-structured interviews with four experienced school-based mathematics mentors from a university-based ITE partnership in England where a shift towards the use of standardised resources has been observed. By exploring mentors' experiences of learning mathematics, becoming and being a teacher and being a mentor, the study develops an understanding of how mentors support the subject knowledge development of student teachers and the potential personal, structural and contextual factors which may shape their perceptions and practice.

The findings identify that despite current ITE policy guidance, experienced mentors adopt an educative approach to mentoring which is cognisant of the emotional impact of becoming a teacher. They also develop a *specialised mathematical knowledge of teaching and mentoring* which includes pedagogical knowledge of learning to teach mathematics. The practice architectures in place across a range of contexts - ITE experiences, previous and current working environments, and wider educational policy - are significant in shaping this knowledge, the perceptions and practice of mentors,

and therefore the learning opportunities available for student teachers. Mentors in this study emphasise the importance of the ITE year as a time to explore new ideas and to work collaboratively with experienced teachers to develop mathematical knowledge for teaching. Rather than particular approaches to teaching and learning mathematics, this research shows that it is collaborative working environments in schools which are especially influential in the development of student teachers' mathematical knowledge for teaching; integrating student mathematics teachers into these established cultural practices enhances their opportunities to learn from experienced teachers. However, current pressures in schools often constrain such collaborative practices.

This research offers insights for policymakers and ITE providers seeking to ensure that future mathematics teachers develop the mathematical knowledge for teaching required to be an effective teacher. It may also provide a helpful starting point to consider the subject-specific knowledge of learning to teach developed by mentors in other subject areas, with implications for wider ITE policy. The study recommends prioritising the development of collaborative school environments and placing greater emphasis on the subject-specific learning processes of student teachers within ITE policy. Additionally, it highlights the importance of including a focus on the subject-specific knowledge of learning to teach within the ITE secondary mentor curriculum.

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Glossary of terms

Academy A state funded school independent of local authority control.

Core Content Framework (CCF) A policy document outlining the minimum curriculum entitlement for Initial Teacher Education courses in England.

Early Career Framework (ECF) A two-year training and support programme for all new teachers in England.

GCSEs Compulsory examinations completed by all pupils at the end of Key Stage Four.

Initial Teacher Education/Initial Teacher Training (ITE/ITT) The first stage of professional development for new teachers in England. It involves a one-year course leading to an award of Qualified Teacher Status. There are a range of ways to complete this year.

Initial Teacher Training Early Career Framework (ITTECF) A three-year framework combining the CCF and ECF to support the professional development of new teachers across their Initial Teacher Education year and first two years of teaching.

Key Stage Three A phase which includes the first three years of secondary school in England, Years 7-9.

Key Stage Four A phase which includes the fourth and fifth years of secondary school in England, Years 10-11. At the end of this time, pupils complete compulsory national examinations.

Multi Academy Trust (MAT) A group of schools independent of local authority control, governed by a single set of trustees.

Ofsted A government department that inspects and regulates services providing education and skills for learners of all. This includes schools and Initial teacher Education providers.

PGCE A one-year academic teaching qualification which combines university-based learning with placements in schools.

SCITT A one-year school-based teacher training course managed by a Multi Academy Trust.

Chapter 1: Introduction and context

1.1 Introduction

This research investigates the personal, contextual, and structural factors influencing how school-based mathematics mentors, experienced teachers within mathematics departments, work to support student mathematics teachers during their school placements which form a significant part of their Initial Teacher Education (ITE) course. My aim is to find out from mentors how their experiences as learners and teachers, and the contexts they work within, influence their understanding of what student teachers need to learn mathematically to become good teachers and how they support them with the development of their mathematical knowledge for teaching during school placements.

In policy documentation, the Department for Education use the term Initial Teacher Training (ITT) instead of ITE. However, ITE is used more widely within the university-based teacher education sector, reflecting a view that the development of student teachers is a complex process that involves more than training; it requires the development of reflective and critical thinking skills and a deeper understanding of their subject and how pupils learn to enable them to become teachers to know how to act professionally when supporting the learning of all pupils. Throughout this work, I use ITT when referring to policy documents, otherwise I use ITE.

In this introduction, I set out the research focus and make a case for the importance and value of this research for mentors, teacher educators, policymakers and ultimately student teachers and the pupils they will go on to teach. My research aims and questions are then stated with a brief outline of my chosen methodology and my

positionality as a researcher. Following this, I explore the contexts within which this research is taking place, considering the current landscapes of schooling and teacher education in England. At the end of the chapter, I provide an outline of the rest of the thesis.

1.2 Value of research

Successful outcomes for pupils, in terms of enjoyment of learning mathematics as well as good exam results, require high quality teachers (Darling-Hammond et al., 2017; EEF, 2021; Hattie, 2012; Ofsted, 2023). School-based mentors, experienced mathematics teachers working closely with student teachers during their placement, play a significant role in the development of new teachers, in their socialisation into the profession, supporting the emotional demands of becoming and being a teacher, and in learning to teach mathematics (Izadinia, 2016; Lofthouse, 2020; Shanks, 2014). Excellent mathematics teaching requires teachers to have good mathematical knowledge themselves, but also an understanding of how pupils learn mathematics, the challenges they may face and how mathematics can be taught to enable all pupils to learn (Ball et al., 2008; EEF, 2022; Shulman, 1987). The development of this mathematical knowledge for teaching (Ball et al., 2008) forms a crucial part of their early development as teachers. Mentors are well placed to support the development of this knowledge, however, whilst there is a wealth of research exploring the nature of mathematical knowledge needed to be a good teacher (Ball et al., 2008; Fenema & Franke, 1992; Rowland et al., 2014; Shulman, 1987) , there is limited research that explores mentors' understanding of the subject knowledge development needs of student teachers and how they conceive their role in this.

The importance of a good mathematics education in society today cannot be overstated. Mathematics plays a significant role in everyday life and work. Success in mathematics, as measured by a pass at GCSE level, enables access to further education opportunities and greater choice for future work, resulting in higher earnings for individuals (Academy for the Mathematical Sciences, 2024) and is described as a central pillar in the UK economy. Consequently, mathematics occupies a powerful place within the school curriculum and within the performance and accountability measures currently in place (DfE, 2025c), ensuring it is a priority focus for school leaders.

This research take place during a time of significant challenge and change in teaching and teacher education in England. Increasing control has been exerted through educational policy (Ellis & Childs, 2023) with the market review of the ITE sector (DfE, 2021a) resulting in greater prescription and regulation of ITE courses (Horden & Brooks, 2023; Mutton et al., 2024). Recruitment and retention of mathematics teachers has been persistently challenging, with significant under recruitment to ITE mathematics courses since 2011-12. The figures in 2024-25 show that the target was missed by 27% (DfE, 2025a). In addition to this, mathematics teachers are more likely to leave the profession than other secondary subjects, with a third leaving within five years and 11% after just one year (DfE, 2024d). These challenges with recruitment and retention affect some schools and pupils more than others. Schools with a greater proportion of pupils from disadvantaged backgrounds or in Key Stage Three classes are more likely to have unqualified or inexperienced mathematics teachers or to have mathematics taught by non-specialists (Allen & Sims, 2018; McLean & Worth, 2025). This undoubtedly has an impact on pupils' learning, with those from disadvantaged backgrounds who do well in

Key Stage 2 not achieving as highly as other pupils at GCSE (DfE, 2024a). New mathematics teachers come from an increasingly wide range of disciplinary backgrounds with just 38% having a mathematics degree (Worth, 2024) so the subject knowledge development needs of student teachers are varied. Student teachers are also entering a workplace where the nature of the teacher's role is changing with a move towards the use of standardised resources within mathematics departments (Traianou et al., 2025).

A wealth of research (e.g., Darling-Hammond et al., 2017; Hobson et al., 2009) and current educational policy (DfE, 2025b) recognise the importance of mentors to support the development of student teachers, however, there is little guidance about the subject-specific nature of their role. This research aims to hear from experienced mathematics mentors and understand their perceptions of their role and their priorities and practice as mentors. It identifies the *specialised mathematical knowledge for teaching and mentoring*, developed by experienced mathematics mentors, which encompasses their own mathematical knowledge for teaching (Ball et al., 2008) and their mathematical knowledge of learning to teach, an understanding of the nature of student teachers' initial mathematical knowledge, the assumptions and challenges faced by student teachers and the strategies to support this development. In addition, this research seeks to understand the wider influences that inform, enable and constrain mentors in their practice, finding that ITE experiences, previous and current working contexts and educational policy are all significant.

This research is important for ITE providers as they work with student teachers and mentors during their ITE course, in developing more subject-specific guidance within

their mentor curriculum, supporting the development of teachers who can understand and meet the needs of all pupils learning mathematics. With recognition of a lack of subject-specific focus within the Early Career Framework (House of Commons Education Committee, 2024) and in current ITE policy (DfE, 2025b), it is also important for policymakers who shape the landscapes within which student teachers, mentors and teacher educators work together.

1.3 Research aims and questions

The issues set out above informed the formulation of my research aims and questions. My research aims are:

- to understand mathematics mentors' perspectives on the subject knowledge that teachers need, and to find out how they work with student teachers to support this development
- to understand mathematics mentors' working contexts and the factors that influence their practice as a teacher and mentor

The research questions I explore are:

- How do mathematics mentors understand the subject knowledge development needs of secondary mathematics student teachers during their PGCE year?
- How do mathematics mentors understand their role in the subject knowledge development of secondary mathematics student teachers?
- What personal, structural, and contextual factors influence mathematics mentors' perceptions and practice?

1.4 Positionality

In my current professional role as a university-based PGCE secondary course leader and mathematics tutor, I work with a wide range of schools in the region and have a strong understanding of the local landscape and the range of school contexts in which student teachers learn to teach. I also have extensive experience of teacher education and a detailed understanding of what it means to learn to teach mathematics. However, as someone who has previously been a teacher of mathematics and a school-based mentor, I bring to this research my own beliefs and perspectives about mathematics, teaching and learning mathematics and mentoring as well as my understanding of the challenges of learning to teach.

My interest in the subject knowledge development of student teachers and the role of mentors has arisen from my work with both groups over many years. In my Masters research, my dissertation explored the perspectives of subject knowledge development from the student teachers' perspective. However, I am also keen to learn from the mentors that I work with and better understand what happens in school. To do so, in this research, I needed to adopt a highly reflexive approach to ensure that I remained open to being challenged and learning from the mentors' perspective. (Cohen et al., 2018). Throughout all stages of the research process, I have been aware of my beliefs and perspectives, bringing them to the fore in all decision making, being astute to potential bias that could influence my approach during the research process (Yin, 2014), seeking to minimise it. At each point, reflections with my supervisors as critical friends to challenge my thinking, actions, interpretation, and decision making at all stages have been essential.

In addition to my own beliefs and perspectives, I have also been mindful of how I may be perceived by those involved in my research. Established professional relationships with mentors already existed, with time invested in ensuring that the tutor-mentor relationship was not hierarchical, instead recognising the different areas of expertise that each person brings when supporting the development of student teachers. However, as the person responsible for mentor development within the PGCE course, and as a former tutor of student teachers who have gone on to become mentors, there were challenges to navigate to ensure that within a different context, mentors felt that they could be honest and open with me. For this research, from the first point of contact with mentors I was clear that I was interested in learning from their perspective and that there were no right answers to give (Brinkmann & Kvale, 2015). Throughout all stages of planning for this research, the impact of my positionality was considered, particularly in the selection of a sample group of mentors. Further detail about this can be found in Chapter 3.

1.5 Research context: changing landscapes

The last thirty years have seen considerable change in all aspects of education and teacher education in England with increasing control exerted through educational policy (Ellis & Childs, 2023). The rise of neoliberalism has led to a market-based approach within the sector, and increased consumer choice in terms of types of schools and routes to become a teacher. A technicist model of teaching is evident throughout this raft of changes, with a narrowing conception of what it means to be a good teacher and tighter restrictions on the structure of ITE courses (DfE, 2025b). Prescription of the content of these courses and the knowledge a teacher needs to

develop is now set out within the Initial Teacher Training and Early Career Framework (ITTECF) (DfE, 2024b). As a result, England's ITE programmes are now the most tightly regulated teacher education courses in the world (Ellis & Childs, 2023). This raises questions about the impact of these changes on the potential learning of student teachers and the types of teacher developed.

In this section I provide a brief history of the evolution of the landscape of schooling in England, exploring the impact of recent policy changes on the working lives and professional learning of mathematics teachers. I then consider how ITE in England has been shaped by a sequence of policy changes in recent decades, exploring the purpose of initial teacher education, the concept of partnership and the role of mentors within current systems.

1.51 Changing landscapes in education: schools

In recent years, the school system in England has changed significantly from a local authority led system to one where most schools are academies, independent of the local authority. Driven by a desire to improve educational outcomes and compete with higher performing countries identified in PISA 2006 (DfE, 2010; DfE, 2012; OECD, 2007), this process of academisation has resulted in a market model of education (Voisin & Dumay, 2020) with some suggesting a reduction in the autonomy of individual teachers in the classroom (Parcerisa et al., 2022; Traianou et al., 2025) and opportunities to be involved in professional decision making at an individual school level varying widely (Ofsted, 2019).

Rise of academies

Before the Education Reform Act (1988), most schools in England were under local authority control. However, this legislation, which also introduced the National

Curriculum, led to the fragmentation of the structure of schooling, providing greater choice for parents through the creation of City Technology Colleges (CTCs) and grant-maintained schools. These schools had greater autonomy than those under local authority control, reducing the remit of local authorities at the time. With a change in government at the end of 1990s, Labour continued this marketisation approach to schooling, with the introduction of academies. Having the same freedoms that had been available for grant-maintained schools, they aimed to replace previously failing schools with the intention of overcoming low achievement in some areas. Another change in government resulted in the Conversative' s white paper, *The Importance of Teaching* (DfE, 2010) which set out new priorities for education, establishing a need for a self-improving school system that performed more highly in comparison with other countries. Central to these changes was an intention to reform the National Curriculum and teaching training, reduce bureaucracy within schools and provide greater autonomy for teachers, something observed in higher performing countries (OECD, 2007). Continuing to offer greater freedoms for schools and greater choice for parents, the Academies Act (2010) accelerated the fragmentation of the school landscape, enabling any school judged 'Outstanding' by Ofsted to become a converted academy. Academies, directly funded by government, had greater freedom over their own finances, could set their own curriculum and term times, employ unqualified teachers and create their own pay and conditions for staff. Later the same year, this offer opened to all schools, with the provision of a financial incentive for converting to an academy. The move to academisation was swift; half of all secondary schools were academies by 2012-13 (DfE, 2013) and currently over 80% of secondary schools are academies (Lucas et al., 2023).

Development of MATs

As more schools became academies, Multi-Academy Trusts (MATs), groups of schools under a single governing body, were established to replace much of the role previously provided by the local authority. Promoted to support academies to collaborate and improve outcomes by working together, since 2017 they have been the dominant model of governance for secondary schools in England (DfE, 2022; House of Commons, 2017). Whilst one of the main intentions of academisation was to improve pupil academic outcomes, research suggests significant variation across academies and MATs (Bernardinelli et al., 2018; Gorard & Siddiqui, 2019).

MATs can be local, regional or national and vary in terms of size with most secondary academies in MATs of less than 10 schools (Lucas et al., 2023). MATs also adopt a diverse range of working practices (Greany & McGinity, 2021). Some take an approach of *earned autonomy* (Greany & Higham, 2018), allowing individual schools to retain their own ways of working if external indicators, such as exam results and Ofsted inspections remain good. Others take a more corporate approach, with the school curriculum and policies along with terms times and the structure of the school day decided centrally. Worth and Van den Brande (2020) found that higher levels of teacher autonomy were associated with higher job satisfaction and a greater intention to remain in the profession, which may be a factor in the higher staff turnover reported within MATs than local authority schools (Hodge et al., 2024). With student teachers undertaking placements across these different contexts, it is important to understand the impact this variation may have on their professional learning opportunities during placements as they work alongside their mentor and other experienced teachers.

In the next section, I explore in more detail the changing role and autonomy of mathematics teachers within this new structure for schooling in England.

1.52 Changing landscapes in education: the role of the mathematics teacher

The changing landscape for schools has had an impact on the concept of what it means to be a good teacher as well as the professional development opportunities available for teachers. Increasing levels of control over the work of teachers, through the adoption of standardised approaches within some MATs and increased government regulation within educational policy and accountability structures, calls into question the professional status of their role (Traianou et al., 2025).

What does it mean to be a professional teacher?

A professional is someone who has access to specialised professional knowledge that is a mark of their expertise (OECD, 2020; Winch, 2023) but teaching has not had the same status as other professions, such as law or medicine. Whilst some have sought to bring clarification to the complex and specialised knowledge of a teacher (Ball et al., 2008; Grossman et al., 2009; Shulman, 1987), conceptions remain contested (Oancea, 2014). Professional teacher knowledge is context specific, with school structure and culture influencing beliefs and practice (Rowland & Ruthven, 2010; Van Driel & Berry, 2010), highlighting that what it means to be an expert teacher will be different within different settings (Berliner, 2001). A current focus on standards and outcomes, evident throughout educational policy in England, portrays teacher professionalism as managerial (Sachs, 2016) or organisational (Evetts, 2009) in nature. This has resulted in transmissive professional development opportunities, preparing teachers to implement reforms and priorities set by school leaders or educational policy (Kennedy, 2014) as

they respond to immediate needs and policy changes (Ofsted, 2024b). In contrast, Evetts' (2009) definition of occupational professionalism adopts a more democratic approach (Sachs, 2016) aiming to give more autonomy to staff, something that was intended through the Academies Act (2010), but which has not always been realised for individual teachers (OECD, 2020; Traianou, et al., 2025).

Most MATs set a core curriculum centrally but allow some freedom to innovate at a school level (DfE, 2022). However, performativity measures and standardised assessment processes across academies within a MAT may restrict this opportunity to innovate within the classroom (Parcerisa et al., 2022). With more centralised planning taking place within some MATs, particularly in mathematics (Traianou et al., 2025), and pedagogical decisions made by others within a MAT, the work and autonomy of a class teacher in these schools has been reduced in scope (Voisin & Dumay, 2020).

Centralised planning aimed to reduce persistent issues around workload, but Traianou et al. (2025) found that there was no difference between workload in schools adopting standardised and non-standardised approaches. Guidance from DfE (2016a, p.5) to address unnecessary workload suggested that fully resourced, collaboratively planned resources should be in place to support teachers, stating that it was important that "individual teachers understand the 'what' and 'why' of the curriculum… [to be] freed to teach in a way that best suits their professional judgement and experience." Since then, with teachers often not involved in centralised planning, the nature of planning has changed, shifting their focus to interpreting the decisions made by others to adapt them to meet the needs of their pupils. In some school contexts, a more rigid approach to the use of standardised resources has reduced teachers' autonomy further, becoming a

deliverer in the classroom, leading to claims of de-professionalising the workforce (Traianou et al., 2025). Teachers from England rank in the bottom few countries when asked about their level of autonomy in the classroom, the opportunities to participate in school decision making and when rating the collaborative culture within their school (OECD, 2020). A rigid, centralised approach is at odds with the findings from the Teaching and Learning International Survey (TALIS) in 2018 which highlighted the need to strengthen professional autonomy and collaborative cultures in order to promote good teaching and learning outcomes, commenting that "those trained only to reheat pre-cooked hamburgers are unlikely to become master chefs" (OECD, 2019, p.4). It is also at odds with more recent recommendations in the Curriculum and Assessment Review (DfE, 2025d) which highlight the need for teachers to have professional autonomy within proposed changes to the national curriculum, to choose lesson content and how to teach it; current practice in some contexts is a long way from this.

What does it mean to be a mathematics teacher?

Whilst Greany and McGinity (2021) found that just three out of twenty-two MATs in their research adopted standardised approaches to most parts of the school curriculum, more recent research indicates that 54% of secondary schools take a standardised approach to planning, most commonly in maths and English (Traianou et al., 2025). This may be due to high stakes accountability, where mathematics is double weighted in Progress 8 scores, making the pupil outcomes more significant for the overall progress measured for the school (DfE, 2025b). Whilst Progress 8 was suspended temporarily due to the pandemic, it will be reintroduced in 2026-27, making it a continued focus for schools.

Standardised approaches to teaching and learning mathematics can be effective if they are of high quality, developed through collaboration and with professional development provided for those involved (DfE, 2016a; Lee & Feng, 2007; Shalem et al., 2018). However, within MATs, standardised curricula are often rolled out very quickly, with decisions made by a small number of people; meaningful, collaborative practices involving classroom teachers are disappearing (Parcerisa et al., 2022; Traianou et al., 2025). Research suggests that mathematics teachers need to learn to respond flexibly to pupils in the classroom (Ball et al., 2005; Baumert et al., 2010; EEF, 2022; Gess-Newsome, 1999; Van Driel & Berry, 2017), therefore a one size fits all approach to teaching mathematics is potentially limiting to the learning of pupils. As student teachers learn to teach in these environments, it raises questions about the understanding, knowledge and skills that they develop during placements, potentially limiting their learning in some contexts.

Alongside changes to planning and teaching practices within academies, there have been changes to discourses about the teaching of mathematics within educational policy, with a more technical breakdown of the subject and increasing prescription about how to teach it (DfE, 2021b; Ofsted, 2021). The Ofsted mathematics research review (Ofsted, 2021) suggested a more atomised approach to the teaching of mathematics that was not present previously in discussions amongst mathematics teachers. The focus on declarative, procedural and conditional knowledge promotes teacher-led approaches and learning through repeated practice, neglecting the role of discussion to develop understanding. Within the mathematics education community, it was criticised by many due to the misuse and cherry-picking nature of evidence to support claims (Compton & Boylan, 2024: Gilmore et al., 2021), a narrow, static

conception of mathematics and mathematics teaching and a lack of coherence with other policy documents (Watson & Back, 2021). For example, the aims of the National Curriculum for mathematics (developing fluency, reasoning and problem solving) are not reflected within it and the development of conceptual understanding and use of visual representations, central to a mastery approach promoted by the Maths Hubs, are ignored.

Professional learning opportunities for mathematics teachers

The current context in schools provides several challenges for accessing high quality formal and informal professional development for mathematics that is subject-specific in nature. Workload pressures, cost, and a lack of staff to provide cover create potential barriers to engage with opportunities that are available (Ofsted, 2024b). Despite a desire by teachers and school leaders to support teachers to develop their practice, formal opportunities are more likely to focus on short term crisis management approaches to professional development, reflecting the pressure that school leaders feel to respond to immediate pupil needs and changes in educational policy (Ofsted, 2024b), and MAT or school improvements (Boylan & Adams, 2024). In Ofsted's recent review of teachers' professional development, a high proportion of teachers said that they "rarely received training that allowed them to reflect on their practice and embed learning" (Ofsted, 2024a, para 12). Whilst high quality professional development that is subject-specific and practice-based has a more positive impact than generic professional development (Cordingley et al., 2019), only 24% of recent professional development received by teachers had this focus (Ofsted, 2024b). In England, teachers are less likely to experience this type of professional development than teachers in other high performing countries (Cordingley et al., 2019; OECD, 2019). In addition to the

factors listed above, informal professional development opportunities such as working collaboratively with colleagues, considered valuable by teachers, can be further reduced through an increase in the use of standardised resources (Parcerisa et al., 2022; Traianou et al., 2025) and a lack of time in school. This raises questions about the potential impact this may have on student teachers, in terms of their understanding of what it means to be a teacher, and their conceptions of professional development and its purpose.

In light of the financial constraints that impact engagement with professional development, it is unsurprising that regional Maths Hubs, offering free professional development, play a significant role in the current provision of mathematics professional development. Established by National Centre for Excellence in Mathematics Teaching (NCETM) in 2014, their initial role was to respond to concerns about the shortage of mathematics teachers, relevance of qualifications for pupils and the professional development opportunities for mathematics teachers (Smith, 2004). Currently, their main focus is to support teachers to implement an East Asian mastery style approach to teaching mathematics, adopted from high performing countries in PISA 2006, to improve the quality of mathematics education and raise educational outcomes in England. With Year 9 pupil outcomes for mathematics in England significantly above the international average in the Trends in International Mathematics and Science Study (TIMSS), a mastery approach was recognised by some as contributing to sustaining this position in the rankings (DfE, 2024e), but others suggest that evidence for this is inconclusive (Boylan & Adams, 2024).

Maths Hubs provide opportunities for teachers to work collaboratively but a narrow focus on mastery potentially neglects the chance to provide more transformative professional development opportunities where teachers have greater agency in their professional learning (Boylan et al., 2023) and can explore alternative approaches to teaching and learning that would develop their practice further. In addition to this, with mastery interpreted in a range of ways within schools and MATs, referring to a style of teaching, a type of curriculum, a type of understanding or level reached (Boylan & Adams, 2024), collaboration with others may be difficult and perhaps unhelpful. As Maths Hubs are often located in MATs; within a competitive marketplace, this can also create tension and impact engagement as, for example, schools with a lower Ofsted rating might be concerned about being taken over if their performance drops (Greany et al., 2023).

Recent government advice (DfE, 2022, p.18) positions MATs as the best source of professional development for their staff, stating "it is families of schools working together in the single governance and accountability structure of a multi academy trust who can most effectively share good practice, support their schools to improve, and provide opportunities for staff." Management structures within MATs often have directors of mathematics who work across schools to share and develop good practice however, this approach potentially misses the opportunity to learn from others working in similar or different contexts which could enhance understanding of how pupils learn mathematics (Francis & Hutchings, 2018).

Having recognised the changing landscapes in school and in mathematics teachers' working lives and professional development, I now go on to consider recent changes

within initial teacher education and how changes to wider educational contexts may influence the potential learning opportunities for student mathematics teachers and their understanding of what it means to be a teacher.

1.53 Changing landscapes in education: teacher education

In England, the last decade has seen momentous change to the landscape of ITE with current educational policy situating teaching as a craft learnt from observation and imitation (McIntyre et al., 2019) and promoting a particular ideology of teaching based on cognitive science (Hordern & Brooks, 2023). A summary of these policy changes is presented below in Table 1.1.

Table 1.1

Summary of recent ITE policy changes

2015	2016	2019	2021	2022	2024	2024
Carter review of Initial Teacher Training completed	Non-statutory Mentors Standards introduced	Core Content Framework created (statutory from September 2020)	Early Career Framework introduced	ITT Market Review and reaccreditation of ITT/ITE courses	Implementation of new quality requirements for ITT/ITE courses	Review of CCF and ECF, combined to ITTECF (statutory from September 2025)

The recent change of language to 'trainee teacher' rather than 'student teacher' reflects a focus on assessment and meeting standards. Biesta (2012, p.8) suggests that this focus on competencies "runs the risk of forgetting what characterises education-namely that education always needs to engage with questions of purpose, content and relationships" and does not encourage student teachers to develop the professional judgement required to respond contingently when teaching (EEF, 2022; Feiman-Nemser, 2001a).

Initial teacher education has long been a focus for successive governments seeking to improve educational outcomes in England, weakening the role of universities within the sector. Whilst Lofthouse (2023, para 6) contends that universities should hold a space for professional learning - "a space in which to think, articulate, share practice, experience dissonance, engage with alternatives, be curious, developed shared language, connect ideas and conceptual understanding and to elicit feedback" – from the 1980s onwards, policymakers have sought to address perceived weaknesses and ensure high quality teachers through increasing regulation (Mutton et al., 2024). Just as the Education Reform Act (1988) led to a fragmentation of the school landscape, the Education Act (1994) resulted in a diversification of routes into teaching. This continued a move towards school-based initial teacher education already established in Circular 9/92, which placed schools in a more central role for ITE, with a "joint responsibility for the planning and management of course and the selection, training and assessment of students" (DfE, 1992, para. 14) and a minimum time in school prescribed. However, a fall in England's international standing in PISA 2006 provided the catalyst for further policy changes, with The Importance of Teaching (DfE, 2010) increasing employment-based routes into teaching and time in school within all ITE courses, prioritising school-led routes over university-based ones.

This expansion of routes into teaching did not bring the swift improvement in standards expected. The Carter Review (DfE, 2015), an independent review of initial teacher training led by the Chief Executive Officer of a School Centred Initial Teacher Training provider, aimed to define, and standardise effective practice in the sector. It was perceived by some as a way to further reduce the role of universities within teacher education, promoting school experiences over other professional learning (Mutton et

al., 2017). This "turn to the practical" (Brown et al., 2015, p.11) was at odds with the rest of Europe and other countries within the UK. The review resulted in the development of the Early Career Framework (ECF) designed to support teachers in the first two years of their career (DfE, 2019a) swiftly followed by the Core Content Framework (CCF) (DfE, 2019b) created to standardise the minimum entitlement of teacher training courses.

Although the CCF and ECF (later combined in the Initial Teacher Training and Early Career Framework (DfE, 2024b)), were not assessment frameworks, they were organised in eight sections linked to the Teachers' Standards, not previously used or designed as a curricular structure. These frameworks set out a series of evidence statements *'Learn that….'* and practice statements *'Learn how to…'* providing the minimum entitlement that all ITE and ECT courses had to cover. Drawing on a common evidence base, the frameworks, which are not subject or phase specific, promote particular ways of teaching (with a focus on cognitive science), narrowing the conception of what it means to be a good teacher and presenting a simplification of what it means to learn to teach. The role of the mentor is supervisory in nature, with student teachers learning through observation and imitation (Hordern & Brooks, 2023). Fidelity to the ITTECF is ensured through its emphasis within the Ofsted ITE Inspection Framework.

Market review: curriculum

More recently, a market review of initial teacher education required all ITE providers to go through a two-stage reaccreditation process and to restructure their courses to meet new quality requirements (DfE, 2021a). Despite the quality of ITE provision being rated highly by student surveys and Ofsted (Ellis & Childs, 2023), and current teachers stating that they had a positive experience on their ITE course (Hordern & Brooks, 2023), the

aim of the market review was stated as enabling "the provision of consistently high-quality training, in line with the CCF, in a more efficient and effective market" (DfE, 2021a, p.4). Whilst standardisation can offer clarity and consistency, it potentially presents a reductive view of learning to teach, suppressing innovation and creativity, qualities recognised as essential in becoming a good teacher (Darling-Hammond et al., 2017; EEF, 2021; OECD, 2020), in a bid to ensure alignment. It also fails to recognise the different learning needs of student teachers who bring with them a wealth of prior educational experiences and potential misconceptions and assumptions (Lortie, 1975). The focus on *Learning that*... and *Learning how to*... neglects *Learning why*..., and the opportunity to consider the purpose of education and learning to teach (Biesta, 2012).

Whilst the CCF set out the content of ITE courses, the market review went further, specifying how this content should be taught, setting new requirements for the structure of ITE courses and for the first time, the development of a mentor curriculum. Curriculum changes for student teachers included the creation of Intensive Training and Practice days (ITaPs) where a "granular" focus for development that would be "immediately practicable and can be utilised in multiple contexts" (DfE, 2025b, p.24) continuing to reflect a simplified conception of teaching as something that can be atomised, observed and replicated. The development of new course materials for ITE courses, such as reading lists and resources used in teaching sessions, were subject to scrutiny by DfE advisors required to ensure fidelity to the new requirements and the CCF before final approval for the course was given. These changes are subject to further scrutiny in subsequent Ofsted inspections.

Market review: mentors

Recent changes in ITE policy have significantly changed expectations of the role of the school-based mentor working with student teachers during their school placements. Previously, mentors were conceived as a supportive colleague on placement, but whilst wider academic research recognised mentors as pivotal in the development of student teachers, they were absent from ITE policy until after the Carter review (DfE, 2015) which identified inconsistencies in practice. The development of the non-statutory mentor standards (DfE, 2016b) had the potential to provide mentors with support and guidance for their role. However, their focus on performance and meeting standards rather than how progress might be achieved led to some suggesting that they presented partial and impoverished view of mentoring (Jerome & Brook, 2019; Peiser et al., 2018).

The role of mentors was a considerable focus within the market review, with ITE providers required to design a research and evidence-based general mentor and lead mentor curriculum that aligned with the CCF and their student curriculum (DfE, 2025b). General mentors were to develop a strong understanding of the student teacher's curriculum and to work closely with them, to provide guidance, support, and feedback. Lead mentors had a much broader remit, working closely with ITE providers to support general mentors, ensure alignment with the ITE curriculum and quality assure their work with student teachers, as well as designing and developing the ITE curriculum, being involved in teaching and mentor development and in recruitment for future student teachers. Whilst this focus on recognising the role that mentors play in supporting and developing student teachers was welcomed by the sector, concerns were raised about the expectations placed on mentors who were required to undertake significant training with no provision of time to do so.

It is surprising that despite high expectations on mentoring within the ITTECF (DfE, 2024b) and the policy guidance for ITE providers (DfE, 2025b), the focus on subject learning of student teachers, and how mentors can support this is limited. A wide range of research highlights that good teachers need to develop their knowledge of subject, how pupils learn the subject and how best to teach (e.g., EEF, 2022; Ball et al., 2008). Current ITE policy guidance has been criticised for adopting a generic approach in its guidance (DfE, 2024c; Hordern & Brooks, 2023), choosing to leave ITE providers to decide what to add for their own contexts, phases and subjects. Mentors are required to have expertise in the subject-specific approaches for pupils' learning, and to support student teachers to understand the prior knowledge and possible misconceptions pupils might have. However, the focus is on the outcomes that need to be achieved by student teachers; it does not consider the subject-specific learning process of student teachers. There is no mention of student teachers' prior knowledge and the subject-specific assumptions, misconceptions and challenges they might face in developing an understanding of how to support the learning of their chosen subject by others.

My research seeks to explore mentors' understanding of the subject-specific learning of student teachers that they work with during placement. It also seeks to understand the potential influences on this understanding, exploring how mentors' prior experiences of learning mathematics and learning to teach, and professional contexts as a teacher and mentor, might impact the ways in which the subject knowledge of student teachers is considered when mentors and student teachers work together during school placements.

1.6 Conclusion and structure of thesis

In this introductory chapter, I set out the rationale for my research. Changing landscapes in schooling and ITE provide new contexts within which student teachers are learning to teach. An increase in the use of standardised resources for the teaching of mathematics in schools has changed the work of mathematics teachers in some schools, and potentially the learning opportunities for student teachers who spend the majority of their ITE course on school placements. With a lack of guidance within ITE policy which considers the subject-specific learning of student teachers, this research aims to hear from experienced mathematics mentors who work closely with student teachers, to learn from their insights developed over time. It also aims to explore the personal, contextual and structural factors that may shape their perceptions and practices as mentors, as they work within changing contexts in schools.

The structure of the rest of the thesis is as follows:

- **Chapter 2**: In this chapter, I review literature relevant to the areas of focus within my research: becoming a mathematics teacher; mathematical knowledge for teaching and being a mentor. The chapter ends with a brief overview of the theory of practice architectures (Kemmis et al., 2013) which will be used as a theoretical, analytical and transformational lens (Mahon et al., 2016) throughout this research.
- **Chapter 3**: The methodology for my research is set out in this chapter. Situating it within a critical realist paradigm, I re-state my research questions and outline my research design, providing a rationale for the qualitative multi-site case study approach adopted and the ethical considerations of this research. Following

this, I explain my approach to data analysis and the development of themes within my research, setting out the dispositional themes which propose potential factors influencing mentors' perceptions and practice.

- **Chapter 4**: Sharing the stories of the four mentors within my research, this chapter aims to give voice to their experiences as learners, teachers and mentors of mathematics teachers. These stories explore the experiential and inferential themes identified in my analysis and use the theory of practice architectures (Kemmis et al., 2014) to identify their individual projects of teaching and mentoring. The chapter ends with a consideration of the similarities and differences in approaches to mentoring across the four mentor stories.
- **Chapter 5**: In this chapter, I present a cross-case analysis of my case studies, drawing on the projects of teaching and mentoring identified in Chapter 4. The chapter focuses primarily on mathematical knowledge for teaching to explore my first two research questions. Through this analysis, elements of experienced mentors' mathematical knowledge of learning to teach are identified.
- **Chapter 6**: Addressing my final research question, I draw on a range of theories in this chapter to explore the dispositional themes identified in Chapter 3 and consider the potential factors that may influence mentors within this research. Theories of mathematical knowledge for teaching (e.g., Ball et al., 2008; Rowland et al., 2014; Shulman, 1987) and the theory of practice architectures (Kemmis et al., 2013) are used to consider the personal, contextual and structural factors that shape mentors' perceptions and practices when supporting the subject knowledge development of student teachers.

- **Chapter 7**: This chapter concludes my thesis, drawing together the main findings of my research and how they may contribute to knowledge about mentoring in Initial Teacher Education more broadly. It also considers the limitations of this research as well as implications and recommendations for future research, policy and practice. It ends with a reflection on the implications of this research on my own professional practice.

Chapter 2: Literature review

2.1 Introduction

This research focuses on the perceptions and practices of experienced mathematics mentors as they work to support the development of student teachers during school placements within their ITE course. As such, there are three main concepts within current research literature to explore:

- becoming a mathematics teacher
- the mathematical knowledge that a teacher needs
- being a school-based mathematics mentor

In selecting articles for this literature review, I started with seminal articles in each area. Next I sought out a range of research- critical reviews, empirical studies, peer reviewed journal articles as well as grey literature such as government documentation and professional responses to policy. Whilst this research takes place in England, research from international contexts was used to develop a wider understanding of research in these areas. Mentoring within teacher education has strong research traditions in Northern Europe, Australia and East Asia, and the US is the site of much research into mathematical knowledge for teaching.

Each area is considered in turn, with links drawn between them throughout the chapter. Following this, I identify a gap in current research literature, namely a lack of research into mathematics mentors' perceptions and practices when working with student teachers to develop their subject knowledge, which this research seeks to explore.

In the final section of the chapter, I draw the discussion together and provide a brief overview of the theory of practice architectures (Kemmis et al., 2013) which is used as a

theoretical, analytical and transformational tool (Mahon et al., 2016) throughout this research, seeking to maintain a dual focus on understanding the perceptions and practice of individuals and the potential factors influencing them.

2.2 Becoming a mathematics teacher

In this section, I consider what is known from research about learning to teach, motivations to teach and assumptions and beliefs that shape early teacher identity development. I also explore the emotional aspect of learning to teach. Whilst current educational policy in England presents a simplified and atomised perspective on learning to teach, a more complex picture emerges from research, acknowledging the emotional impact and the potential tensions involved.

2.21 Learning to teach

Preparation for any profession should develop ways "to think, to perform and to act with integrity" to shape future practice (Shulman, 2005, p.52), but this can be challenging. Becoming a teacher can be fraught with conflict, challenges and emotion as student teachers make sense of themselves as learners and teachers, navigating new professional spaces, and as they make sense of how others learn their subject. Steadman's (2021, p.3) perspective that "learning is influenced both by the capacity to interpret and question social practices and by the emotional reactions to such observations" acknowledges that learning to teach requires an openness to examine previously held beliefs and question things that perhaps had been taken for granted before starting an ITE course, creating uncertainty for the student teacher involved (Flores, 2020).

Whilst many see teaching as something that anyone can do, a wealth of research in early teacher development recognises the complexities in becoming a teacher (e.g., Berliner, 2004). New knowledge and understanding of their subject (Ball et al., 2008) and an understanding of how pupils learn (Shulman, 1986, 1987) needs to be developed alongside new skills, such as reflection and agency (Beijaard et al., 2023) and classroom practices (Darling-Hammond, 2006). However, much of what a teacher knows is tacitly held and invisible to others. New knowledge and skills will remain inert unless student teachers develop intelligent action that enables them to know how to draw on them to meet the needs of diverse pupils in the classroom within a busy classroom (Darling-Hammond, 2006; Feiman-Nemser, 2001a; Mason & Davis, 2013), something that takes years to develop (Berliner, 2001). This domain specific knowledge becomes structured more effectively with greater experience in the classroom so experienced teachers can draw on it more flexibly than new teachers.

As prior experiences within education will be influential in shaping student teachers' starting points, opportunities to analyse motivations, assumptions and beliefs to form new understanding of what it means to be a teacher are essential (Darling-Hammond, 2006).

2.22 Motivations to teach

There are many reasons why people become teachers, however, three broad categories are identified within research: *altruistic*, motivated by a desire to make a difference and do something that is considered worthwhile; *intrinsic*, where a desire to work with children or with the chosen subject is prioritised and *extrinsic*, where status, salary and holidays provide the reasons to join the profession (Kyriacou & Coulthard, 2018). Recent

TALIS 2018 research identified that most teachers in the countries surveyed cited the intrinsic motivation of wanting to influence young people, alongside altruistic reasons as significant in their decision to become a teacher (See et al., 2022). Whilst personal motivation may be a combination of these categories, Andrews and Hatch's (2002) research in England with secondary mathematics teachers found the most common motivations were their own experience of enjoying learning mathematics and wanting to share this, followed by wanting to work with people, both intrinsic motivations.

2.23 Early teacher identity development

Assumptions and beliefs about teaching

Initially, student teachers often start their career with simplistic, intuitive and unexamined beliefs about teaching and learning (Claxton, 1984) which are transmissive in nature (Feiman-Nemser, 2001a) and resistant to change (Eraut, 2000). Exploring these to develop understanding of how best to navigate the realities of current classrooms and meet the needs of diverse learners is essential.

Early teacher identity, influenced by personal, social and cognitive factors, is defined by Flores and Day (2006, p.220) as "an ongoing and dynamic process which entails making sense and (re) interpretation of one's own values and experiences". At a personal level, educational experiences and motivations to teach will inform the type of teacher a person wants to become. They also inform the priorities that student teachers set for their development as they start their ITE course; student teachers may adopt or reject information based on their current idea of what makes a good teacher (Beijaard et al., 2023; Horn et al., 2008).

Student teachers start their career having spent thirteen years in the classroom as a pupil and as they start to learn to teach, they bring with them preconceptions and

beliefs about teaching and learning and mathematics that may enhance or hinder their understanding of how to support the learning of others (Lortie, 1975; Mutton et al., 2010). As student teachers are learning across multiple contexts, in university and schools, their ITE course is important in providing coherence (Beauchamp & Thomas, 2009; Darling-Hammond, 2006: Knight & Sullivan, 2022) as they make sense of their learning environments and their growing understanding of themselves as a teacher of their subject (McIntyre & Hobson, 2016). Student teachers will be subject to a range of controls and influences within contexts that provide different opportunities for learning and development (Kemmis et al., 2014; Brooks, 2021), which led Sjølie and Østern (2021, p.277) to contend that the role of teacher education courses should "support students in navigating how different practices hang together, not expecting coherence or harmony, but learning the skills to anticipate and respond productively to differences and tensions".

Emotional impact of learning to teach

Student teachers' early identities are particularly fragile and easily influenced by others as they make sense of the teacher they want to be and how they want to be seen by others (Day et al., 2006). Beauchamp and Thomas (2009) state that reflection, emotion, agency and context influence the development of identity in student teachers as they make sense of themselves as learners and teachers. The role of subject is particularly important for teachers in the development of their identity (McIntyre & Hobson, 2016), providing a "professional compass" (Brooks, 2016, p.1) or sense of direction for development as a teacher. However, as both subject specialists and subject learners, this constant renegotiation of identity can create tension for student teachers (Thompson, 2023).

Learning to teach is a vulnerable process as student teachers are learners whilst also supporting the learning of others (Kelchtermans, 2017; Lofthouse & Thomas, 2014; Steadman, 2021). They occupy a liminal space (McCaw et al., 2021) "feeling like a student but having to think like a teacher" (Flores, 2020, p.149) with their learning visible to others as they constantly navigate new situations and make mistakes in front of pupils and other teachers. Resilience and courage are required to continue to work with pupils and other teachers (Le Cornu, 2009).

Despite schools being familiar contexts, student teachers describe a lack of belonging and feeling like a stranger as they navigate new physical environments, develop relationships and an understanding of the cultural practices that exist (McCaw et al., 2021). Some report feeling like a fraud, "one must pretend to know how to teach and hope that no one realises" (ibid, p.402), trying to understand a complex environment and their place within it, making sense of the type of teacher they want to be and how to achieve this. More specifically, Pillen at al. (2013) identified common tensions of managing the teacher- pupil relationship, demonstrating care as a teacher alongside being expected to be tough and developing a reasonable work-life balance. When considering the process of learning to teach, student teachers also found managing conflicts between their perceptions of learning to teach and those of others supporting them a challenge (Pillen et al., 2013; Steadman, 2021). The transition shock of early teaching experiences, as student teachers encounter the reality of the classroom, and the mismatch between this and their expectations, requires student teachers to continually re-examine their beliefs and values and how they develop their practice as a teacher.

For student teachers who have had a successful school and university experience, learning to teach is often the first time they encounter significant challenges when learning themselves. The complexity of learning to teach means that it takes time to make progress. Learning to occupy that liminal space between knowing and not knowing, to develop an ability to make decisions when still uncertain (Shulman, 2005), and to learn to "dance in the disequilibrium" (McCaw et al., 2021, p.403) can hinder the development of confidence in student teachers.

Mentors are considered significant in supporting this transition and the emotional impact of learning to teach (Pillen et al., 2013; Shields & Murray, 2017) providing a space to explore uncertainties. Student teachers also value opportunities to work things out for themselves, suggesting the importance of mentors asking questions rather than providing solutions at times (Mutton et al., 2010), stepping back to enable them to develop greater responsibility and agency (Shields & Murray, 2017). Student teachers consider mentors as significant in the development of their identity, but this is not something always recognised by the mentors themselves (Izadinia, 2016).

Becoming a mathematics teacher also presents additional emotional and pedagogical challenges linked to the performative nature of the subject. This will be explored further within the following section.

2.3 Mathematical knowledge for teaching

Student mathematics teachers in England currently come from a wide range of disciplinary backgrounds with 38% having a mathematics degree (Worth, 2024). Whilst those without mathematics related degrees are aware of the need to develop their mathematical knowledge further as a teacher, many who have a background of strong

mathematical achievement think they already have all the mathematical understanding that they need to be a teacher (Davis & Renert, 2013a). However, for all professionals, knowledge used in different contexts requires further learning (Eraut, 2000), something that has been explored in depth within teaching (Shulman, 1986). Whilst strong qualifications might indicate a good foundation for teaching a subject, they are not sufficient as student teachers begin to support the learning of others (Coe et al., 2014; Davis & Renert, 2013b). In agreement with Shulman (1986), Baumert at al. (2010, p.139) found that such subject knowledge "remains inert in the classroom unless accompanied by a rich repertoire of mathematical knowledge and skills relating directly to the curriculum, instruction, and student learning."

Previous educational experiences will shape the nature of a student teacher's own mathematical knowledge as well as their views of mathematics as a subject and their early beliefs about how it should be taught (Petrou & Goulding, 2011; Schoenfeld, 2012). Due to a focus on exam performance throughout their own schooling, their own mathematical understanding may be instrumental and fragmented in nature when what is needed in practice as a teacher is a rich, connected understanding of mathematics that enables them to respond flexibly to pupils' needs when teaching (Davis & Simmt, 2006; Gess-Newsome, 1999; Hill et al., 2005). Central to this is understanding how pupils learn new mathematical ideas, which Davis and Renert (2013b, p.9) express as needing to become an "expert who thinks like a novice", including novices who may see and understand mathematics very differently.

In the following sections, I explore debates within research about mathematical knowledge for teaching and how this is developed by student teachers.

2.31 Debates about mathematical knowledge for teaching

The specialised subject-specific knowledge that is a mark of a teacher's professional expertise has been widely researched and debated since Shulman's seminal work in the 1980s. At a time when ITE courses were generic in nature, his research with student teachers elevated the importance of developing subject knowledge for teaching, identifying content knowledge, curriculum knowledge and pedagogical content knowledge (PCK) as subject-specific categories (Shulman, 1986) which became part of his wider taxonomy of teacher knowledge (Shulman, 1987). Content knowledge considers the student teacher's own mathematical knowledge along with an understanding of how mathematics is structured, a distinction that has much in common with Schwab's (1978) substantive and syntactic knowledge. The concept of PCK, an amalgam of knowledge of subject and pedagogy, was defined by Shulman (1986) as:

> for the most regularly taught topics in one's subject area, the most useful forms of representation of those ideas, the most powerful analogies, illustrations, examples, explanations and demonstrations- in a word, the ways of representing and formulating the subject that make it comprehensible to others. (p.9)

It includes an understanding of what makes a concept easy or difficult to understand and the common misconceptions that might arise for pupils, as well as how to structure, represent and connect new mathematical idea.

PCK is widely accepted within research in mathematics education as practical professional knowledge for teaching that is subject-specific in nature, but Shulman's

initial work has been critiqued and developed by others. Some highlight the absence of beliefs within his knowledge base (Ernest, 1989; Fennema & Franke, 1992; Lannin et al., 2013), acknowledging the significant influence that beliefs play when teaching mathematics within their own research. Petrou and Golding (2011) suggest that Shulman's taxonomy is static, promoting a transmission approach to teaching. Others contend that PCK is ill-defined (Baumert at al., 2010; Ball et al., 2008) or just a deeper understanding of content knowledge (Krauss et al., 2008; Lannin et al., 2013). Further critique of Shulman's ideas include challenging his assertion that content knowledge is transformed into PCK. Gess-Newsome's (1999) alternative view that PCK is an outcome of the integration of distinct types of knowledge (subject, pedagogy, context), arising from the experiences of teaching and reflection has much in common with others who recognised the cultural, contextual, and collective nature of PCK (Fennema & Franke, 1992; Scheiner, 2022).

Some researchers suggest that any focus on defining different categories of mathematical knowledge is unhelpful (Davis & Renert, 2013a; Watson, 2008) highlighting instead the need to develop an awareness of mathematical thinking with Davis and Renert (2013a, p.245) suggesting that mathematical knowledge for teaching is a "learnable disposition rather than a domain to be mastered." Mason and Davis (2013) suggest that this way of being as a teacher requires the development of critical reflective and collaborative skills so that a teacher develops the mathematical knowledge to know how to act in the moment when teaching, what to give attention to, what to emphasise, connect or ignore to support the learning of pupils.

Other researchers have sought to bring greater clarification to Shulman's ideas through their own subsequent models. For example, Fennema and Franke's (1992) focus on the situated nature of mathematical knowledge for teaching within their model places consideration of beliefs and context central to developing knowledge of mathematics, pedagogy and understanding of learners, recognising the interactive and dynamic nature of knowledge created through the act of teaching. Rowland et al.'s (2014) knowledge quartet, a model designed for lesson observation of mathematics lessons within a primary setting, identifies foundation knowledge (consideration of beliefs about teaching and learning mathematics) underpinning three other categories: transformation (knowledge-in-action, required for planning and teaching); connection (relating to coherence and structure) and continency. In agreement with Mason and Davis (2013), contingency focuses on a teacher's readiness to respond to learning within a lesson, to think on one's feet and respond to pupils' answers, something that cannot be fully planned for in advance but that can be developed through teaching experience, discussion and reflection.

Within mathematics education, Ball et al.'s (2008) *Domains of mathematical knowledge for teaching* has been influential. Whilst not addressing previous concerns about beliefs, their model aimed to draw together ideas about different categories of mathematical knowledge and ways of thinking about mathematics. Building on Shulman's dual focus within content knowledge, they include an additional category of specialised content knowledge, highlighting the depth and thoroughness with which a teacher would need; a relational understanding (Skemp, 1976) of topic to be able to teach it well (Figure 2.1). Although rooted in a teacher's practice, it could be developed outside of the classroom as it does not require additional knowledge of pupils. It

involves developing an understanding of how and why something works, learning multiple methods and the links between then, being able to define and explain mathematical concepts and understand mathematical errors, encompassing many ideas expressed by Schwab (1978) and Skemp (1976).

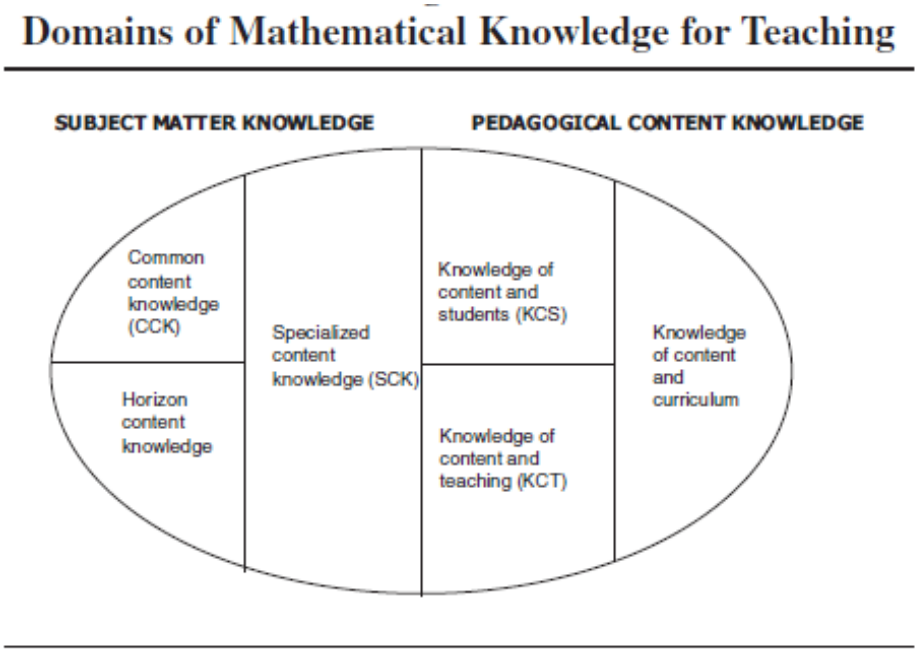


Figure 2.1

Domains of mathematical knowledge for teaching (Ball et al., 2008, p.403)

Addressing concerns that Shulman's definition of PCK needed further clarification, Ball et al. (2008) identified sub-domains of knowledge of content and students, knowledge of content and teaching and knowledge of content and curriculum. Knowledge of content and students involves understanding what pupils may find hard or confusing when they are learning mathematics, common misconceptions that might arise within a topic and how to make sense of ideas that pupils might share as they respond to

questions in class. Knowledge of content and teaching refers to knowledge of how to plan teaching to support pupils to learn. It includes knowing how to break down and sequence new mathematical ideas in ways that aid understanding, how to represent ideas in different ways, how to choose examples that address misconceptions. Knowledge of content and curriculum involves understanding the purpose and structure of the school curriculum and was previously a separate category in Shulman's teacher knowledge base. Together, these subdomains aim to develop a way of thinking about teaching and learning mathematics that enables teachers to make pedagogical choices that can anticipate and respond to the needs of pupils in the classroom.

Having considered debates around the nature of mathematical knowledge for teaching, in the next section I explore what is known about how this knowledge is developed by student teachers.

2.32 Developing mathematical knowledge for teaching

So far, my review of the literature has shown that whilst strong content knowledge is a good foundation for teaching, it is not sufficient to support the learning of others. Becoming a mathematics teacher requires the development of new understanding of mathematics. In this section I consider what is known from research about the development of mathematical knowledge for teaching.

Depaepe et al.'s (2013) systematic literature review identifies the different ways in which the development of PCK has been researched in recent years. Those with a cognitive perspective of PCK focus on gaps in teachers' knowledge and how to develop it. For example, Kinach's (2002) work with student teachers explored their understanding of a good explanation as she worked with them during a mathematics method course. With

student teachers initially providing rule-based explanations without reasoning when teaching about negative numbers, Kinach adopted a dialogic approach to teaching student teachers that involved identifying and assessing their current explanations before discussing and developing ways to improve them, enabling them to realise that memorising was not the same as understanding.

Those with a situated perspective of PCK explore its development within the classroom or school context, drawing on observations, interviews and lessons to generate an understanding of how teachers' mathematical knowledge is enacted (Hill et al., 2005). Like Kinach (2002), Horn (2009) also focused on the development of explanations when teaching, but did so within school departments, exploring the impact of collaborative discussion with teachers during student teachers' placements. He found that conversations with less experienced colleagues focused more on the development of procedural understanding when discussing pupil misconceptions, but when the department had more experienced teachers, consideration of the conceptual difficulties that led to pupil misconceptions were discussed. Lannin et al.'s (2013) small scale research with student mathematics teachers explored the development of their PCK throughout their ITE course, finding that PCK developed in different ways due to an individual's content and pedagogic knowledge, their school context, and their reflection on their own learning leading to the prioritising of different types of understanding as a teacher, something also highlighted by Brooks (2016).

Van Driel and Berry (2010, p.658) suggest that the development of PCK is complex and takes time to develop stating that "until a teacher has gained sufficient confidence and experience and mastered basic classroom skills, the development of PCK as a readily

accessible and useful translation of subject-matter knowledge into classroom practice may be delayed.", something that was observed in Horn's (2009) research above. It is not something that can be learnt from an expert teacher and then immediately implemented in practice. However, mentoring and collaborative learning communities can provide opportunities to develop PCK, for example, through observation and post-lesson discussion (Rowland et al., 2014), collaborative discussion focused on pupil learning (Horn, 2009; Lannin et al., 2013; Nilssen, 2010), lesson study (Ní Shúilleabháin, 2016) and instructional courses (Kinach, 2002).

Teachers are often unaware of the specialised subject-specific knowledge that they have developed (Van Driel & Berry, 2010). However, as practising teachers, mentors are well positioned to play a key role in the development of this subject-specific knowledge when working with student teachers. In the next section, I move on to consider research linked to mentoring within education more broadly before returning to consider current research about their role in subject knowledge development.

2.4 Mentoring

Mentors play a pivotal role in the development of student teachers (Darling-Hammond et al., 2017; Ellis et al., 2020; Hobson et al., 2009) but despite a vast body of research into mentoring in education, it remains a contested practice (Brondyk & Searby, 2013; Kemmis et al., 2014). The complex and multifaceted nature of mentoring means that social, developmental, and learning theories provide different lenses through which mentor practice can be considered, resulting in a "plurality of theories" (Kemmis et al., 2014, p.154) and a lack of agreement about what constitutes best practice and how to develop it (Dominguez & Hager, 2013; Brondyk & Searby, 2013). A range of purposes for

mentoring are also evident across different educational contexts (Kemmis et al., 2014). Clarity within research of mentoring in education has been hindered by comparison of professions where mentoring roles are dissimilar (Clutterbuck, 2013), a lack of comparison across similar fields (Hobson & van Nieuwerburgh, 2022) and the challenge of isolating the impact of mentoring from support provided in other ways (Hobson et al., 2009).

Historical, social, and political influences as well as individual beliefs and experiences will shape both the learning environments in schools and universities and the learning dispositions of mentors and student teachers. In this section, I consider the range of purposes of mentoring in education, the role of context when learning to teach, the nature of the role of the mentor and the different approaches identified within research. This section ends with consideration of research that links mentoring and the subject knowledge development of student teachers, identifying a gap in current research and highlighting the purpose of this research.

2.41 Purposes of mentoring

Reviewing international literature on mentoring reveals a range of purposes for mentoring within educational policy and research, including improving recruitment and retention of new teachers, developing teaching quality and improvement in outcomes for pupils (Bullough, 2012; Darling-Hammond et al., 2017). In addition to these purposes, mentors themselves report significant benefits of being involved in mentoring new teachers (Hobson et al., 2009).

Educational policy increasingly positions mentors as significant in the retention of new teachers (Ingersoll & Strong, 2012; Darling-Hammond et al., 2017; DfE, 2019c). The

most recent workforce data for teaching in England reports that 12.8% of teachers leave within one year, rising to 19.9% after two years, with mathematics teachers more likely to leave that other subjects (DfE, 2024d). The main reasons provided by teachers for leaving the profession include high workload and poor wellbeing (DfE, 2024f). For early career teachers, a mismatch between the expectations and the reality of classrooms is also a significant factor in their decision to leave teaching (Perryman & Calvert, 2020) as well as a lack of support (Ingersoll & Strong, 2011). However, the right level of support is also the reason teachers stay (Hatley & Kington, 2022; Jerrim, 2024). The role of mentors in providing support to address retention was a significant focus within the current Recruitment and Retention strategy in England (DfE, 2019c). Whilst recent figures identify a slight increase in retention for teachers after one year of teaching (DfE, 2024d) the reason for this is unclear. In countries where there is a higher retention rate within the profession, Darling-Hammond et al. (2017) identified strong mentoring programmes as a common feature within teacher preparation and induction. In these programmes, there is a focus on developing student teachers' specialised subject-specific knowledge of teaching. Mentors play a significant role in working with student and early career teachers to develop their content and pedagogical knowledge during placements with those sharing the same subject specialism found to be most effective (Hobson & Maxwell, 2020).

Developing teaching and better outcomes for pupils is also commonly recognised as a purpose of mentoring (Bullough, 2012: DfE, 2019b; Ingersoll & Strong, 2011; OECD, 2020). However, approaches to achieve this vary widely and are linked to cultural and policy expectations about what it means to be a good teacher (Kemmis et al., 2014). A

mentor's own experiences of learning mathematics (Lejonberg et al., 2018), learning to teach mathematics (Richter et al., 2013) and beliefs about teaching and learning mathematics (Crasborn et al., 2011; Korthagen, 2004) are significant when working with student teachers. However, this can create conflict when working with student teachers who may not share the same perspectives about teaching (Izadinia, 2015; Pillen et al., 2013; Shanks, 2014). In addition to this, mentors and student teachers do not always have a shared understanding of the purpose of their mentoring relationship (Hobson et al., 2009; Hudson, 2013; Izadinia, 2016). Lofthouse (2018) highlights a shift in recent years with mentors reporting that student teachers are more focused on the standards for assessment and are increasingly risk averse, perhaps unsurprising given the culture of accountability and performativity in England throughout their own schooling and the need to build early confidence as a teacher (Knight & Sullivan, 2022). In England, a technicist view of learning to teach within educational policy positions the mentor as an expert to copy, an approach which can lead to conflict if mentor and student teacher do not share similar views on approaches to teaching and learning (Steadman, 2021). However, in northern Europe and East Asia, more reflective, developmental approaches are promoted within educational policy, supporting mentors to develop student teachers as reflective practitioners. This is made possible by additional professional development qualifications for mentors in Norway (Lejonberg et al., 2018), changes within educational policy in Singapore (Ng, 2012) and separation of mentor and assessor role in Germany (Jones, 2001). In China, a culture of collaboration that exists across the profession ensures that there is sufficient time for student teachers to work developmentally with experienced teachers, collaboratively planning to improve their practice (Lee & Feng, 2007).

Mentoring can also be conceived as a way to shape whole school practices. This could be ensuring approaches, identified as good practice, are replicated, building on established wisdom and experience (Ng, 2012; DfE, 2019b) or refining and developing current understanding of how to teach (Aderibigbe et al., 2018), enabling individuals, departments, schools, and wider educational systems to innovate (Hobson & van Nieuwerburgh, 2022; Kochan & Pascarelli, 2012; Thorton, 2014). However, this is not without its challenges. Even when innovation and collaboration is encouraged, wider performativity measures or cultural expectations may restrict what is possible in practice. For example, respect of the elder within Japanese culture means that an apprenticeship approach to mentoring, where the student teacher copies their mentor, is prevalent despite collaboration being encouraged (Asada, 2012).

A final purpose of mentoring evident with research is the positive impact mentoring can have on mentors' wider professional development (Hobson et al., 2009), through opportunities to discuss teaching and learning with others and develop their own reflection (Lopez-Real & Kwan, 2005) as well as learning from student teachers (Ambrosetti et al., 2014; Lejonberg et al., 2018). Positive outcomes for mentors also include increased knowledge and skills as a teacher, increased confidence and a satisfaction in being involved in the success of the student teacher (Hobson et al., 2009). However, contextual conditions in schools may mean the positive potential of the mentor's role is not fully realised. One of the most consistent challenges identified within research is a lack of time provided for the role of the mentor which can result in increased stress and workload (Bullough, 2005; Hobson et al., 2009; Lee & Feng, 2007; Maud et al., 2024). With the outcomes of student teachers not significant for the

performativity and accountability measures for school, some mentors report a lack of support and recognition for mentoring within the school setting, which can result in feelings of isolation (Hobson et al., 2009; Maud et al., 2024).

2.42 Context of mentoring

Learning environments will be influential when mentoring student teachers. Kemmis et al. (2014) contend that mentors are enabled and constrained by the practice architectures that exist within educational contexts. These architectures reflect ideologies underpinning wider educational policy and cultural expectations. Comparing approaches to mentoring new teachers in three different countries, they highlighted how the semantic, physical and social spaces in which mentoring takes place will be influential, fostering different understandings of the role of the mentor, how this can be enacted and on the type of teacher developed. For example, within a tradition of collaborative action research already established in education in Finland, Kemmis et al. (2014) see mentoring as a process of *collaborative self-development*. Whilst the mentor will be a more experienced teacher, a recognition that all participants bring different knowledge from their own experiences seeks to establish non-hierarchical relationships and an openness to learn from each other. The social space for learning is outside of the school context, enabling open discussions about professional wellbeing and learning. This supports teachers to raise questions and develop a sense of their role in their on-going self- development as teachers as well as engagement and development within a wider community. In Sweden, a supportive but hierarchical approach is evident. Sitting outside of the assessment process but within the school context, mentoring is conceived as *support*, mentors and new teachers observe each other and meet regularly with time provided for this. New teachers receive support to develop their

practice as a teacher and their understanding of being a professional. In Australia, mentoring is conceived as *supervision*. With educational policy focused on teacher effectiveness and standards, mentoring is formal in nature with mentors positioned as gatekeepers to the profession, determining whether the required standards have been met. Kemmis et al. (2014) suggest that teachers within this context develop a focus on performance and compliance.

However, Kemmis et al. (2014) acknowledge that in reality, within different countries, a range of approaches to mentoring will co-exist and student teachers may experience all three forms of mentoring mentioned above. In common other previous research (Crasborn et al., 2011; Lejonberg et al., 2018; Richter et al., 2013), Kemmis et al. (2014) highlight that the learning dispositions, values and beliefs of the mentors and student teachers involved will also be influential.

England has many similarities with Australia, with a supervisory approach to mentoring reflected in the non- statutory mentor standards (DfE, 2016b) that arose out of the Carter review (DfE, 2015) and in the current ITTECF (DfE, 2024b). Wider educational policy, performativity and accountability measures, and Ofsted subject reviews will influence practices within MATs and individual schools, potentially creating an expectation that good teaching is about performance and compliance to a particular way of teaching. Hobson et al.'s (2009, p.211) review of literature on mentoring identified a need for "contexts free from excessive emphasis on externally determined goals and agenda" to create effective conditions for mentoring, yet the direction of travel within ITE policy in England since then is at odds with this.

2.43 The multi-faceted nature of the mentor role

With a range of purposes for mentoring evident, the role is often described in research as multi-faceted (Ambrosetti, 2010; Brondyk & Searby, 2013). Being sensitive to the stage of learning and the emotional needs at the time, mentors may need to act, for example, as a coach, sponsor, teacher, guide, facilitator, friend, counsellor, role model, co-learner, at different times, reflecting the psychological, sociological, and cognitive aspects of the role (Dominguez & Hager, 2013). Four main aspects of the mentor's role are evident across research and policy: supporting the emotional impact of learning to teach (Feiman-Nemser, 2001a; Izadinia, 2016); socialisation of the student teacher into the profession and their understanding of what it means to be a teacher (Izadinia, 2016); developing their knowledge and skills in becoming a teacher (Hobson et al., 2009: Feiman-Nemser, 2001a) and assessing progress (Jones, 2001). Within educational policy in England, there is greater focus on the final two aspects of the role, potentially overlooking the importance of providing support that develops student teachers' sense of belonging within a school and their resilience to manage the demands of their new role, both considered significant when becoming and remaining a teacher (Kelchtermans, 2017; McCaw et al., 2021; Shields & Murray, 2017). The multi-faceted nature of the mentor role is summarised in the definition by Hobson and Maxwell (2020) who conceptualise mentoring in education as:

> a formal, one-to-one relationship.... between a relatively inexperienced teacher (the mentee) and a relatively experienced one (the mentor), which is intended to support the mentee's (though may also support the mentor's) learning, development, and well-being. (p.185)

Whilst this definition of mentoring recognises the importance of well-being when learning, with the mentor well placed to provide this support through developing a relationship which is open, it also recognises the reciprocal learning possible within the mentor role, something identified by others (Ambrosetti et al., 2014; Lejonberg et al. 2018).

Importance of mentor- mentee relationship

At the heart of mentoring, is a supportive relationship between a more experienced teacher and a novice (Hobson & van Nieuwerburgh, 2022). The vulnerable nature of learning to teach is well documented (Kelchtermans, 2017; Lofthouse, 2018; Shanks, 2014; Steadman, 2021) and requires a strong, trusting relationship to be developed between student teachers and their mentor (Hobson et al., 2009; Lofthouse & Thomas, 2014). However, the mentor's role as an assessor, unavoidable within current educational requirements in England, can compromise the level of openness in the mentoring relationship (Ambrosetti at al., 2014) and create performative rather than learning spaces (Sjølie et al., 2019). This focus on assessment can also result in the student teacher concealing perceived weakness or their developmental needs (Hobson & Malderez, 2016; Hobson & McIntyre, 2013) particularly around subject knowledge (Youens & McCarthy, 2007).

Importance of socialisation into the profession and workplace

Student teachers highly value support from mentors to navigate a new profession and a new workplace environment (Izadinia, 2016; Lofthouse, 2020; Shanks, 2014). Mentors are credited with supporting student teacher to manage expectations about teaching, when early idealism about the role is confronted with the reality of the classroom during

placement experiences (Perryman & Calvert, 2020; Voss & Kunter, 2020), something that increases the emotional exhaustion and stress experienced by student teachers. Fostering a sense of belonging through collaboration with others (Shields & Murray, 2017) can help to reduce the vulnerability felt by student teachers. Mentors can support student teachers to develop the capability and resilience required to be a teacher (Ellis et al., 2020) and help to reduce feelings of isolation (Ingersoll & Strong, 2011), increasing their confidence and openness to ask for help and guidance (Hobson et al., 2009). Student teachers need to understand what it means to be a professional teacher and learn to adapt to the social and cultural norms and expectations within their placement school and department in order to foster a sense of belonging (Kelchtermans, 2017). This may be particularly challenging if their new school context is substantially different from their own experience of schooling, requiring them to question their understanding of what it means to be a teacher as they make sense of a new environment.

Importance of the development of understanding of how to teach

Whilst developing a good relationship and providing emotional support are an essential part of the mentor's role, they are not sufficient in developing a student teacher's understanding of learning and their practice in the classroom (Bullough, 2005). They need to learn to teach their subject and to develop a clear sense of their identity as a teacher (McIntyre & Hobson, 2013). However, with their primary role as a teacher, mentors can feel outside their comfort zone when try to support student teachers as they learn to teach (Lejonberg et al., 2018) as their own teaching comes under scrutiny (Bullough, 2005). Hobson et al.'s (2009) review of literature on mentoring in education identified that research on the impact of mentoring on quality of teaching is limited due

to challenges of disentangling this from other experiences during PGCE year. However, student teachers report the benefits of learning from mentors through observing them teach, discussing lesson planning, being observed when teaching and discussing their teaching, receiving feedback, support and guidance through post-lesson discussions (Ambrosetti, 2010).

2.44 Approaches to mentoring in research

Given the variety of purposes and contexts within which mentoring student teachers takes place, and the multi-faceted nature of the role, it is unsurprising that a range of theoretical frameworks for mentoring in education are evident within research. Pivotal work by Feiman-Nemser (1998, 2001a) first made the distinction between *traditional* and *educative* approaches, suggesting that the latter recognised the complexity of learning to teach and provided opportunity for the development of a way of thinking that would sustain ongoing development as a teacher. In this section, I consider theoretical frameworks developed since then under these headings before considering the wider contexts influencing approaches adopted. Many, including Feiman-Nemser herself, acknowledge that a range of approaches may be beneficial for different purposes at different stages of a teacher's development (Brockbank & McGill, 2012; Feiman-Nemser, 2001a) and that the context within educational policy and schools as well as the individuals involved will be influential in the approaches used (Kemmis et al., 2014). This will also be explored below.

Traditional Approaches

A traditional approach to mentoring, as reflected in the ITTECF (DfE, 2024b) is rooted in behaviourist theories of learning (Kemmis et al., 2014; Van Ginkel et al., 2016; Wang &

Odell, 2007). Within research, traditional approaches have been described as an apprenticeship model (Feiman-Nemser, 2001b); supervision (Kemmis et al., 2014); situated apprentice (Wang & Odell, 2007) or performance-oriented (Brockbank & McGill, 2012). These approaches portray an atomised and competency-based model of mentoring, where knowledge, skills and values are transferred from mentor to student teacher; learning to teach is about replication and conforming to current ways of working rather than seeking best practice and learning through inquiry and reflection (Feiman-Nemser, 2001b; Kochan & Pascarelli, 2012) leaving beliefs unexamined (Feiman-Nemser, 2001a). This perspective of mentoring is reflected in the ITTECF (DfE, 2024b) and the current ITT guidance criteria (DfE, 2025b) in England where a mentor is an expert teacher who can articulate their practice and has a clear understanding of the standards required; the mentor's role as an expert is to smooth the student teacher's path and provide direct guidance to develop a set of skills and techniques that can be observed in the classroom.

Traditional approaches offer some benefits for mentors and their student teachers: mentors report an increase in self-efficacy (Lejonberg et al., 2018), with sharing quick fixes for classroom performance boosting the confidence of student teacher and mentor. Mentors are placed within their comfort zone, sharing what they do know and understand about teaching and learning rather than stepping into a more reflective space about learning to teach, bringing uncertainty (Lejonberg et al., 2018). With their identity as a teacher firmly established, mentors are likely to adopt the role of expert when mentoring as they would do when teaching (Crasborn et al., 2011). In addition to this, traditional approaches provide opportunities to build on the wisdom of practice

(Hudson, 2013; Shulman, 2000) developed by experienced teachers meaning that the need to reinvent the wheel is avoided (Kemmis et al., 2014). In adopting common practices from within the school context, student teachers may also start to fit in and develop a sense of belonging (Kelchtermans, 2017).

However, whilst traditional approaches might foster early confidence in student teachers, a focus on replication over innovation adopts a narrow perspective of teaching and learning and can result in superficial learning if performance is prioritised above understanding (Aderibigbe et al., 2018). Feiman-Nemser (2001a) sees traditional approaches to mentoring as insufficient in educational contexts as student teachers need to develop intelligent action which enables them to respond intuitively to situations in the classroom; knowing how to act and draw on knowledge is not something that can be copied from others (Lofthouse, 2018). Leaving initial beliefs about teaching and learning mathematics unexamined reduces the potential to understand how to develop a wider range of approaches to support the learning of all (Claxton, 1984; Wang & Odell, 2002). With a focus on performance in the classroom, traditional approaches may also lead to judgementoring (Hobson & Malderez, 2016), where a mentor adopts an evaluative rather than developmental approach, or teacher fabrication (Hobson & McIntyre, 2013), where a student teacher conceals difficulties, further compromising the open relationship required to ensure student teachers can be supported to develop their teaching.

Educative approaches

In contrast to traditional approaches to mentoring, Feiman-Nemser (2001a) suggests that educative approaches, rooted in social constructivist learning theory, provide

experiences that promote the professional growth of student teachers and the mentors working with them (Hobson et al., 2009; Ng, 2012; Richter et al., 2013; Van Ginkel et al., 2016). Adopting a more reflective, inquiry-based view of learning, educative approaches are dialogic, with discussion between mentor and student teacher aiming to develop understanding of learning and classroom practice and their identity as a teacher. Central to these approaches is the development of reflective skills to enable continued learning (Aderibigbe et al., 2018; Berliner, 2001; Harrison et al., 2006).

Kochan and Pascarelli (2012) categorise educative approaches as transactional or transformational. A transactional approach conceives the mentor and student teacher as co-learners as described above but a transformative approach, extends this collegiality further: joint inquiry and creativity feature as the mentor and student teacher question things that have previously be taken for granted in the mentor's practice. This transformative stance has much in common with others such as a critical constructivist approach (Wang & Odell, 2007) developmental mentoring (Brockbank & McGill, 2012; Harrison et al., 2006) and Kemmis et al.'s (2014) view of mentoring as collaborative self-development, emphasising the reciprocal nature of learning within this relationship.

The benefits of educative approaches for mentors and students include their positioning as co-learners of teaching. Adopting a reflective stance enables both to develop skills to learn in and from practice (Aderibigbe et al., 2018). Working collaboratively to plan, teach and analyse practice, the mentor can adopt the role of instructor or facilitator as needed to guide the learning of the student teacher in a scaffolded way (Lofthouse & Thomas, 2014), blending showing and telling with asking and questioning (Feiman-Nemser, 2001b). This creates agency for the student teacher,

developing their thinking about teaching and their capacity to respond contingently in the classroom when working with pupils.

Whilst offering an approach to mentoring that enables both mentor and student teacher to learn at a deeper level, there are considerable challenges with educative approaches. Mentors are no longer experts and are placed outside their comfort zone, potentially undermining their confidence, and becoming more aware of what they do not know (Bullough, 2005; Lejonberg et. al., 2018). Mentoring in this way requires an understanding of learning to teach and requires an expertise that goes beyond being a good classroom teacher (Lofthouse & Thomas, 2014). Whilst they have expertise as classroom teachers of their subject and understanding of their school context, they may be unaware of the knowledge that they have developed as experienced teachers, much of which is drawn on intuitively when teaching. Berliner (2001) suggests that knowledge is structured more effectively and drawn upon more flexibly by experienced teachers compared to student teachers, highlighting that experienced and novice teachers think and act in different ways. Time and support are needed to help mentors develop their understanding of how others learn to teach their subject (Hobson et al., 2009). Also, what can be lost in educative approaches is the potential to learn from the wisdom of others and build on established and well-honed practice, placing an unnecessary burden on mentors and student teachers.

Having considered the mentor's role in supporting student teachers as they learn to teach, the next section considers their role in the subject knowledge development of student teachers.

2.45 The mentor's role in the development of mathematical knowledge for teaching

Within the current context for ITE, the university and school settings provide different opportunities for learning and developing mathematical knowledge for teaching. Each context plays a role in developing knowledge further, either reinforcing or challenging initial beliefs about mathematical knowledge and teaching and learning (Ernest, 1989; Rowland et al., 2014). Whilst a student teacher may initially be confident in their own subject knowledge or more concerned about gaps in their own content knowledge, during school placements the need to be able to do more than just explain things clearly to pupils becomes evident.

As a teacher working in school, mentors are well placed to support the development of student teachers' mathematical knowledge for teaching. Depaepe et al.'s (2013) systematic literature review on the development of PCK in student teachers suggests that collaborative working cultures provide a context to develop student teachers' understanding in this area, with consideration of textbooks, discussion of teaching experiences and videoing highlighted as ways to do this. However, this will only be possible if a strong, supportive and open relationship between mentor and student teacher is developed.

The university setting was previously seen as the place for subject knowledge development of student teachers. Consequently, research mainly focuses on the ways in which university tutors develop various aspects of subject knowledge (e.g., Kinach, 2002; Kleickmann et al., 2012; Lannin et al., 2013). There is a lack of research that explores mentors' perspectives and practice related to the development of subject knowledge for teaching.

Research that does connect mentoring and subject knowledge development highlights a range of challenges experienced by mentors and student teachers. Some mentors perceive subject knowledge development to be a significant part of their work (Klieger & Oster-Levinz, 2015; Lopez-Real & Kwan, 2005) whilst others shy away (Hobson et al., 2009) due to a lack of confidence. As mentioned previously, mentors themselves may also be unaware of the nature and range of their own subject-specific knowledge that they draw on day to day when they are teaching (Van Driel & Berry, 2010). The tacit nature of their mathematical knowledge for teaching and their decision making when they teach mean it can be difficult to articulate this to student teachers, placing mentors outside their comfort zone or perceived area of expertise (Bullough, 2012; Lejonberg et al., 2018).

Other challenges arise from the contexts within which mentors and student teachers are working together. As explored in Chapter 1, the rise of academies and MATs has reduced teacher agency in many schools, with many mathematics lessons planned centrally (Traianou et al., 2025). This standardised approach to teaching mathematics may restrict the freedom teachers have when teaching themselves and may have an impact of how teaching and learning is explored by a mentor working with a student teacher. In addition to this, accountability and performativity pressures may mean that schools focus on the performance of pupils in external exams (Brown et al., 2015; Ofsted, 2023) which is then reflected in how mentors are able to work with student teachers. This raises questions about the experiences that student teachers have during school placements as some contexts may provide more limited opportunities to explore alternative approaches to teaching and learning.

For student teachers, the adjustment from an academic to pedagogic understanding of mathematics presents a challenge to their early perceived strengths (Shulman, 1986). The vulnerable nature of student teacher identity highlighted within research (Flores & Day, 2006) means it can be destabilised by early experiences on the course. A recognition that teachers need to be able to do more than clearly explain makes them aware of the complexity of teaching that perhaps they had not recognised prior to starting their course, and something that they feel they need to conceal due to the assessor role of the mentor (Youens & McCarthy, 2007).

2.5 Theory of Practice Architectures

Within my literature review, I have considered research about becoming a mathematics teacher, the mathematical knowledge for teaching needed to support the learning of pupils and the role that mentoring plays in supporting and developing student teachers. In doing so, I have set out how personal, contextual and structural factors may influence the ways in which mentors and student teachers work together. In my research, to make sense of these different potential influences on mentors' perceptions and practices, I draw on the theory of practice architectures (Kemmis et al., 2013) which I now outline briefly below.

The theory of practice architectures (Kemmis et al., 2013; Mahon et al., 2016) is used in a variety of ways in my research, as:

- *a theoretical* lens through which to view education and professional practice and understand the complex relationship between practices and what makes them possible

- an *analytical* resource to understand how context enables and constrains practice as teachers and mentors
- a *transformational tool* to find ways to develop future practice recognising that the local and national context and the individual involved will influence the practice of mentoring.

Teaching and mentoring are social practices, and the theory of practice architectures provides a way to understand how such practices are formed, sustained and transformed. Distinguishing practices from actions (which form a part of practice), Kemmis et al. (2013) suggest that practices consist of three interrelated elements which together form a particular project: sayings (language and discourse) doings (activities and work) and relatings (social relationships and power dynamics). The project of a practice comprises of the aims that motivate the practice, the actions that take place (sayings, doings, relatings) and the ends that the mentor aims to achieve. Mahon et al., (2016) suggests that

> Being social and situated, practices are not just shaped by the experience, intentions, dispositions, habitus, and actions of individuals. They are also shaped and prefigured intersubjectively by arrangements that exist in, or are brought to, particular sites of practice. (p.7)

The arrangements therefore "pre-figure though they do not pre-determine people's practice" (Kemmis et al., 2014, p.156) as practice is also shaped by practice traditions, inherited ways of thinking, acting and relating, as well as the current working context. Reciprocally, over time, the history, experiences, beliefs and intentions of individuals and the social context shape arrangements that exist, acknowledging the fluid nature of

the arrangements and evolution of both context and practice. Summarised in Figure 2.2 below, Kemmis et al. (2013) states that practice is located in three interrelated spaces:

- Semantic space through *cultural-discursive arrangements*: the ways in which teaching mathematics and mentoring student mathematics teachers is understood and discussed (sayings)
- Physical space through *material-economic arrangements*: space and resources available for teaching mathematics and mentoring (doings)
- Social space through *socio-political arrangements*: the ways in which people relate to each other as teachers and mentors (relatings)

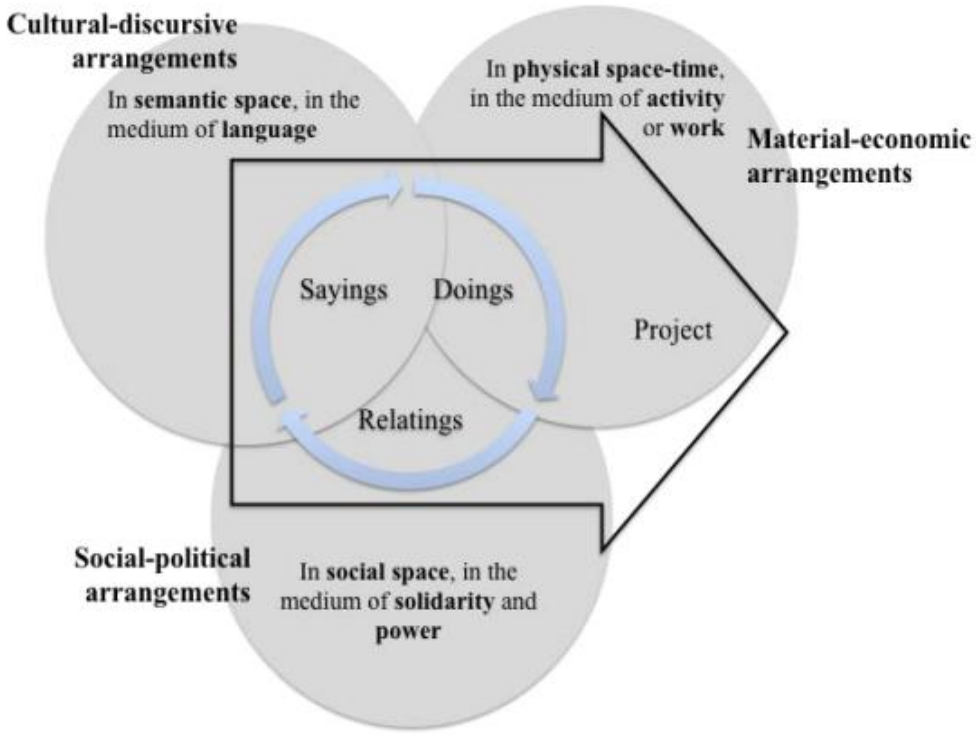


Figure 2.2

The media and spaces in which sayings, doings and relatings exist (Kemmis et al., 2013, p.34)

The mentors in this research are involved in the interconnected practices of teaching and mentoring, with changes in one practice affecting the other. Their own experiences of learning to teach will also be significant, creating perceptions of what it means to be a teacher and mentor. Kemmis et al.'s (2013) ecologies of practices recognises that these related practices are dynamic and interdependent, offering a way to understand how these networks of social practices are shaped, maintained and potentially transformed over time.

2.6 Conclusion

Throughout this chapter, I explored literature related to three key concepts within my research:

- becoming a mathematics teacher
- the mathematical knowledge that a teacher needs
- being a school-based mathematics mentor

Consideration of what it means to learn to teach identified the role that motivation to teach and the initial assumptions and beliefs held by student teachers play in shaping their early teacher identity development. Whilst current educational policy in England presents a simplified and atomised perspective on learning to teach, a more complex picture is evident from research, acknowledging the emotional impact and the potential tensions involved as these assumptions and beliefs are challenged through experiences on an ITE course. The need to develop initial subject knowledge, often fragmented and instrumental in nature, to be able to support the learning of others, was highlighted with the performance nature of mathematics presenting a further challenge for some

student teachers who think they already know all the mathematics they need to know. Research on mentoring identifies the multi-faceted nature of their role as they support the student teachers they work with, and a wide range of approaches linked to the purposes and contexts within which mentors and student teachers are working together. Mentors are well placed to support with the development of student teachers' subject knowledge, but there is a lack of research in this area, something this research seeks to address. The theory of practice architectures (Kemmis et al., 2013) provides a theoretical lens, analytical tool and transformational resource (Mahon et al., 2016) to draw these different factors together and consider my research questions.

Next, I move on to explain the methodology for this research which aims to learn from experienced mathematics mentors but also consider the impact of wider changing landscapes in schools on their perceptions and practice when supporting the subject knowledge development of student teachers.

Chapter 3: Methodology

3.1 Introduction

In this chapter, I set out the methodology for my research with experienced mathematics mentors. Whilst random controlled trials are currently favoured as evidence within education, this small-scale approach provides a rich opportunity to explore the perceptions, practice and working contexts of mentors, developing a more nuanced understanding of their experiences and the range of factors that may be influential in their practice. By considering my ontological and epistemological position, I show how my chosen research design aligns to my research aims and questions. The chapter details my approach to sampling, data generation and ethical considerations before outlining how data was analysed, ensuring fidelity to the critical realism paradigm. The four dispositional themes identified within my research are shared. A summary of how the research was planned, conducted and analysed to ensure trustworthiness in the findings, is provided at the end of the chapter.

3.2 Ontological and epistemological position

Underpinning this research design are a set of ontological and epistemological assumptions. These provide a lens through which all aspects of the research are viewed, influencing how meaning is constructed and interpreted (Kivunja & Kuyini, 2017). From the outset, I have been keen to hear and understand the perspectives of mentors as they work with student teachers to develop their subject knowledge for teaching. Initially, I considered this research to be situated within an interpretive paradigm, aiming to understand the subjective experiences of individuals, “the ways in which individuals and social groups create, modify, and interpret the world in which

they find themselves" (Cohen et al., 2018, p.6). As mentors perceive their roles in different ways, working in different contexts, I recognised the existence of multiple realities. However, in an interpretive paradigm, there is an assumption that *all* reality is socially constructed. Whilst I did want to hear directly from mentors, I was aware of many personal, structural, and contextual factors (such as changing landscapes in schools) that may impact the ways in which mentors are able to work as teachers. These may also influence their perception of their role and purpose as a mentor (Kemmis et al., 2014).

Recognition of the existence of this objective reality, independent of what mentors might express, means that this research does not sit within a relativist ontology as I originally thought. Instead, a critical realist approach, with a realist ontology (acknowledging there is something real to find out about) and subjective epistemology (acknowledging that different people will know and experience things in different ways), seemed more appropriate to this research.

3.21 Critical realism

Critical realism occupies an ontological space between positivism and interpretivism. Where a positivist approach fails to notice the social nature of knowledge development, an interpretivist approach can over-privilege human perspectives (Clark, 2008). Critical realism recognises the wider existence of knowledge and structures that influence behaviour whilst also respecting the importance of social meaning and human perspectives. Whilst it has an explanatory focus, it seeks to go beyond description to explain the causes underlying the events and experiences of individuals. However, it is critical in that it recognises the fallibility of its findings, noting that multiple

interpretations may be possible but making use of suitable theories to provide rigorous descriptions and convincing explanations for the conclusions reached (Stutchbury, 2022).

An important feature of critical realism is the recognition that human knowledge is only part of reality. In critical realist ontology, a distinction is made between the observable world and the real world, which cannot be observed but whose effects can be. Reality is stratified into three connected levels: the *real, actual,* and *empirical* (Bhaskar, 1975). The *real* level is independent of people and involves the underlying structures and relations that exist, creating events and experiences. The *actual* level involves the experiences and events that can occur, independent of an individual's own experiences, whereas the *empirical* level involves an individual's interpretation of experienced events, their observations, perceptions, and interpretations. A focus on identifying the causal mechanisms in the *real* level enables the critical realist researcher to make sense of how personal, structural, and contextual factors can (but may not) interact to produce certain events, moving from understanding *what* is happening to *why* (Vincent & O'Mahoney, 2018). Whereas a positivist approach would seek to make predictions or general laws, a critical realist approach is less deterministic and seeks to reveal causal tendencies that are contingent on a range of factors and are possible to justify rationally, whilst being open to further revision over time (Archer et al., 2016).

Bhaskar (1998) argues that in both positivist and interpretivist approaches to research, there exists an "epistemic fallacy" where ontology and epistemology are conflated and what is real is reduced to what we can know from our senses- through experiments, observations, or dialogue. The iceberg metaphor (Figure 3.1) illustrates the limitations of

epistemic fallacy; if we focus only on what can be observed, we fail to consider influential factors underlying these observations.

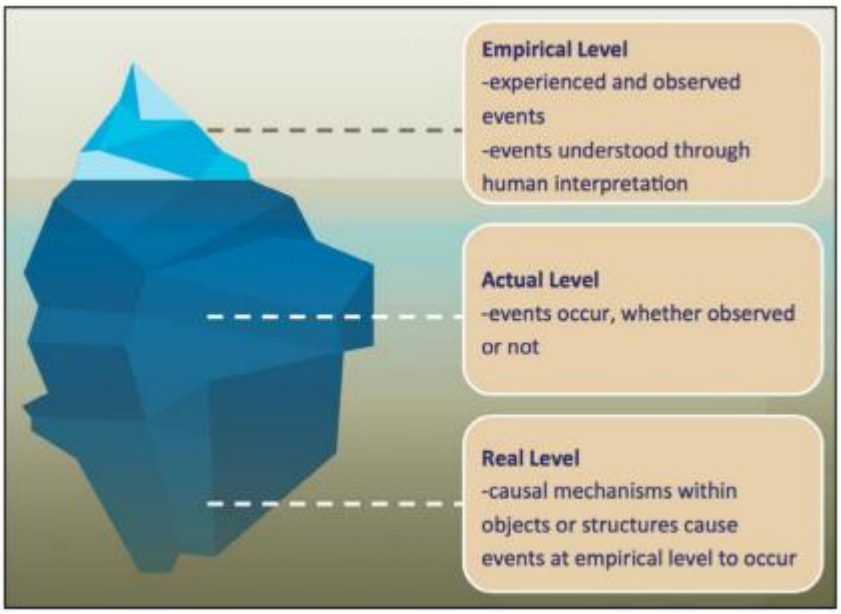


Figure 3.1

Iceberg metaphor for critical realist ontology (Fletcher, 2017, p.184)

This conception of reality fits with the dual focus of my research as I seek to understand how mentors perceive their role and the factors that influence this.

3.22 Structure and Agency

Critical realism assumes the existence of structures that may constrain and/or enable the agency of individuals within contexts. Archer's (2003) concept of *analytical dualism* recognises the interdependence of structure and agency and their reciprocal capacity to effect change, sometimes operating over different timescales, recognising the potential causal powers of both. Structure pre-dates action, providing a historical background that constrains or enables individuals with intended and unintended

consequences, leading to reproduction or transformation, and elaboration of the structures that previously existed (Figure 3.2).

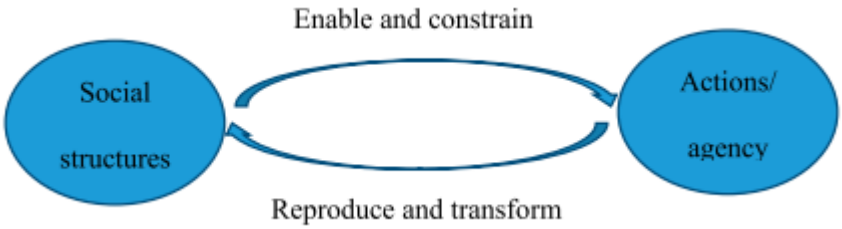


Figure 3.2

The relationship between structure and agency (Stutchbury, 2022, p.116)

By studying what mentors share about what they do and why, it can reveal and aid understanding of the social structures that may influence what is possible.

When considering the work of mentors in schools, a wide range of structural factors are at play, with the relationships between them significant (Archer, 1995; Kemmis et al., 2013; Wynn & Williams, 2012). The theory of practice architectures (Kemmis, et al., 2013) provides a way to zoom in on particular contexts and analyse interrelated arrangements within a context that may influence mentors' perceptions and practice: cultural-discursive (sayings), material-economic (doings) and socio-political (relatings), recognising that practices are shaped by the experiences, dispositions and actions of individuals but also that they are shaped and pre-figured (but not pre-determined) by the arrangements within a specific site. The mentors in this research are involved in the interconnected practices of teaching and mentoring, with changes in one practice affecting the other. My research focuses on understanding the perceptions and practice of experienced mathematics mentors within a particular context, but in common with

Archer (2003), this theory recognises the influence of prior experiences as practice traditions that are brought to the current site of practice.

Drawing on the work of Archer, Scott (2010) identifies five types of object in the social world which have their own structure and can enable or constrain individuals in their practices: embodied objects, social discourses, modes of agency, institutional and systemic norms, and social markers. His typology recognises both personal and contextual structures that may influence a mentor's perceptions, practice and agency within their role. Table 3.1 below has been adapted from Stutchbury (2022, p.118) to demonstrate:

- the relevance of these different structures for my research focus
- how these ideas link to the theory of practice architectures

These structures are not mutually exclusive and may not all emerge as relevant within my research, but they provide a way to consider the range of different internal and external structures that might be influential on a mentor's perspectives and practice. Scott's (2010) typology of structures was used to inform the planning of interview questions to ensure that questions asked enabled exploration of all areas of focus within this research.

Table 3.1

Types of structure (adapted from Stutchbury, 2022, p.118)

Type of structure (Scott, 2010)	Description (interpreted for my research focus)	Link to practice architectures (Kemmis et al., 2013)
Embodied objects	Structures that restrict the potential for action or change e.g., the curriculum, use of standardised resources, exam processes, lack of time, performativity measures, Teachers Standards.	• **Material-economic arrangements:** spaces and resources available for teaching and mentoring
Social discourses	Structures that can effect change but may not e.g., ideas, values and attitudes about mathematics, teaching and learning, or mentoring. They are possessed by all but might also be exercised and/or actualised, effecting change, depending on the agency of individuals and the alignment of their values with their school/MAT.	• **Cultural-discursive arrangements:** ways in which teaching mathematics and mentoring student teachers is understood and discussed by individuals • **Socio-political arrangements:** the ways in which people relate to each other as teachers and mentors
Modes of agency	Structures linked to personal identity e.g., background, past experiences of teaching, learning to teach or being mentored, professional relationships and role within school/MAT.	• **Cultural-discursive arrangements:** ideas about teaching and mentoring brought to site (history, experiences) • **Socio-political arrangements:** relationships within school as teachers, mentors, student teachers
Institutional and systemic norms	Social norms and accepted ways of working within a school or MAT or ITE programme e.g., roles, hierarchy, relationships, use of standardised resources, use of meeting time, time for mentoring, access to professional development.	• **Cultural-discursive arrangements:** ways in which teaching mathematics and mentoring student teachers is understood and discussed within institutions • **Material-economic arrangements:** spaces and resources available for teaching and mentoring • **Socio-political arrangements:** the ways in which people relate to each other as teachers and mentors, hierarchy, power, trust
Social markers	Gender, race, class i.e., factors that may influence how individuals are treated and their access to resources.	• **Cultural-discursive arrangements:** ways in which teaching mathematics and mentoring student teachers is understood and discussed • **Material-economic arrangements:** spaces and resources available for teaching and mentoring • **Socio-political arrangements:** relationships within school as teachers, mentors, student teachers

3.23 Restatement of research aims and questions

My research aims are:

- to understand mathematics mentors' perspectives on the subject knowledge that teachers need, and to find out how they work with student teachers to support this development and why
- to understand mathematics mentors' working contexts and the factors that influence their practice as a teacher and mentor

Current educational policy in England positions mentors as teacher educators and gatekeepers to the profession. Whilst it is widely recognised that student teachers need to develop an understanding of mathematics that enables them to respond to the needs of all pupils in their classrooms (e.g., Ball et al., 2008; EEF, 2022), there is limited research that explores mentors' understanding of the subject knowledge development needs of student teachers, how they conceive their role in this and the factors influencing this within changing landscapes in education.

My research questions are:

- How do mathematics mentors understand the subject knowledge development needs of secondary mathematics student teachers during their PGCE year?
- How do mathematics mentors understand their role in the subject knowledge development of secondary mathematics student teachers?
- What personal, structural, and contextual factors influence mathematics mentors' perceptions and practice?

My first two research questions aim to provide an opportunity to gain insight from the experiences of mentors. My final question seeks to explore what might be happening at the *real* level, understanding the causal mechanisms and powers that may provide some explanation for mentors' perceptions and practice in the area of subject knowledge development.

3.3 Research design

3.31 Case study

Whilst specific research methods are not suggested within the critical realist paradigm, a case study approach is often considered appropriate (Wynn & Williams, 2012). To explore my research questions, I planned a multi-site case study that was both exploratory and explanatory. The case was "experienced mathematics mentor in context." All mentors worked within the same ITE secondary partnership.

A case study approach is considered appropriate for critical realist research (Hu, 2018; Wynn & Williams, 2012) as it involves "an intensive study with a limited number of cases where the researcher systematically analyses the interplay between the ontological layers" (Bygstad et al., 2016, p.85). This allowed me to balance exploring the subjective experiences of the mentors involved and seeking to develop knowledge and understanding of personal, contextual and structural factors of the complex social world in which mentors work. A case study approach enabled me to catch a "close up of reality and rich description" (Cohen et al., 2018, p.377). The 'how' and 'why' of explanatory qualitative case study research (Yin, 2014) also aligned with a critical realist focus on causal tendencies (Hu, 2018). Due to the importance of understanding the context within which mentors were working, contextual information about each

mentor's education and career development as a teacher and mentor was recorded at the outset of the research process. (See Table 3.2 below).

3.32 Sampling

For my research, I wanted to hear from experienced mathematics mentors currently working within the ITE secondary partnership. A high turnover of mathematics mentors annually, with teachers often moving on to take up other responsibilities within their department or school, meant that there was only a small group of mentors who had more than a few years of experience in the role. For ethical reasons, I excluded mentors who had previously been my tutees during their PGCE course and those working with my current student teachers. Within these constraints, to ensure that I had a sufficient sample to select from, I defined 'experienced mentors' as those with more than three years of experience working as a mentor on ITE courses. They were purposively sampled to achieve maximum variation of context, aiming to enhance the validity of my findings (Merriam & Tisdell, 2015). The mentors selected worked in schools within small or large MATs or schools that were not academies. This reflected the diverse nature of school contexts in which student teachers were learning to teach within the ITE secondary partnership. A sample of four mentors provided the opportunity to achieve a depth of analysis without being overwhelmed by a large volume of data. Brief details of the mentors involved in this research and their working contexts are provided in Table 3.2 below, with pseudonyms used to ensure anonymity.

Table 3.2

Information about mentors and their working contexts

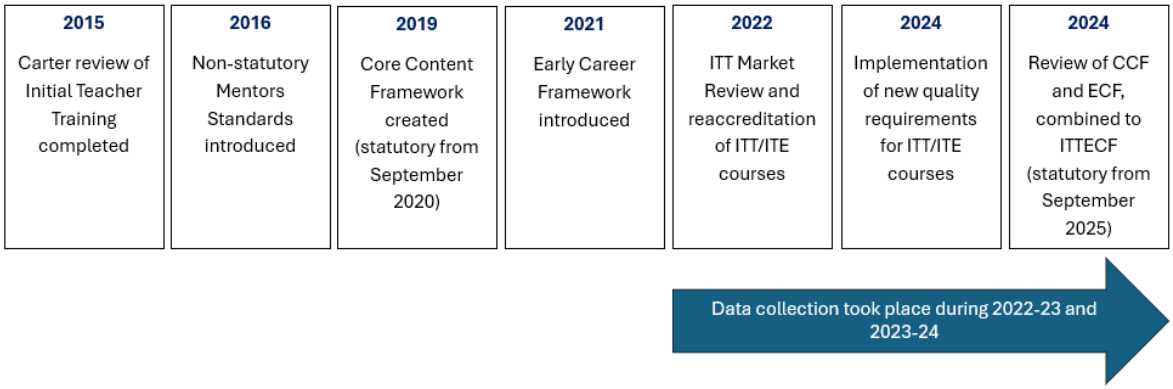
Name	Length of time as teacher	Length of time as mentor	Current school context	Length of time at this school
Sam	11 years	8 years	11-18 school in small MAT	11 years
Alice	10 years	4 years	11-18 school, local authority	5 years
Jessica	8 years	6 years	11-18 school in small MAT	8 years
Adam	22 years	17 years	11-16 school in large MAT	1 year

A common criticism of case study research is that small sample sizes mean that generalisations are not possible (Yin, 2012). However, my sample was not intended to represent a population, and I did not want to make statistical generalisations. Instead, I wanted to explore "information-rich cases" (Braun & Clarke, 2022, p.14) that had the potential to maximise my understanding, aiming to make cautious, context-specific claims from my research data. In keeping with a critical realist approach, I drew on theoretical ideas related to teaching and learning mathematics (e.g., Ball et al., 2008) and mentoring (Kemmis et al., 2014) to develop new understanding and reveal causal tendencies in the real world that shape the social world, an outcome in line with Bassey's (1999) concept of fuzzy generalisations.

Data collection took place during 2022-23 and 2023-24. Below, Table 3.3 shows the ITE policy changes taking place at this point. As these changes would have had more impact on ITE staff than school-based mentors, I did not believe they would influence the perspectives and practice of mentors during this time.

Table 3.3

Summary of recent ITE policy changes with data collection



3.33 Research methods

To explore the experiences and perspectives of my mentors, I planned a sequence of three semi-structured one-hour interviews. Appendix 2 contains information about the planning and structure of the interviews that I refer to throughout this section.

Mentors are busy people and the "implicit nature of much professional know how" (Eraut, 1994, p.42) means that the reasons behind the actions that they take are rarely articulated. However, this is what I wanted to be made explicit. Archer et al. (2016) conceive interviews as a way of reconstructing internal conversations, enabling participants to think reflexively and interpret actions that have been taken subconsciously.

The sequence of three interviews was planned to take place within a two-month period, each interview with a specific but connected purpose, designed so that together, they became part of one story that reflected each mentor's experiences, perspectives and practice developed over time as a learner, student teacher, teacher and mentor. My research questions were used as a starting point to plan the interview schedule. Interviews were semi-structured, aiming for the mentor's voice to guide data generation (Bourke, 2014). The focus of each interview is set out in Table 3.4 below. Appendix 2b shows how the questions within each interview mapped to my research questions.

Table 3.4

Purpose of each research interview

Interview	Focus
1	To explore the mentor's life history as a learner of mathematics and reasons for becoming a teacher
2	To explore their view of mathematics and teaching and learning mathematics as a teacher
3	To explore their perceptions of being a mentor to student mathematics teachers and their practice linked to subject knowledge development

Whilst I wanted to adopt a phenomenological approach where mentors' lived experiences and interpretation of events were clearly heard, questions were planned so that they went beyond the descriptive, aiming to consider causal data as well as empirical data, focusing on realist concepts like events, people, structures, and culture that reveal real, unobserved, and unacknowledged influences (Brönnimann, 2022). I also drew on the typology of structures (Scott, 2010) set out in Table 3.1. Working closely with my supervisor as a critical friend, I identified and developed a framework of questions for each interview, some initial general prompts followed by some more specific follow up questions (Appendix 2d). Initial prompt questions were also provided on cards so that mentors could refer to them within the interview if needed. I adopted a hierarchical focused approach (Tomlinson, 1989) when planning questions and prompts; follow up questions were used contingently during the interview, asking more directed questions only if needed, keeping the interview as open as possible. By taking this approach, mentors were able to speak freely, giving the opportunity for additional areas relevant to them to be discussed alongside areas anticipated by me in advance.

Within the interview, I was aware that I was asking mentors to discuss things rarely articulated. To address this:

- **I shared an outline of the focus for each interview in advance.**

  I wanted to avoid the situation that can arise in a work interview scenario, where having to give an answer on the spot does not provide time for reflection and consideration. Whilst adopting this approach could lead to manufactured responses, I felt in this case that by sharing the focus but not the individual questions, it would lead to more informed and thoughtful ones (Haukås & Tishakov, 2024). I also hoped that this transparency about the purpose of each interview would address any perceived power imbalance between myself as the researcher and the mentors involved (Brinkmann & Kvale, 2015). At the start of each interview, I took time to brief mentors about the purpose of each interview again and answer any questions before checking consent and starting the interview.

- **I created time for mentors to build up my understanding within and across interviews.**

  Drawing on a phenomenological approach, I planned questions that started with the recall of events and experiences (Brinkmann & Kvale, 2015). These could then be returned to as the interview progressed, asking more probing follow up questions, providing opportunity to add more detail and share further insight. Allowing the mentor to move beyond description to reflection, I aimed to understand what might be happening at the *real* level to shape their experiences and perspectives (Brönnimann, 2022). Following the recording of the interviews, I made notes of key things that had struck me during the interview and additional information, such as non-verbal communication. I also reflected on the questions asked, allowing me to make minor adjustments and plan follow up within subsequent interviews.

Building on the information provided in Table 3.4, a brief outline of the purpose of each interview is provided below with interview questions and resources in Appendix 2.

First interview

The purpose of the first interview was to enable mentors to share their experiences as a learner and reasons for becoming a teacher. Research recognises the influence of an individual's own experience as a learner (Schoenfeld, 2012), the process of becoming a teacher (Klieger & Oster-Levinz, 2015; Richter et al., 2013) and the beliefs and values held as a teacher related to mathematics (Ernest, 1989), as significant in a mentor's practice with student teachers.

Second interview

The second interview focused on the mentor's role as a teacher and explored their beliefs about teaching and learning mathematics and their perception of the mathematical knowledge a teacher needs to develop. Just as a teacher will shape a pupil's view of mathematics in the classroom, a mentor will be influential in identifying priorities for learning and shaping a student teacher's understanding of the type of knowledge that is valuable for them as teachers (Lejonberg et al., 2018). I wanted to develop an understanding of how mentors had arrived at their current perspectives as teachers, the influences that had been significant so far and how their understanding had changed during their time as a teacher.

Third Interview

The final interview focused on being a mentor, their view of the purpose of mentoring and the ways in which they conceived and enacted their role. Drawing on the work of Brondyk and Searby (2013) and Ambrosetti et al. (2014), a card sort activity was created to stimulate consideration of the multi-faceted nature of a mentor's role and their

individual priorities, seeking to make tacitly held views explicit. Building on previous interviews, this interview explored how mentors worked with student mathematics teachers to develop their mathematical knowledge for teaching and why they adopted these approaches.

3.34 Positionality

My positionality and existing professional relationship with mentors needed to be acknowledged and mediated to ensure the creation of an environment where mentors could speak freely. In case study research, the researcher is a pivotal part of the research process, which brings advantages and disadvantages to consider. Merriam and Tisdell (2015) highlight the need for relational ethics and, as a researcher, I was acutely aware of the potential impact of my role, my current relationship with mentors and my own views related to this research. As previously highlighted in Chapter 1, I already had strong professional, respectful relationships with the mentors who were research participants. I also had a strong understanding of the local school context and of research around mentoring, teaching and learning mathematics, and student teacher development, allowing me to respond contingently within the interview process. However, with my responsibility for leading the PGCE mathematics course and mentor development sessions, mentors could feel there is a right answer to give or be reluctant to be open about the challenges of being a mentor. I worked closely with my supervisor to create a set of prompts to address potential concerns, through initial email communications and during the interviews (see Appendix 2c for example of interview pre-amble). Before, during and after each interview, I aimed to create a relaxed environment where they knew there were no correct answers and that I was keen to learn from them. During interviews, I aimed to “strive to be objective but… be ever

mindful of (my) subjectivities" (Bourke, 2014, p.3), being interested in what the mentors told me, but not guiding them in any way. I also needed to be careful not to assume that I knew what they were talking about, probing for fuller explanations from them, acting as a novice to their experiences to ensure that their voices were heard and interpreted clearly (Brinkmann & Kvale, 2015).

3.4 Ethical considerations

Throughout all stages of the research, I endeavoured to act with sensitivity and integrity (BERA, 2024), managing the tension between wanting to probe and find out more with respect for the individual involved and what they were comfortable to share (Brinkmann & Kvale, 2015). I followed the ethical principles of respect for persons, beneficence, and justice (Belmont Report, 1979) which applies to all research involving people. At every stage of this research, from its conception, planning and conducting to analysing and reporting, an attitude of ethical mindfulness was necessary to ensure that the principles set out by BERA (2024) guided the research and help to navigate any issues that arose (Cohen et al., 2018). Heggen and Guillemin (2012, p.467) describe this as "actively attending to, and framing, the interview process in terms of its ethical implications for the researcher and the participant".

Ethical approval was sought from the University of Nottingham ethics committee before mentors were approached to see if they would be part of the research. Consent needed to be voluntary, informed, and on-going (BERA, 2024), so it was essential that I ensured that all mentors understood the purpose of the research, what was involved for them as a participant, any potential risks of being involved, how data generated would be stored and used, and their right to withdraw at any time without giving a reason. To support

mentors in their decision to be involved, an information sheet and consent form (Appendix 1) outlining the research process and ethical considerations were shared in plenty of time for questions to be asked and further detail provided if needed. As part of the university ethics process, a Data Management Plan was created and approved, outlining how data would be stored securely and how confidentiality and anonymity at all stages of the research would be ensured.

The location of the interviews required ethical consideration: they needed to take place somewhere where the mentor could speak freely and where they felt most comfortable. Herzog (2012) highlights the needs to explore the pros and cons of this choice with participants and to let them decide, which is the approach I took. As a result, some interviews took place at school, in classrooms or meeting rooms, others at university.

Sensitivity in the framing of questions was required to ensure that mentors did not feel their school, their perspectives or practice as a mentor were being called into question. Ensuring confidentiality for all involved and non-traceability within subsequent writing was essential to allow mentors to speak freely about their working contexts and their experiences of working within student teachers.

Situational ethics refers to the need to resolve any difficulties that arise during the research process (Merriam & Tisdell, 2015). My supervisors' understanding of my field of inquiry was essential, enabling a reflective space to do this. However, for things that arose during the interview process, my sensitivity as a researcher, understanding of this area of research, relationship with the mentors and understanding of the school contexts was important, allowing me to act ethically in the moment.

3.5 Data analysis

When analysing my data, I wanted to ensure a continued focus on the different ontological layers within critical realism, recognising and valuing the subjective world of the experienced mathematics mentor in context but also seeking to understand the objective realities that might influence their subjective experiences. Braun and Clarke (2022, p.9) assert that themes "are constructed at the intersection of the data, the researcher's subjectivity, theoretical and conceptual understanding and training and experience." My understanding of the field provided me with a wide range of insight from experience and theoretical ideas to draw from, however, a highly reflexive approach was required to acknowledge and address my own potential biases throughout these stages. My supervisors, also with an understanding of the field, provided an important space to reflect and be challenged. After initial exploration of different approaches, Wiltshire and Ronkainen's (2021) realist approach to thematic analysis was chosen as a way to analyse my research data, proposing the development of *experiential, inferential* and *dispositional* themes linked to the *empirical, actual* and *real* ontological layers. Below, I set out in more detail the reasons for the choice made.

3.51 Realist Thematic Analysis

Thematic analysis enables the identification of patterns (or themes) within data (Braun & Clarke, 2006) though a rigorous and structured process. A highly reflexive, iterative approach of developing and refining codes and themes is needed throughout as a linear approach can hinder knowledge production (Braun & Clarke, 2019). There are a wide range of approaches within thematic analysis, from coding reliability, which draws on positivist assumptions with pre-determined themes conceived as buried treasure waiting to be discovered, or buckets into which codes can be deposited (Braun &

Clarke, 2022) to reflexive thematic analysis (Braun & Clarke, 2019) which takes an inductive data-driven approach to initial coding with themes developed by the researcher as interpretive stories. Neither approach is appropriate in critical realist research which aims to understand subjective experiences *and* develop causal explanations. Fryer (2022) proposes a critical realist approach to thematic analysis, with a narrow focus on developing themes which provide causal explanations. In contrast, Wiltshire and Ronkainen's (2021) critical realist approach to thematic analysis seeks to combine the surface level descriptions of coding reliability and the deep reflection characteristic of reflexive thematic analysis, with themes developed at all ontological layers characteristic of critical realism. These are:

- *Experiential* themes (at the empirical level) which describe the participant's experiences, perspectives, beliefs and feelings from the data.
- *Inferential* themes (at the actual level) which attempt to go beyond the data to hypothesise and make tentative broader statements that are more abstract in nature and linked to theoretical concepts. Within critical realism, this process of conceptual redescription is described as abductive reasoning (Fletcher, 2017).
- *Dispositional themes* (at the real level) aim to theorise about the causal mechanisms that create events and experiences. The process of retroduction proposes possible explanations by drawing on relevant theories, making links between experiences and events and the potential structures in place that produce them (Bygstad et al., 2016; Hu, 2018) aiming to explain why things appear the way they do.

These themes are distinct but inter-related, and whilst they may all be present in the researcher's thinking throughout the stages of analysis, a structured, yet iterative, process is followed, moving from *experiential* to *inferential* to *dispositional* themes. Wiltshire and Ronkainen's (2021) approach seemed more appropriate for the context of my research, providing me with a way to balance retaining a focus on the mentor's stories and seeking the casual explanations underpinning them. When generating inferential and dispositional themes, to develop my abductive and retroductive reasoning, I drew on theoretical models of mathematical knowledge for teaching (e.g., Ball et al., 2008; Shulman, 1987) as well as the theory of practice architectures (Kemmis et al., 2013).

Analysing interview transcripts

Following the interviews, I noted down my initial reflections (See Appendix 3 for sample). Research interviews were recorded and transcribed verbatim as soon as possible after they had taken place using Office 365 software. Greater familiarisation with the data was achieved through listening to the recording several times as transcripts were checked and edited for accuracy. Attention was given to punctuation to ensure that the meaning was retained as accurately as possible, aiming to ensure descriptive validity (Maxwell, 2012). In addition, transcripts were sent to mentors following completion for transparency and to check accuracy, further enhancing their descriptive validity. As I edited the transcripts for accuracy and became more familiar with them, I also made further notes about key things that stood out to refer back to later in the analysis process.

Generating experiential themes

Considering each mentor in turn, initial experiential themes were developed from the first set of transcripts. Taking an inductive, descriptive approach, handwritten labels were added to extracts in the margins of the transcripts, focusing initially on mentors' experiences, perspectives, beliefs and feelings from the data that related to the main concepts within my research questions:

- becoming a mathematics teacher
- the mathematical knowledge that a teacher needs
- being a school-based mathematics mentor

Whilst this provided a clearer focus for my analysis, it perhaps limited my overall findings. As a novice researcher, I sought guidance from my supervisors and worked with them to develop my coding on the first transcript before considering the others, aiming to enhance the interpretative validity of my analysis (Maxwell, 2012). I also reviewed the reflective notes I had made following the interviews, to check the accuracy of my interpretation of mentors' spoken words, and the notes made during transcription to triangulate early codes and ensure a reflexive stance.

This process was repeated for each mentor, checking if experiential themes identified within the first set of transcripts were present again but also seeking out additional themes. Any new ones were checked within other transcripts. with initial experiential themes recorded. These initial codes were reviewed and refined, adapting the framework used by Wiltshire and Ronkainen (2021). The prevalence of themes across the sample was also recorded in a spreadsheet. Appendix 4 shows a sample from this coding process and the development of experiential themes. Checking evidence across

all mentors allowed me to check the empirical adequacy ensuring there was sufficient data underpinning my initial experiential themes (Wiltshire & Ronkainen, 2021). The strength of each theme was noted to reflect whether it was true to all mentors, allowing similarities and differences in their stories to become evident. Returning to my transcripts again for further cycles of coding, these initial experiential themes were refined and removed as needed. Each cycle of coding was retained in a spreadsheet to ensure a clear chain of evidence (Yin, 2012).

At this point, I created a descriptive account of each mentor's story, identifying key features and quotes that exemplified their experiences, perceptions and practice. This proved valuable in providing a clear foundation for the next steps in analysis.

Generating inferential themes

Whilst experiential themes are data-driven, inferential themes aim to go beyond the data to consider what might be happening in the world. Requiring creativity to make inferences about what might be possible beyond the mentors within the study, abductive reasoning involved conceptual re-description of ideas expressed by mentors, moving towards more abstract language (Jagosh, 2020). My understanding of the field of research allowed me access to a wide range of theoretical ideas about teaching and learning mathematics and mentoring to draw on at this point, but I also needed to ensure that this process of abductive reasoning retained interpretive validity (Wiltshire & Ronkainen, 2021; Maxwell, 2012) and did not reflect my own views. During the process of reviewing and refining my experiential themes, my notes showed that I had already started to think more conceptually about the themes within my data from mentors, something that Wiltshire and Ronkainen (2021) suggest is not uncommon. In

doing so, I was able to group together some of the experiential themes together to inform inferential ones. An example related to mathematical knowledge for teaching is included below in Table 3.5. Drawing on my understanding of theories about learning to teach mathematics (e.g., Ernest, 1989; Fenema & Franke, 1992; Rowland et al., 2014), references to different assumptions often held by student mathematics teachers at the start of their PGCE course were grouped in one inferential theme:

Table 3.5

Developing an inferential theme

Inferential theme	Related experiential themes
It is plausible to claim that experienced mathematics mentors develop an understanding of assumptions often held by student teachers about teaching and learning mathematics	• Some mentors state that student teachers think that learning mathematics is easy (Code 11) • Most mentors believe that student teachers can assume they have no more maths to learn as a teacher (Code 30)

Further examples of the development of inferential themes can be found in Appendix 5 which contains an extract from my spreadsheet to show how some of the inferential themes related to teaching were developed from experiential ones, ensuring they were rooted in the interview data.

Generating dispositional themes

This stage of analysis aimed to build on experiential and inferential themes already identified and begin to generate dispositional themes through retroductive reasoning. Dispositional themes, at the real level, aim to identify potential powers or causal mechanisms that could exist. Retroductive reasoning involves drawing on theoretical ideas to identify these causal mechanisms underpinning events experienced by participants (Jagosh, 2020), seeking a sound logical basis for the claims made, but

acknowledging the fallibility of the claims: alternative explanations may be possible. It requires the researcher to move from concrete experiences to more abstract ones and back again, ensuring theoretical validity (Maxwell, 2012) by seeking a coherence between the data and the concepts and theories used to provide explanations. Within my research questions, the key concepts of becoming a mathematics teacher, mathematical knowledge for teaching and mentoring provided a range of theories to draw on. In addition, Kemmis et al.'s (2013) theory of practice architectures enabled a dual focus on the individual mentor and the context in which they are working, seeking to understand the arrangements within the school context, enabling and constraining their practice and shaping the type of student mathematics teacher developed. Four dispositional themes were identified in this research:

- the existence of *specialised mathematical knowledge for teaching and mentoring*
- the impact of educative ITE experiences on conceptions of teaching and mentoring that shape mentors' initial and ongoing practice and perceptions
- the role that collaborative working cultures in schools play in enhancing mathematical learning opportunities for student teachers and mentors
- the impact of wider structural contexts in school and educational policy creating arrangements that enable or constrain subject-specific teaching and mentoring approaches

Drawing on the approaches set out by Wiltshire and Ronkainen (2021), Figure 3.3 below provides an example of how the second dispositional theme above was arrived at, with three different levels of themes (experiential, inferential and dispositional) considered

together to ensure that the claims in my analysis were logical and supported by evidence within the data. Further examples of how dispositional themes were developed from experiential and inferential themes can be found in Appendix 6. These dispositional themes are explored in more detail in Chapter 6.

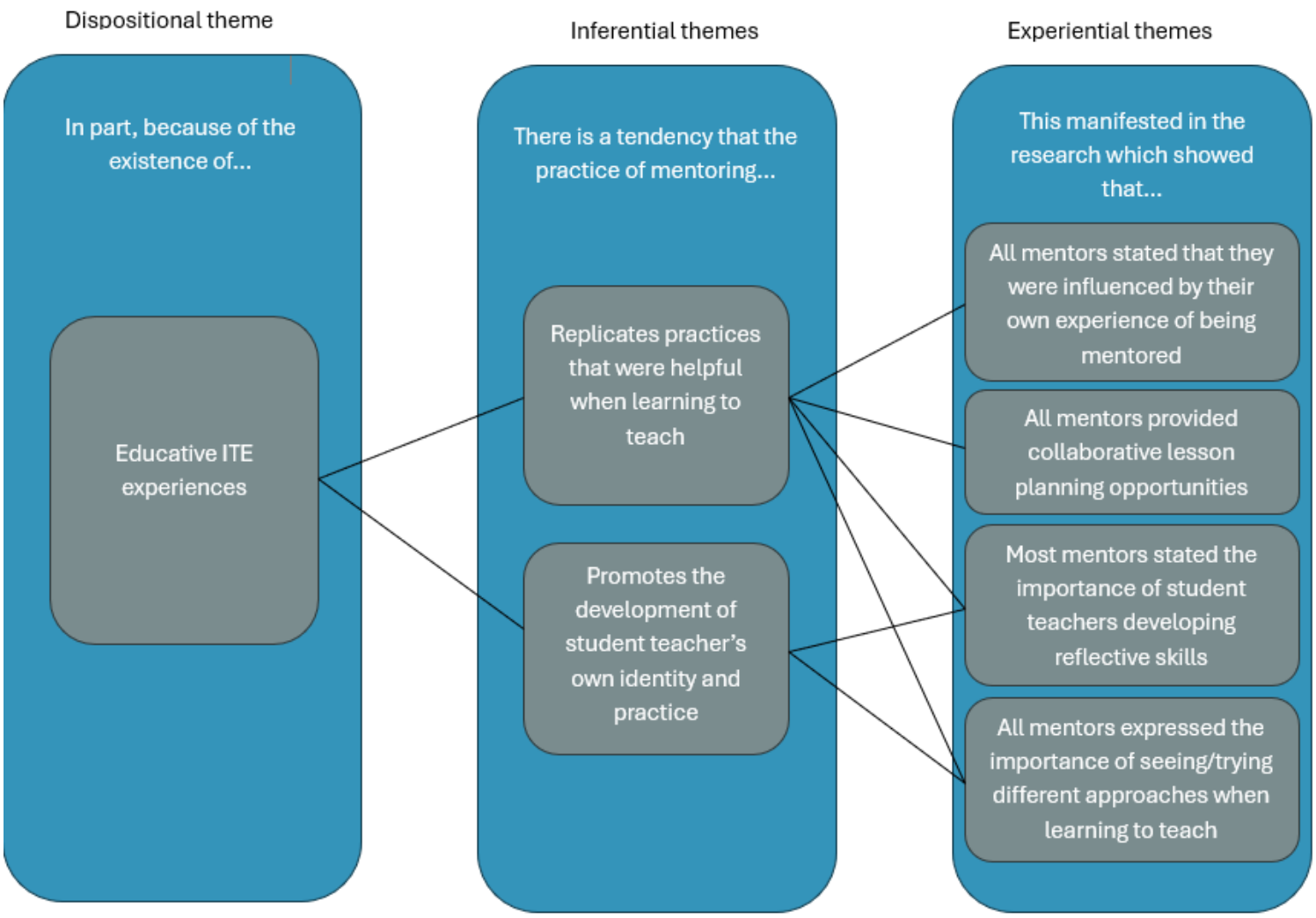


Figure 3.3

An example of forming a dispositional theme from analysis

3.6 Trustworthiness and rigour

The outcome of qualitative research should be authentic and consistent with the data that has been generated, but the concepts of reliability and validity from positive research can be problematic when analysing qualitative data (Bassey, 1999). Trustworthiness and rigour are alternative terms used within qualitative research. Lincoln et al. (2011) identify the need for rigour that is both methodological (related to methods chosen and their alignment with the research questions) and interpretive (related to how outcomes are judged), ensuring consistency throughout the research process. Throughout this chapter so far, I have aimed to demonstrate ontological and epistemological congruence throughout my research process. Miles and Huberman (1994) also emphasise the importance of the researcher as an instrument of validity, with their skill, reflective and ethical approach significant.

Within my chosen methodology, drawing on the work of Merriam and Tisdell (2015), I adopted the following strategies to ensure the trustworthiness of my findings.

- Planning interview questions that were coherent with the research questions and ensuring they were used contingently to enable participants to share their own stories (Brinkmann & Kvale, 2015; Tomlinson, 1989)
- Purposive sampling to ensure maximum variation within sample selection (Merriam & Tisdell, 2015)
- Checking transcripts with participants to ensure the factual accuracy of data, ensuring descriptive validity (Maxwell, 2012)
- Familiarising and immersing myself in the data, developing a deep understanding of the research interviews (Braun & Clarke, 2006)

- Reviewing early coding with supervisors to check for interpretation of data and ensure interpretative validity (Maxwell, 2012) and evidence for nascent themes, ensuring empirical adequacy (Wiltshire& Ronkainen, 2021)
- Reviewing emerging findings with supervisors regularly to challenge potential biases
- Keeping a clear audit trail/chain of evidence (Yin, 2012) of coding and theme development to demonstrate how themes were arrived at
- Developing rich descriptions of mentors' accounts (Cohen et al., 2018)
- Adopting a highly reflexive and ethical stance throughout all stages of the research process from planning to analysis and writing up

3.7 Conclusion

This chapter sought to explain and justify the methodological approach taken to explore my research questions within a critical realist paradigm, aiming to:

- ensure that the individual stories of experienced mathematics mentors working in different contexts could be heard and understood
- seek potential causal mechanisms that influence their perceptions and practice as they work to support student teachers during their school placements

It also identified the dispositional themes arising from this research which underpin subsequent chapters. In the second half of my thesis, drawing on the research interviews and analysis, I set out the findings and discussion arising from my research.

Chapter 4: Mentors' stories

Throughout this research, there has been a need to balance developing an understanding the perspectives of individual mentors and making sense of the factors influencing their teaching of mathematics and mentoring of student mathematics teachers during placements. To manage this, in subsequent chapters, I have structured my findings and discussion in the following way:

- **Chapter 4**: Aiming to ensure that the stories of each mentor in this research are clearly heard, this chapter draws on the theory of practice architectures (Kemmis et al., 2013) to provide their individual accounts
- **Chapter 5**: Focusing primarily on mathematical knowledge for teaching, addressing my first two research questions, this chapter presents a cross-case analysis of my case studies, identifying elements of experienced mentors' *mathematical knowledge of learning to teach*
- **Chapter 6**: Addressing my final research question, this chapter draws on a range of theories (e.g., Ball et al., 2008; Kemmis et al., 2013; Rowland et al., 2014) to explore the dispositional themes identified in my research and consider potential causal mechanisms that may exist for the mentors within this research

4.1 Introduction

In this chapter, drawing on the experiential and inferential themes arising from my analysis, I share the perspective of each mentor separately, seeking to create a rich account of their stories as learners, teachers and mentors. Their priorities and practices around subject knowledge development form part of these stories.

Drawing on Kemmis et al.'s (2013) theory of practice architectures, I provide an account of the mentor as a teacher and as a mentor, identifying the *sayings, doings* and *relatings* that inform their project (or purpose) of teaching and of mentoring. In their comparison of mentoring in different countries, Kemmis et al. (2014) conceptualise three different types of mentoring which were discussed in Chapter 2.4. These were *mentoring as supervision*, *mentoring as support* and *mentoring as collaborative self-development*. These conceptions of mentoring will be drawn on in establishing each mentor's project of teaching and mentoring which comprise of the different *aims* that motivate their practice, different *actions* that take place (sayings, doings, relatings) and different *ends* or *intentions* for learning. Each mentor story takes the following structure:

- Contextual information about their school and career
- Project of teaching followed by a more detailed exploration of the mentor's perspectives and practice as a teacher
- Project of mentoring followed by a more detailed exploration of the mentor's perspectives and practice as a mentor
- A brief overall summary of their story

Following the stories, I draw together common themes and contrasts in relation to approaches to mentoring that are evident across these experienced mathematics mentors in different contexts.

4.2 Sam

Contextual information

Sam is a career changer; having completed a mathematics degree, he worked in insolvency for several years, before embarking on a PGCE course at university. His motivation to teach came from needing a change, wanting a job that felt rewarding and would allow him to share his love of mathematics. He has been a teacher for 11 years, always at the same school. During this time, he trained as a Mastery specialist with the local Maths Hub and has previously been a Key Stage Three coordinator within the mathematics department. He has been a mentor for eight years, working with a range of providers and different routes into education. At the time of this research, the school had recently become part of a MAT with nine secondary schools.

Sam sees mathematics as a way to understand the world we live in, describing it as “the underlying structures that bring systems to life.”

4.21 Sam's project of teaching

Sam's project of teaching is one of *ongoing, collaborative self-development*, aiming to learn from and with colleagues and pupils to develop his mathematical knowledge for teaching and approaches to teaching and learning. Informal and formal discussions and professional development within the department and across the MAT are a significant source of professional learning. When teaching, Sam focuses on helping pupils develop a relational understanding of mathematics, creating an interactive classroom environment where discussion and collaboration between pupils is encouraged.

Figure 4.1

Sam's project of teaching

Becoming and being a teacher

Sam is keen to share his love of mathematics, a subject that he sees as creative and something that helps to make sense of the world as well as navigate life. His own experiences, at school and during his PGCE year, inform his priorities now as a teacher. In addition to this, through his previous career in insolvency, Sam became aware of the impact of a lack of mathematics skills on some people's experiences in life and felt that it was important for all people to be good at mathematics.

Sam had a positive experience at school, valuing relationships with teachers, especially those who communicated an enthusiasm for their subject and who demonstrated a care for pupils as individuals. He enjoyed mathematics at school as he was successful at it, but at university he struggled when learning which challenged his view of himself as a mathematician.

> It all just plummeted, and I failed with my second year and that was a real massive eye opener- it was a real "Oh wow, this is the thing I've been passionate about all my life, this is the thing I've been good at as well" and it was my own fault because I wasn't putting any effort in.

This experience was pivotal in shaping his understanding of how people learn mathematics and the emotional impact of struggling to learn and is one that he is open about with his pupils. Commenting on his own initial mathematical knowledge, Sam stated that "when I started [teaching], I saw things very much as standalone topics."

During his ITE year, experiences of not knowing how to support pupils or respond to their questions helped him understand that teachers need to know

> not just necessarily the connections between the different mathematical knowledge but also the connections with how the pupils are going to take that on board or not take it on board more importantly.

The classroom environment that Sam seeks to create is one that is curious, open and supportive, something he experienced and valued at school. The importance of understanding "Why?" is reflected in his approach to teaching, where mistakes are welcomed, misconceptions are discussed to develop deeper understanding and connections between mathematical ideas are made explicit. Whilst his own experience of learning mathematics at school was not as collaborative, his experiences on his PGCE course led to him adopting this approach as a teacher. Pupils are encouraged to work with and learn from each other as well as with the teacher with Sam adapting his teaching to meet the needs of the class and being open to learning from his pupils.

> I try to build a culture of not being afraid to get things wrong, not being afraid to ask, and for asking for help. If you are struggling, trying not to just sit there and not do anything. I try to build a culture where you're wanting to give answers.

Consequently, collaborative tools, like mini white boards and visualisers, as well as discussion form a significant role in learning, drawing on correct and incorrect pupil responses, to develop understanding across the class.

Sam's PGCE course was also significant in developing his understanding of different approaches to teaching and the complexity of supporting pupils to learn mathematics. During school placements, Sam reported that mentors and teachers were supportive and enthusiastic about teaching mathematics, adopting a collaborative approach to planning

and teaching as a department, sharing ideas and discussing how to ensure all pupils were successful.

> The teachers were just so passionate about trying to find better ways of teaching and trying to find ways that would engage the kids.
>
> Even in classes that were more challenging, they were still trying to get kids to really think and really engage through the use of white boards, different activities, the use of IT in different places.

As an experienced teacher, Sam remains curious about learning mathematics himself, deepening his understanding as a teacher through collaboration with others. He believes that all pupils can learn mathematics through effort and support. However, prior to his own difficulties when learning mathematics at university, he had thought people had fixed ability in mathematics. Sam's own subsequent struggles and later success allowed him to see learning mathematics very differently. He now thinks that with effort and support all pupils can make progress. A significant experience for him as a teacher was working with a lower set of Key Stage Four pupils who were not expected to do well by others but achieved good results in their GCSE mathematics through their own determination to succeed and the support of Sam as their teacher.

As a teacher, Sam actively seeks out opportunities to work with and learn from others. Within school, a culture of discussing teaching and learning mathematics has been established in the department, formally and informally. His head of department plays a role in this, creating time to share ideas across the team within department meeting time and regular communications. Informally, teachers choose to come together in their own

time to discuss things like misconceptions, exploring how to address them and use them within teaching.

> There is very much a culture within our department of collaboration and looking at it from wanting the kids to succeed.
>
> [A teacher] has lots of projects going on, trying to improve certain areas of the curriculum and so asks staff to come together in their own time to see, to try to make it better, we talk about misconceptions probably more than anything else.

This supports newer colleagues in the department, but Sam also sees this as part of his on-going learning as a teacher. Beyond school, Sam has trained as a mastery specialist with the local Maths Hub. He sees mastery as "a fancy word for teaching well" which promotes exploring ideas with pupils in greater depth, consolidating ideas about teaching and learning mathematics that were explored within his PGCE year. Opportunities to learn from others across different schools are also brokered through the director of mathematics within the MAT who is pro-active in seeking out what teachers would like to focus on within MAT-led professional development and also through sharing good practice across departments.

The school Sam works in has recently introduced a set lesson structure that all teachers need to adhere to. Sam expresses some frustration about the impact of this whole school policy within his classroom, needing to find ways to make it work for teaching and learning mathematics. He describes how staff must

> get round the edges as much as we possibly can because there isn't a lot of room for discussion, for thinking about things in a deeper way, they're [SLT] very much wanting "Here's how you do something, now go and practice it."

However, within the department, pre-planned resources for Key Stage Three, created by members of the department, can be used flexibly by teachers. Sam values this as a way to reduce workload for experienced teachers. When considering the mathematical knowledge that a teacher needs, Sam focuses on misconceptions, knowing how to help pupils make connections in mathematics, having alternative approaches to draw on and being able to respond flexibly to meet the needs of individual pupils.

4.22 Sam's project of mentoring

Sam's project of mentoring has elements of mentoring as *collaborative self-development* and *support* (Kemmis et al., 2014). Sam supports the student teacher with their transition into the profession, socialisation into school and department, their development as a professional and their understanding of mathematics and ways to teach mathematics. He aims to integrate them into the collaborative working culture within the department where there is a focus on developing a deeper understanding of mathematics and how pupils learn mathematics. Sam actively seeks out the opinion of his student teachers and encourages them to discuss their views and ideas about teaching mathematics and their development as a student teacher. As such, Sam positions himself as expert and co-learner with his student teacher. Sam also prioritises the well-being of student teachers, aware of the emotional impact of learning to teach.

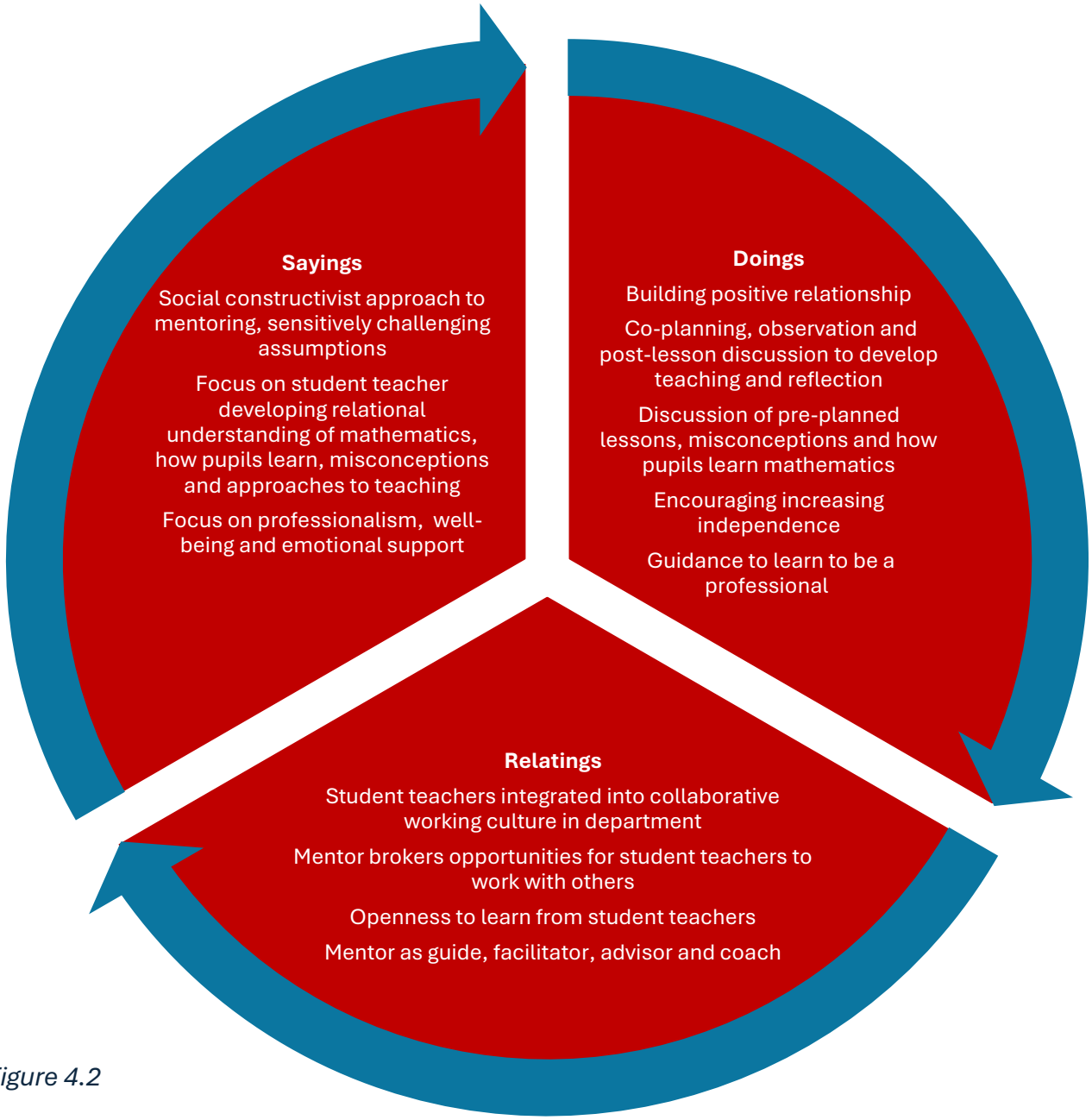


Figure 4.2

Sam's project of mentoring

Being a mentor

Sam understands that learning to teach is not easy. He prioritises developing a supportive, trusting relationship, so that student teachers feel welcome and able to learn. This had been beneficial when he was learning to teach.

> My priority is that they start to feel comfortable in that environment because it is daunting if you've come freshly out of university, never worked anywhere.

For Sam, being a mentor involves more than supporting student teachers to learn to teach mathematics; they need to learn how to be a professional and develop a wider understanding of what it means to be a teacher. Sam is flexible in the way he works with his student teachers, adapting to their strengths and areas for development, reflecting his approach as a teacher. He aims to create opportunities for student teachers to work with different members of the department and expose them to a wide range of practice and perspectives, through observing and discussing teaching, something that had been helpful for him as a student teacher. Sam finds that student teachers often start with assumptions about teaching and learning mathematics, thinking there is no more mathematics for them to learn when they start their ITE year, and that teaching mathematics will just require them to explain things clearly.

> Student teachers have a tendency to take over the lesson. They see their role as them presenting and doing and I think there is a lot of misconception in society in that it's the teacher's job to do so. And if the teachers are doing that, then the pupils are really not doing that much usually.

Sam feels that some teachers reduce the mathematical knowledge developed when adopting more traditional approaches to teaching.

> You could spend your teaching career effectively, really dumbing down the mathematics, just teaching them this little granular part of mathematics…[doing] so many different bits that aren't really connected and you are just going to repeat this process over and over again, but I don't think you get a good understanding of mathematics and the mathematical knowledge without the connections between them.

Instead, when working with student teachers, Sam aims to support them to develop a deeper, more connected understanding of mathematics as well as an understanding of how pupils learn, the challenges pupils may face and different ways to represent and teach a mathematical concept. He recognises that this can be a challenge when student teachers have found mathematics easy to learn and have not had much experience of teaching.

> When I was learning to teach one of the things I found the hardest was- people kept talking about misconceptions. For the life of me, I have always been good at mathematics, so one of the hardest things for me to do, and still is, is to figure out where kids could go wrong.
>
> You can say what the misconceptions are but until you understand the relevance of them with those children in front of you, do you take it on board? Do you understand the importance of it?

Following experience in the classroom, Sam thinks that post-lesson discussions provide a rich opportunity for learning. Trying to discuss this before teaching has limited impact as the student teacher often does not understand why it is necessary. Whilst the

department has standardised resources for Key Stage Three classes that student teachers can use when teaching, these have been developed by experienced teachers.

> The person that prepares them has excellent subject knowledge and really understands what the misconceptions are. As they [student teachers] look through them, we talk through them as well. And the bits that they see as the important parts of the pre-prepared lesson aren't necessarily what I would see as the important parts.

He finds that student teachers often remove the most important sections that would provide good discussion and learning in the classroom as they do not understand the significance of them, highlighting differences in mathematical thinking between experienced and new teachers. Opportunities to follow up within post-lesson discussions can be hampered by moving on to the next topic quickly.

Sam acknowledges the compressible nature of learning mathematics and the challenges of this when learning to teach.

> I know how to solve a quadratic equation. I can do it 15 different ways. Do I remember the lessons that taught me how to do those ways? Not in the slightest! And that's something that [student teachers] don't deal with well, they can just do it "I can solve a quadratic equation, so why can't the pupils?". "Because at one point you didn't know how to do it. And how did you get to know it?". You don't know that- you don't remember that journey because that journey was difficult and the brain has developed in a way that it tries to minimise you remembering difficulties.

Understanding the mathematical learning journey is essential as a teacher, but Sam acknowledges that this takes time to develop.

Reflecting on his approach to mentoring, Sam acknowledges how his practice has evolved over time.

> I think I used to have a lot of conversations, I remember saying "In my PGCE we did this…this was a good idea…this is what I was told" whereas now, I don't think I ever say that. It is more along the lines of "So, I know we've done this before, we could do this in the future, what do you think?" I think I have grown [as a mentor]

Sam comments that schools have significant structures in place to support ECTs and the mentors working with them, perhaps due to the part they play within the current performance accountability measures, but he finds that the same support is not available in school for mentors working with student teachers.

4.23 Sam's summary as a teacher and mentor

Drawing on the theory of practice architectures, Sam's projects of teaching and mentoring reveal that a social constructivist, collaborative approach to learning is common across his practice as a teacher and a mentor, as is his focus on developing a deep, relational understanding of mathematics. Whilst all the mentors in this research identified the need for student teachers to develop a relational understanding of mathematics, Sam was the only one who spoke explicitly about doing this when teaching pupils, aiming for them to understand "Why?" and make connections within the subject. When working with student teachers, he adds to this by supporting them to develop an understanding of how others learn, drawing on a range of different approaches that involve different teachers. His intention is to support student teachers to develop a way

of thinking about mathematics and teaching and learning mathematics that will support their ongoing development as a teacher beyond the PGCE course, adopting an educative and reciprocal approach to mentoring. Like Jessica, integrating student teachers into the department and involving them the wider department is important within Sam's practice as a mentor. In addition, his care for individuals and understanding of the challenges of learning, whether that is learning mathematics or learning to teach mathematics, is evident throughout his practice, and he prioritises building relationships of trust and openness to ensure a supportive learning environment.

4.3 Alice

Contextual information

Alice completed a mathematics degree before doing a PGCE at university. Her motivation to teach came from the enjoyment of helping others learn through a range of experiences during school and university. She has been a mathematics teacher for 10 years, during which she has worked at three different schools. She has been at her current school, run by the local authority, for five years. Alice has had a range of curriculum roles within her career, as Key Stage Five coordinator and currently as assistant subject leader for mathematics. She has been a mentor for four years, working with PGCE students and Early Career Teachers.

Alice describes mathematics as both a language and a process to be able to explain and understand things. At school, she enjoyed the black and white nature of mathematics and the feeling of being successful.

4.31 Alice's project of teaching

Alice project of teaching is one of *ongoing self- development,* aiming to develop her mathematical understanding and approaches to teaching and learning. Critical reflection and working informally with colleagues one-to-one provide valuable opportunities to do this. Being a teacher means having agency to develop her own lessons to suit the needs of her classes. Lessons are carefully structured to ensure all can make progress and she seeks to engage pupils through using a variety of tasks. Alice's ongoing learning as a teacher is facilitated formally through courses and qualifications that consider various aspects of her role as a teacher, and through informal one-to-one conversations with colleagues.

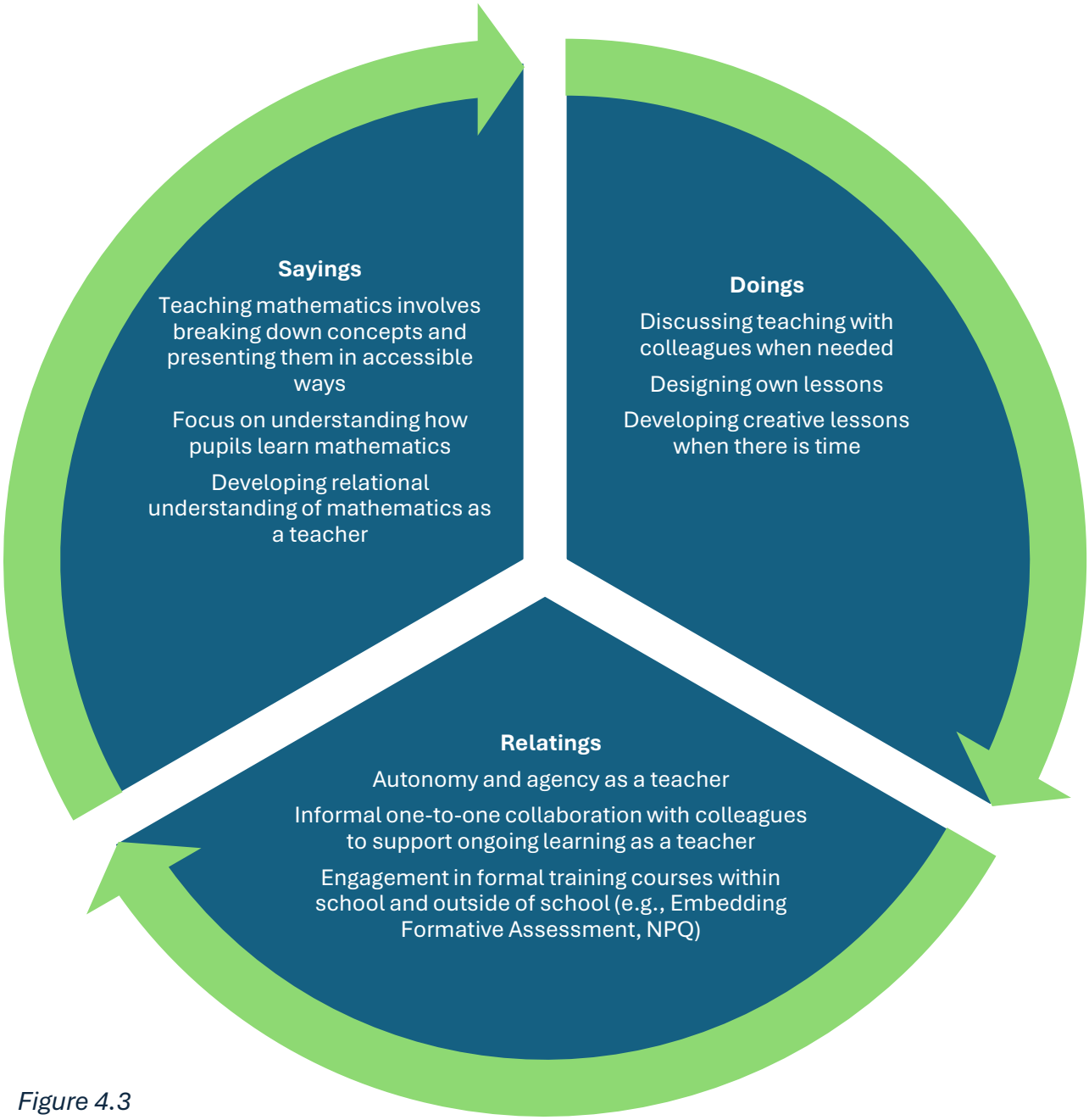


Figure 4.3

Alice's project of teaching

Becoming and being a teacher

As a teacher, Alice enjoys the freedom to work in ways that suit her and her pupils. Whilst she initially taught how she had been taught, with instruction from the teacher followed by time to practice and to provide individual support, with more experience, she now adopts a range of approaches, thinking very carefully about how to present ideas in ways that will help all pupils make progress. When possible, she likes being creative, developing tasks that will engage and enthuse pupils, providing clear relevance for their learning but highly enjoyable for both pupils and teacher. Below she describes a favourite lesson she had taught recently on currency conversions.

> I planned that they had to create their own little shops, or could use the shops that I had created, and they had a shopping list that they had to go and buy. They also had a different currency each and they all had to convert their currencies to make sure they weren't getting cheated out of it and so, a bit more interactive.

A lack of time to develop innovative ideas means that she is not able to do this often, but she strives to make all lessons interesting.

When Alice was at school, relationships with her teachers were important, with good teachers identified as those who were knowledgeable and fostered an open, supportive environment where it was ok to make mistakes, something she now aims to do. As a learner, Alice was focused on her performance, doing well in tests, stating that she was not interested in understanding why something worked mathematically or where ideas came from as a pupil.

> [As a learner] I'd ask my teacher "Just tell me what I need to do, what's the formula? I don't care why or where it is coming from, just tell me the formula."

As an experienced teacher, Alice now understands the need to develop a more connected understanding of mathematics, to be able to answer 'Why?' which often arises when teaching. She enjoys working with and learning from other teachers, sharing ideas and supporting others with subject knowledge development, seeking out one-to-one opportunities to do so, replicating experiences that were beneficial when she was learning to teach. Alice acknowledges that it took some time for her to develop the mathematical understanding required to create lessons where there was a mathematical coherence throughout and to support all pupils to learn.

> I have kind of learnt how to really look at the work, like the concept, and how you can explain it... to really unpick the important parts that they need to know to then be able to access the higher learning

Previously, she included things like starters in lesson plans because she had been told to, but understanding of their significance came with more experience as a teacher.

> I did have routines back then, but they weren't as rigorous, or I was just doing them for the sake of doing them like a starter. "OK, I just need a starter." Whereas now I'm like "Right, my starter is retrieval because they need to practise what I've taught them."

Teaching mechanics and statistics at A level, areas she did not enjoy at school herself, helped to deepen her understanding of the topics as well as how to teach them. Currently, Alice is focused on how to develop the understanding of pupils who find mathematics very difficult, working out ways to break down ideas and present them so that they can access higher levels of mathematics; her Head of Department has been

pivotal in supporting the development of this aspect of her teaching, working collaboratively and sharing ideas and resources.

In the past, Alice moved schools when she lost her agency as a teacher and whole school standardised approaches to teaching and learning were imposed on the mathematics department without consultation or consideration of context.

> So, they wanted us to do a retrieval starter, which we were like "Yep, fine. Got that." Then you had to introduce your concept and then you had to do silent time, no matter what, they had to do silent time after that bit. Then they had to do peer work, group work and then silent time. The MAT leaders weren't listening to the mathematics department which was the best one in the school.... And we were like "Well, ok, we can't do silent time in mathematics after group work because the kids won't understand, they need to talk to each other. But we could do silent time with the starter."

With requests made by the mathematics department met with resistance by senior leaders, Alice felt that an insistence on consistency across all subjects rather than flexibility within departments restricted learning within the mathematics classroom. A lack of voice, for staff and pupils, and the absence of professional trust as a subject specialist led to her leaving the school.

Whilst Alice's current school provides the freedom to plan and teach her own lessons, whole school professional development initiatives have reduced the opportunity to discuss teaching and learning mathematics as a department, something Alice sees as a loss.

> We used to have…regular meetings where we would then discuss, like algebra, how we would teach certain topics in algebra, what different ways to teach "Oh, you know what, that is a brilliant idea!" …we used to do that, but we don't have time anymore.

However, she seeks to do so informally in her own time. Alice also takes part in wider professional development opportunities. She has completed the National Professional Qualification in Leading Teacher Development (NPQLTD) as well as an Embedding Formative Assessment (EFA) programme that has been facilitated by her current school. Alice felt that her NPQTLD helped her become a better manager but has not had an impact on her teaching of mathematics. For the EFA programme, development time has been provided by the school for all staff to be involved in this and to work collaboratively to develop their practice as teachers in this area. To develop her teaching further, she engaged with a coaching course, which made her more reflective. She also actively seeks out the views of pupils when trying out new approaches in the classroom to develop her teaching further.

4.32 Alice's project of mentoring

Alice's project of mentoring is one of *support* (Kemmis et al., 2014) enabling a student teacher's transition into the profession, socialisation into school and department, their development as a professional and their understanding of how to teach mathematics. There is a particular emphasis on providing choice about how to teach and supporting the development of reflective skills to facilitate ongoing learning. One-to-one collaboration takes place between mentor and student teacher, with Alice adopting an inquiry approach to develop their mathematical knowledge for teaching and reflection.

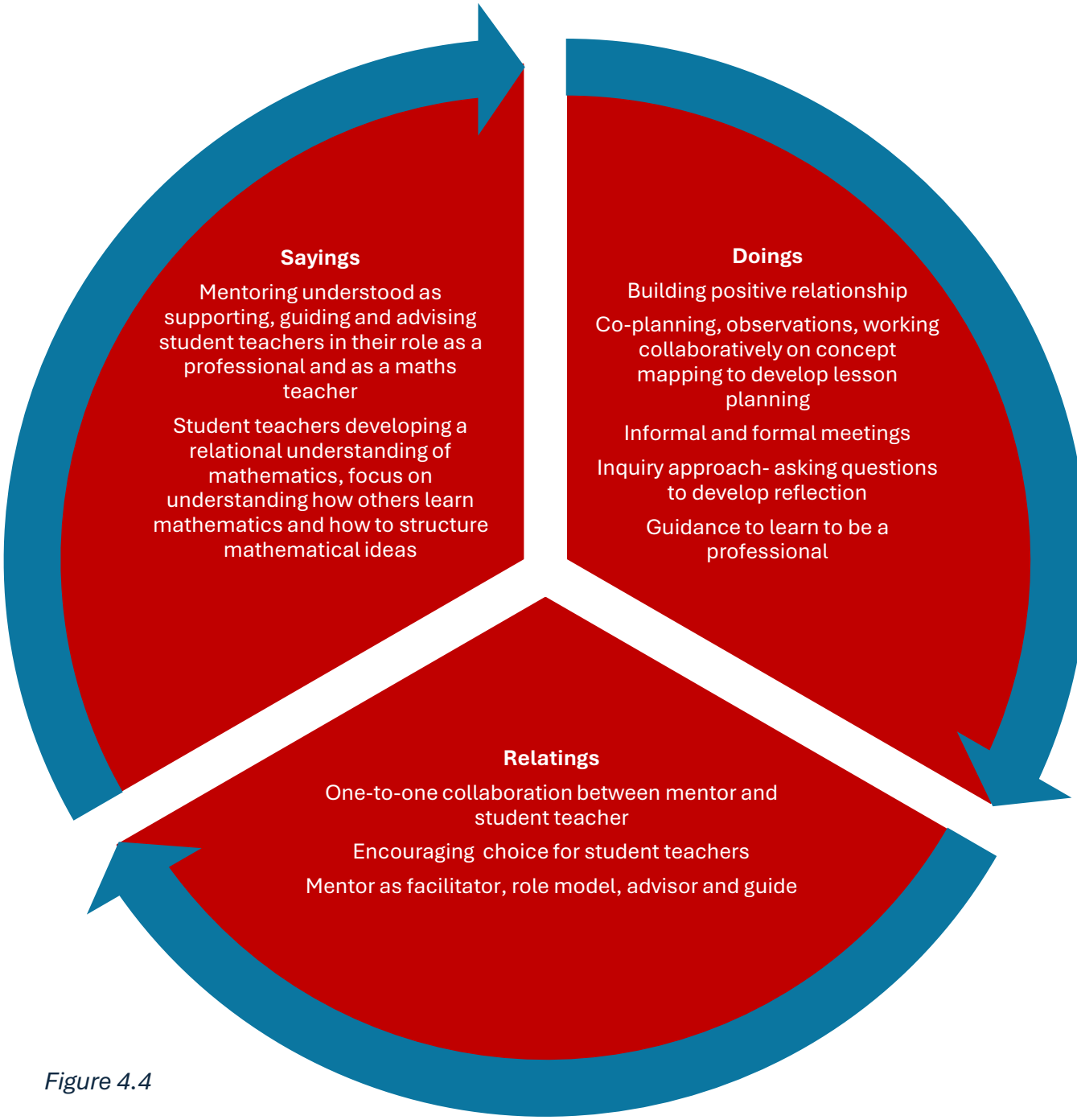


Figure 4.4

Alice's project of mentoring

Being a mentor

When she was learning to teach, Alice described having good, understanding mentors who were calm, patient and asked questions to develop her own thinking as a teacher rather than tell her what to do. They put her at ease and were supportive when things did not go to plan. She was encouraged to try new approaches to teaching and learning, learn from mistakes and build good routines to allow her to work collaboratively with more experienced teachers when planning. Her mentor's focus on the development of her ability to reflect and learn from experiences was significant, asking probing questions, helping her consider possible alternatives, supporting by sharing ideas at times and providing clear guidance when needed. Her experiences of being mentored now inform her approach as a mentor. In particular, the development of reflection is a priority for Alice as a mentor, encouraging student teachers to explain their thinking.

> I try and actively encourage them to be reflective. So, I don't jump in straight with what I thought. I like to try to get mentees to explain, which is what happened to me. As annoying as it was back then, and I was a bit like "This is horrible", it does work, and I think that now I see that I can really reflect myself because my mentor trained me to do it. I think that is very beneficial.

She acknowledges that this is challenging to do and only possible when a relationship of trust has been developed. Lack of time is a challenge to the development of this relationship due to the busy nature of schools and the demands of the PGCE course. She takes a contingent approach when working with student teachers, being more directive when needed but always aiming to develop greater independence over time.

> I like making them reflective rather than directing them, although you sometimes have to. I think it depends on the mentee as well, how you do it. Sometimes you can ask all the questions, and they are not getting the point, so you have to be direct at that point.

She sees her role as a mentor as an advocate, managing the relationships and expectations of other teachers working with the student teacher and developing the student teacher's understanding of what it means to be a professional. The importance of learning in a wide variety of contexts, working with different teachers and classes at different levels is important when establishing a timetable but Alice is aware of potential challenges.

> In our school, we've got freedom, but I know certain teachers want it a certain way. And I know it is hard for mentees because they have to do three different types of teaching with three different people.

When they are teaching her classes, she aims to give them more freedom and choice to plan and teach in a way that suits them, adopting the same approach as her own mentors by encouraging student teachers to try new ideas and learn from them.

To develop their teaching, Alice adopts a facilitator role, aiming to work collaboratively with student teachers when planning. She contends that some student teachers with strong mathematical qualifications can struggle to understand how and why pupils find mathematics difficult to learn. Concept maps developed together provide an opportunity to develop mathematical knowledge for teaching and consider how to sequence ideas in a way that ensure progress for pupils.

> When we work together, I go “Right, I want you to put probability in the middle and everything you know about probability around it” and they do that. … “You are starting from scratch. Where would you start? What would be your first lesson?”. And then get them to plan out a sequence of lessons…. “What knowledge do they need for that? Is that in the right place or does it need to go earlier?”

She also models her approach to planning.

> “Look, this is how I plan. This is where I look. This is what I start to think about” so almost talking through how I plan a lesson live. I’ll start with that. Find out if there are any barriers as to why their planning isn’t going very well. How can we overcome them? That is how I start the process.

Whilst she aims to support by articulating her own decision making, she also encourages student teachers to adopt their own approaches, asking questions to help them consider how pupils learn and how resources they have chosen could be used in different ways.

> So, when they send me a lesson plan, I’ll ask some questions like “Have you thought of this? Have you thought about how you’re going to overcome that? This bit doesn’t flow.”

Understanding misconceptions is explored at the planning stage but also in post-lesson discussion, sharing ideas about how these could be avoided or used as a learning opportunity within a lesson. In addition, she prioritises conversations about how you might explain new concepts and how you can judge if a pupil understands new mathematical ideas. At times, the use of role play, with student teachers rehearsing how

they might manage different scenarios within a lesson, provides good opportunities for learning.

4.33 Alice's summary as a teacher and mentor

Alice's projects of teaching and mentoring reveal the importance of reflection in her own development as a teacher and as a priority for development when working with student teachers. Valuing her agency as a teacher, providing opportunities for student teachers to have freedom and choice when possible is evident in her practice as a mentor. When teaching, Alice aims to ensure lesson structures that enable all pupils to make progress, and as a mentor, Alice adapts the level of direction and support to meet the needs of student teachers. Like other mentors in this research, Alice seeks to support student teachers to develop a rich, connected understanding of mathematics, with a focus on developing clear lesson structures and understanding misconceptions and how to use them when teaching. The development of concept maps, also used by Adam, provides an opportunity to do this collaboratively. Whilst student teachers work with other teachers during their placement, Alice seems to see their wider professional development and subject knowledge development as her responsibility rather than involving other teachers, unlike Sam and Jessica's more collective approaches which reflected an established working culture in their departments.

4.4 Jessica

Contextual information

Jessica completed a degree in economics and started a career in retail before deciding to become a teacher, deciding that she would like to work with children and that she would enjoy the challenge of working across a range of age groups. She has been a teacher for eight years, always at the same school where she also had her main placement during her SCITT course. Jessica has previously had pastoral and curriculum roles within the school and has been a mentor for six years, working with a range of providers and different routes into teaching. The school is part of a MAT which has three secondary schools and four primary schools.

Jessica's view of mathematics is centred on number and problem solving.

4.41 Jessica's project of teaching

Jessica's project of teaching is one of *ongoing, collaborative self-development*, learning with and from colleagues to develop her mathematical understanding and approaches to teaching and learning mathematics. She also sees herself as part of a wider professional community online. When teaching, Jessica aims to develop positive relationships and build confidence in pupils through creating a supportive classroom environment. She engages pupils by using a variety of tasks and encouraging them to work together and ask questions.

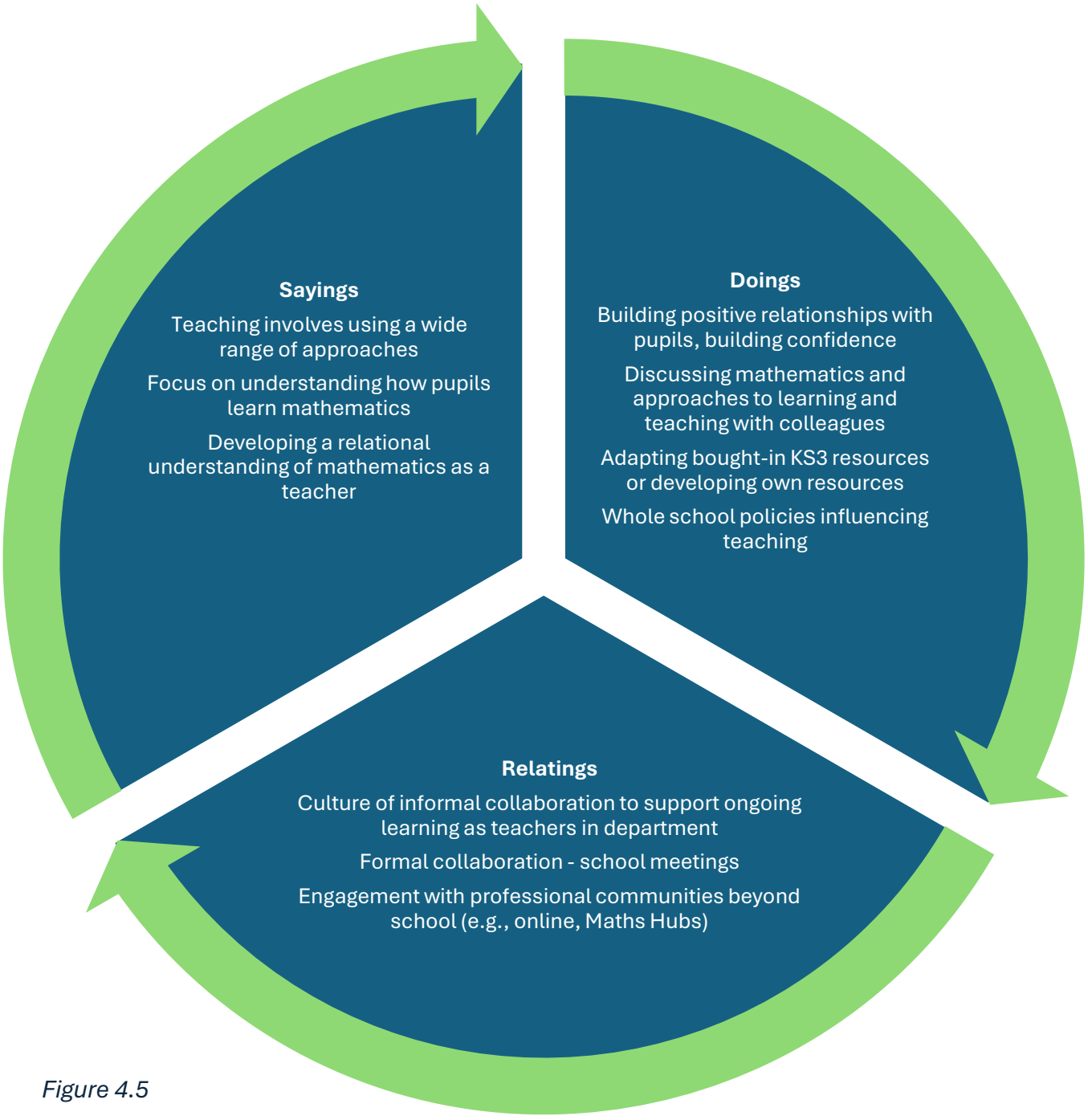


Figure 4.5

Jessica's project of teaching

Becoming and being a teacher

As a teacher, Jessica aims to develop a classroom environment where pupils are engaged and active as learners, using a variety of tasks to create a sense of purpose for learning. She makes use of collaborative tools such as visualisers to develop discussion and ensure progress. She wants pupils to learn from each other and to grow in confidence. When learning mathematics at school, Jessica recognised that her teachers prioritised building good relationships with pupils which made her feel safe and known, something that is now important for her to do for her pupils.

Alice was taught in what she describes as a "chalk and talk" way at school, developing an instrumental understanding of mathematics, focusing on doing well in tests. Success in the subject led to her enjoying it until her final year at school.

> This is a subject that I've loved, and I've not always found it easy, but I've got there and then found Y13 like "What is going on!" because I found it really difficult.

Determination to do well and support from teachers to build her confidence were significant in her success, but even now Jessica states "I never class myself as a mathematician" as she sees this as someone who is knowledgeable and does not struggle when learning.

Jessica described her ITE year as significant, deepening her understanding of mathematics and of the challenges that different pupils face as they learn mathematics; discussion with peers on her course, as well as colleagues on placement were important in this development, with her mentor particularly significant.

> They were so supportive and just really helped me see different ways of teaching and I was really lucky that I got to work with loads of different teachers.... To gain that breadth of knowledge was good.

Through collaboration with her peers and tutor during the SCITT course, she explored how to use resources in different ways, consider mathematical ideas from the perspective of a pupil and develop her understanding of planning and teaching as a result. On placement, whilst working from a scheme of work with some shared resources, teachers in the department had freedom to teach how they wanted.

> I was encouraged to do different types of lessons, to try different things and I think that really helped in all my planning.

This freedom to choose as a teacher is something that Jessica felt enhanced her learning at this point, and something she values now as a teacher. An environment where teachers regularly discussed their teaching and shared ideas created further opportunities for learning as a student teacher. Teachers were also very generous with their time, spending time helping her understand how to plan lessons and developing her mathematical understanding and confidence in teaching less familiar topics. Discussing how her own mathematical knowledge has changed over time as a teacher, her experiences of teaching have helped her to develop a more relational understanding of mathematics.

> I think I could always do maths, give me an exercise, give me 20 questions, I could do it; give me an exam paper, I could do it. I think the links and the awareness of misconceptions have developed a maths teacher.

> It's understanding when kids don't understand something, I think you learn far more from that than you do for anything else because you go “Hang on a minute. How have you got that? Let's work back. What have you done wrong?”

Jessica acknowledges the importance of teachers being able to break mathematics down into steps, understand misconceptions and how to resolve them, understand and anticipate what pupils will find hard and how to plan for this as a teacher. She is keen to continue to develop her approaches to teaching and learning mathematics, seeking out ideas on social media as well as within the department. As a department, there is time to discuss teaching and learning during meetings. Currently, they are considering how to develop their use of manipulatives such as algebra tiles, spending time working together to make sense of them as teachers before bringing them into the classroom.

> We were able to pick it apart and go well “In this scenario, what would you do?”. You know, bring misconceptions out and things, so that’s been really good.

This has arisen due to the interest of a colleague in the department and involvement in the Maths Hub.

Jessica acknowledged the enormous influence Covid has had on her classroom practice. During this time, creative, collaborative ways of working were not possible, and a narrower conception of teaching was possible. Opportunities to observe other teachers and learn from them disappeared. Whilst there has been some return to previous ways of working, she thinks there is more she could do to develop the more interactive environment that was previously in place.

The school that Jessica teaches in has recently become part of a MAT. However, senior leaders have retained autonomy in how the school is run. Within the school, the department has also retained some autonomy.

> I think we are quite lucky, but I do think we take ownership as a department. I suppose it is that old adage- our results are good, and we get left.

The mathematics department has recently purchased pre-planned Key Stage Three resources. Teachers have the freedom to use and adapt these resources or develop their own, with assessment practices the only constraint. Colleagues frequently discuss how to adapt the pre-planned department resources for their own teaching, sharing ideas and reflecting on their use together after lessons.

However, whole school policies, adopted in response to a poor Ofsted report, sometimes impinge on ways of working within the department and mathematics classrooms. At other times, these school policies seem more beneficial for learning. Reflecting positively, a whole school move to reintroduce opportunities to observe other teachers was seen as helpful, and a return to ways of working that had been valued in the past. Other approaches, such as the use of 'Do now' activities, provided a name and structure for something that previously would commonly have been part of a lesson but was now essential. However, a reciprocal reading structure, developed in response to areas raised in an Ofsted inspection report, did not fit easily with the teaching of mathematics.

> SLT and people in charge, they go around lessons going "We know it's being done, but you're just not saying the right words to do it." What is a good thing is that it's not going away. They've said this isn't going anywhere, which is always good. So, we will get there.

Jessica described how she was still getting to grips with it after six months, currently trying to find ways of being compliant to school policy and making it meaningful for the learning of mathematics.

4.42 Jessica's project of mentoring

Jessica's project of mentoring has elements of *collaborative self-development, support* and *supervision* (Kemmis et al., 2014) enabling a student teacher's transition into the profession and integration into the collaborative working culture of the department to support their development as a professional and their understanding of how to teach mathematics. There is an awareness of the Teachers Standards as of something to work towards, but they are not a day-to-day focus. Jessica is sensitive to being a learner and prioritises developing their confidence and brokering relationships within the department to allow them to learn from a wide variety of colleagues.

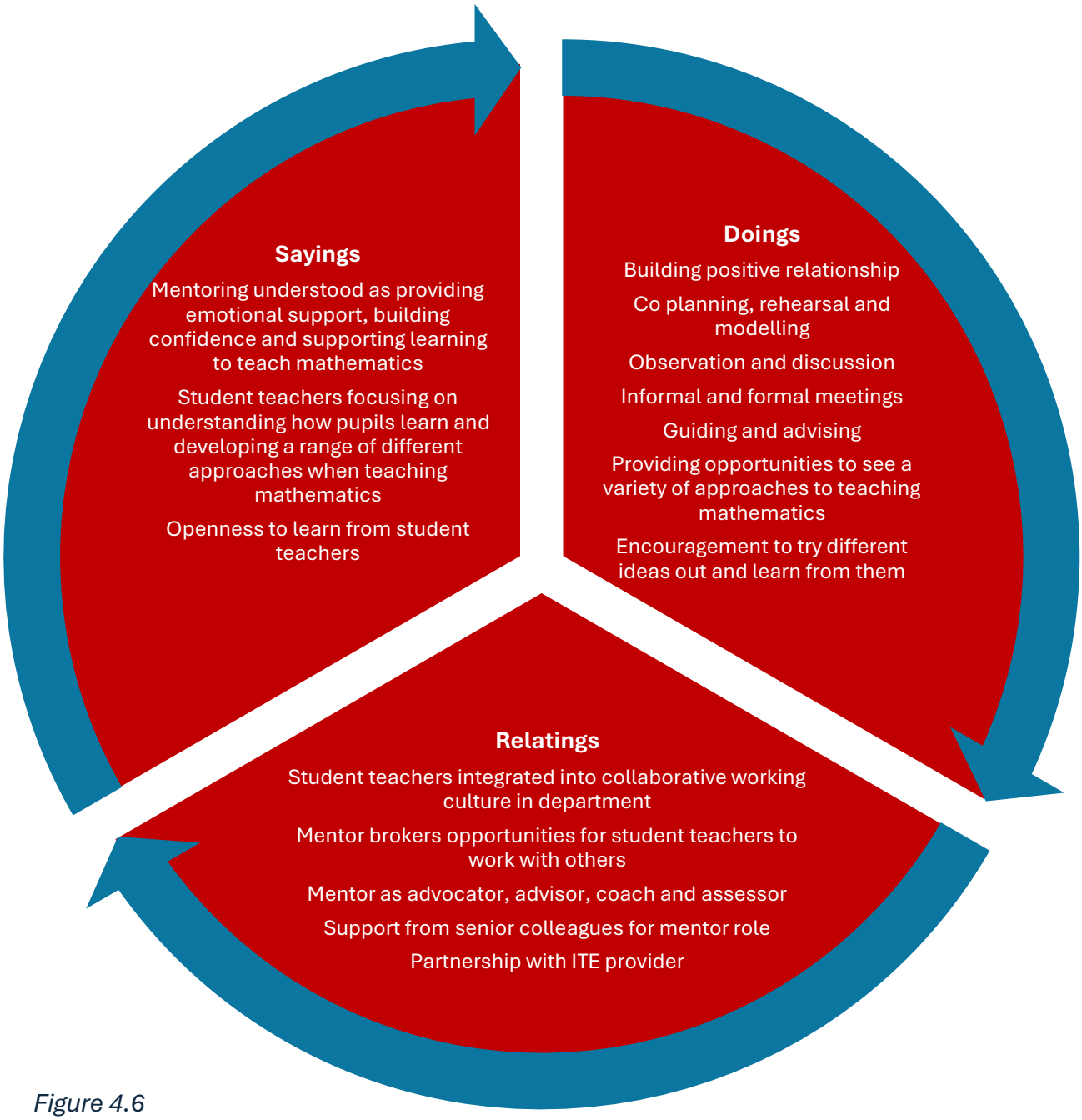


Figure 4.6

Jessica's project of mentoring

Being a mentor

For Jessica, a trusting, supportive relationship lies at the heart of good mentoring, reflecting the type of relationship she values and fosters as a teacher with her pupils. In her role as a mentor, providing time for student teachers to ask questions and work out what they are doing is important.

> I think a lot of it is giving time to trainees to ask questions and work out what they are doing.
>
> It's about working together. Yes, you have more knowledge than they do, but it's about working with them to improve what they are doing rather than saying "You must do this, you must do that" because we are all different in the way we teach, and I think you've got to work together.
>
> I think those who have done well have been those who have been open to listening and taking on board but also working with us to say "This is what I've done. This is what's been really successful."

Involving the rest of the department in this approach enables greater support and guidance to be provided.

> I talk about the trainees a lot, and I think that is because I want everybody to know where they are at, what they are doing so that they can help because it was so helpful for me.

She sees herself as an advocate for the student teacher within the school, ensuring other teachers are aware of the requirements of the placement, what they are managing on their ITE course and understanding their personal circumstances. Like Sam, she also

brokers opportunities to observe and work alongside other teachers, ensuring that they have the breadth of experiences to learn that was important for her as a student teacher.

> If I wasn't sure about anything, I never felt like a drain, so they'd sit creating lesson plans [with me] or go through a topic or if I couldn't work out what I was struggling with or I couldn't work out how to teach it, or to check resources and give ideas....They'd look at different ways of teaching it and they knew because of their experience...I had only been taught it one way...just looking at different viewpoints of a topic really helped

To support student teachers' understanding of teaching and learning mathematics, Jessica provides time for co-planning, ensuring that they have a space to ask questions. She reflects that "they all realised quite quickly it [teaching] was not the same as knowing." She challenges them to consider the perspective of pupils encountering new mathematical ideas and understand their role as a teacher, how they can develop pupils' learning and confidence, for example, providing a rehearsal space for mathematical explanations which then can be developed collaboratively.

> It is what I look at in lesson plans as well. "What misconceptions have you picked out? What things are you thinking about doing in this topic? What are you going to say if a kid says that?"

Following teaching, in post-lesson discussions, she develops their reflection through asking questions.

> "That kid thought that, had you thought about that?"
>
> "Let's go back. Why did you teach it like that? What problems did it create?"

Her approach to mentoring is adapted to the individual, acknowledging that some student teachers value more guidance at times. A student teacher's openness to developing their understanding of mathematics is seen as significant, with some previously high achieving student teachers not always recognising that they have more mathematics to learn as they start out as a teacher.

> I had a student teacher who thought he was the best thing ever and didn't know how to say parallel lines were parallel on a rectangle and you think "You've got all this knowledge.... you're teaching year seven the difference between a rectangle and a parallelogram." I think those that have weaker knowledge are happier to go back and go "Right. What is it I need to know?" They're more prepared to ask.

Jessica's approach as a mentor is also influenced by the expectations and relationships that exist with the ITE provider she is working with. With some providers, she has a genuine partnership, working closely with the university tutor; at other times, she has felt more isolated. Within school, she is also well supported as a mentor.

> We've got a member of SLT who looks after the trainees and he's brilliant. He's a great sounding board. I'm trusted by my head of department, so they trust me to make a decision but obviously want to know about it. I go and talk to our SLT who looks after them all and I can talk to him.... He'll help if we need help or he'll just encourage.

She values the agency and responsibility she is given to make the best decisions for the student teachers she is working with but appreciates a collaborative space to reflect on her practice as a mentor and discuss issues with them. Jessica sees her role as an assessor as a helpful part of being a mentor, providing a clear sense of direction as she

works with student teachers and sets targets. During her time as a mentor, Jessica has developed a greater understanding of the role she plays in supporting the emotional impact of learning to teach and the development of strategies to draw on as a mentor, for example, providing guidance to support their workload and well-being.

4.43 Jessica's summary as a teacher and mentor

Jessica's projects of teaching and mentoring are closely aligned and reveal the importance she places on relationships when learning. In both roles, she seeks to develop confidence, acknowledging the emotional aspect of learning. As a teacher her focus on understanding how pupils learn mathematics, providing variety in the classroom is reflected in the priorities and opportunities she sets for student teachers as she works with them. Like Sam, she aims to integrate student teachers into the collaborative working culture in the department, brokering opportunities to work with a wide range of people. Her encouragement for student teachers to try out new ideas and learn from them reflects her belief that they need to develop a range of ways to support learners in the classroom. Like others, she thinks student teachers need to develop a relational understanding of mathematics and an understanding of how pupils learn, but developing this type of mathematical knowledge is not evident in her project of teaching where there is a greater focus on ensuring progress.

4.5 Adam

Contextual information

After completing a mathematics degree, Adam did a PGCE at university. His motivation to teach centred on wanting to make a difference and sharing a love of maths. He has been a teacher for 22 years, working in three different schools. During his time as a teacher, Adam has had a range of pastoral and curriculum related responsibilities in school, as well as being the Early Career Teacher coordinator at his former school. Adam has 17 years' experience as a mentor and has worked with a range of providers and different routes into teaching. Adam's current school is part of a large MAT with over 40 secondary schools. He has been at this school for one year and is a lead practitioner within the mathematics department.

Adam describes mathematics as a puzzle and himself as a mathematician who teaches other budding mathematicians, wanting pupils to love the subject as much as he does by communicating mathematics in the best way for them.

4.51 Adam's project of teaching

Adam's project of teaching is one of *ongoing self-development,* aiming to help all pupils enjoy and be successful when learning mathematics. He is attuned to challenges of learning and tries to develop classroom environments where pupils feel able to learn. Adam aims to develop pupils' confidence by ensuring success within a lesson, using praise, practice and competition to do so. His philosophy of teaching mathematics and his identity as a teacher continually change through his openness to learn from others and engagement with professional development opportunities such as online mathematics communities, mathematics education books and professional development courses. He has previously valued opportunities to work collaboratively with colleagues.

Figure 4.7

Adam's project of teaching

Becoming and being a teacher

As a teacher, Adam is highly reflective. His openness to learn from others means that his ideas about teaching and learning mathematics are constantly changing, influenced by his experiences of teaching and mentoring. As a pupil, Adam appreciated teachers who were caring and made him feel safe. Being competitive, he liked being at the top of the class and enjoyed feeling successful. GCSEs were straightforward, but Adam struggled more at A level, finding the content hard and the environment in one A level classroom less supportive.

> I couldn't think clearly because I was just thinking "He's going to ask me. I'm good at mathematics but he is going to ask me. I am going to get it wrong. I don't like getting things wrong."

As a teacher now, he aims to make pupils feel safe in his classroom, acknowledging how his own challenges impact his teaching.

> I've been brilliant at it, had struggles and you know, I think that's what makes you who you are, and I think that definitely strengthens me as a mathematics teacher. I have lots of empathy with what pupils are going through.

Adam wants others to love mathematics as much as he does and help them avoid the negative feelings that can arise when you are unable to do mathematics. When teaching, Adam has a similar perspective to other mentors in this research, expressing that teachers need mathematical knowledge

> not just that I can understand it, but I can explain it in a way that the kids are going to understand it…it's about how you communicate the maths as well as understanding it

Initially, Adam expected that he would teach like he had been taught, where teachers explained something and there was lots of independent practice. However, his PGCE course opened new ways of teaching mathematics that he fully embraced initially as a teacher.

> [It was] really discussion based, and I remember the golf shot and designing the racetrack for various graphs and I loved that. I was taken in by all that though. "Yeah, let's get people in my classroom talking about maths and getting involved in it and arguing" and all things that never happened in my maths lessons. But I was so enthused by everything that was presented to me at university, that is the sort of teacher that I want to be. So, my biggest influence for me was that first year when I was at university- it was really, really good for my teaching.

He took an approach of teaching for understanding and enjoyed engaging pupils through interactive teaching approaches. On his first placement,

> I bought my own mini white boards and the 'follow me' cards that we had to produce in the first week of term at the university. And yeah, to see the kids engaging with mathematics in a different way at the start of the lesson. The kids loved it, the staff really enjoyed watching these lessons as well. It was quite nice as a new teacher coming in with these new ideas and seeing this positive response to these things.

During his time as a teacher, Adam's practice has evolved through his engagement with formal and informal learning opportunities and reading about mathematics education. For example, through the Ambition Institute, he had recent experiences of being coached and valued the collaborative, focused nature of these experiences. Taking a narrow focus

for his own development at these times was beneficial for his own learning, something he now seeks to replicate when working with pupils and student teachers. His ideas about teaching and learning mathematics have also been challenged by the student teachers he has mentored, demonstrating a willingness to learn from them. Adam describes working with one particular student teacher.

> Because I was his mentor, I used to say "Look, you need to be doing it this way" and he was like "Well, yeah, probably, but I'm going to try to do it this way". I observed a lot of his lessons, and they seemed to be really, really effective.

This student teacher's focus on practice to build confidence, making connections later rather than develop understanding from the start, challenged Adam's previous teaching approaches and had benefits for learning that he had not previously considered.

A recent move to a new school where there is a whole school policy of using booklets that promote a mastery approach when teaching mathematics has resulted in a further shift in Adam's practice as a teacher. This has created tension, and Adam described being "a bit lost" as he had to fit in with school policy which he does not agree with as a teacher and adapt his approaches in the classroom to meet requirements set by the senior leadership within the school.

> I feel like I know what works and I want to teach the way that I want to teach, and I want to spread that to my department [as a lead practitioner]. Now we are a little bit constrained by these booklets.

Whilst Adam felt that working in this way ensured consistency across classes, he felt the use of the same booklet for all pupils did not suit the needs of those in lower sets. A

planned move to booklets created by the Trust was welcomed by Adam as an improved approach as it aligned more with his current views on teaching and learning mathematics. Despite having more faculty time in this school than previous ones, the focus on formatting booklets reduced opportunities to work collaboratively, with Adam reflecting that time discussing mathematics teaching as a department does not happen in a way that would be helpful.

> We always say that we will do it, but we don't really do it. We could do with using faculty meetings to sit down and just co-plan things together but there just seems to be so many other things that get in the way and we're still trying to produce booklets.

Adam spoke about mathematics teaching in a different way to other mentors in this research. His current priorities appear to be influenced by cognitive science approaches to teaching and learning, with mention of "do now", "retrieval practice", "interleaving" and "high leverage" approaches designed to ensure that pupils can make progress. He has moved away from group and paired work to more individualised learning in the classroom. Whilst Adam has adopted different approaches as a teacher throughout his career, at all points, he aimed to be approachable, creating the safe learning environment that he valued as a pupil, developing a love of mathematics and ensuring success for learners in his classroom.

4.52 Adam's project of mentoring

Adam's project of mentoring has elements of mentoring as *collaborative self-development, support* and *supervision* (Kemmis et al., 2014) prioritising the building of an open trusting relationship between mentor and student teacher where they can develop their understanding of mathematics and teaching and learning mathematics. There is a focus on progress and performance to build confidence through the setting of narrow, actionable targets. One-to-one collaboration takes place between mentor and student teacher with encouragement for student teachers to find their own style of teaching within the constraints in place.

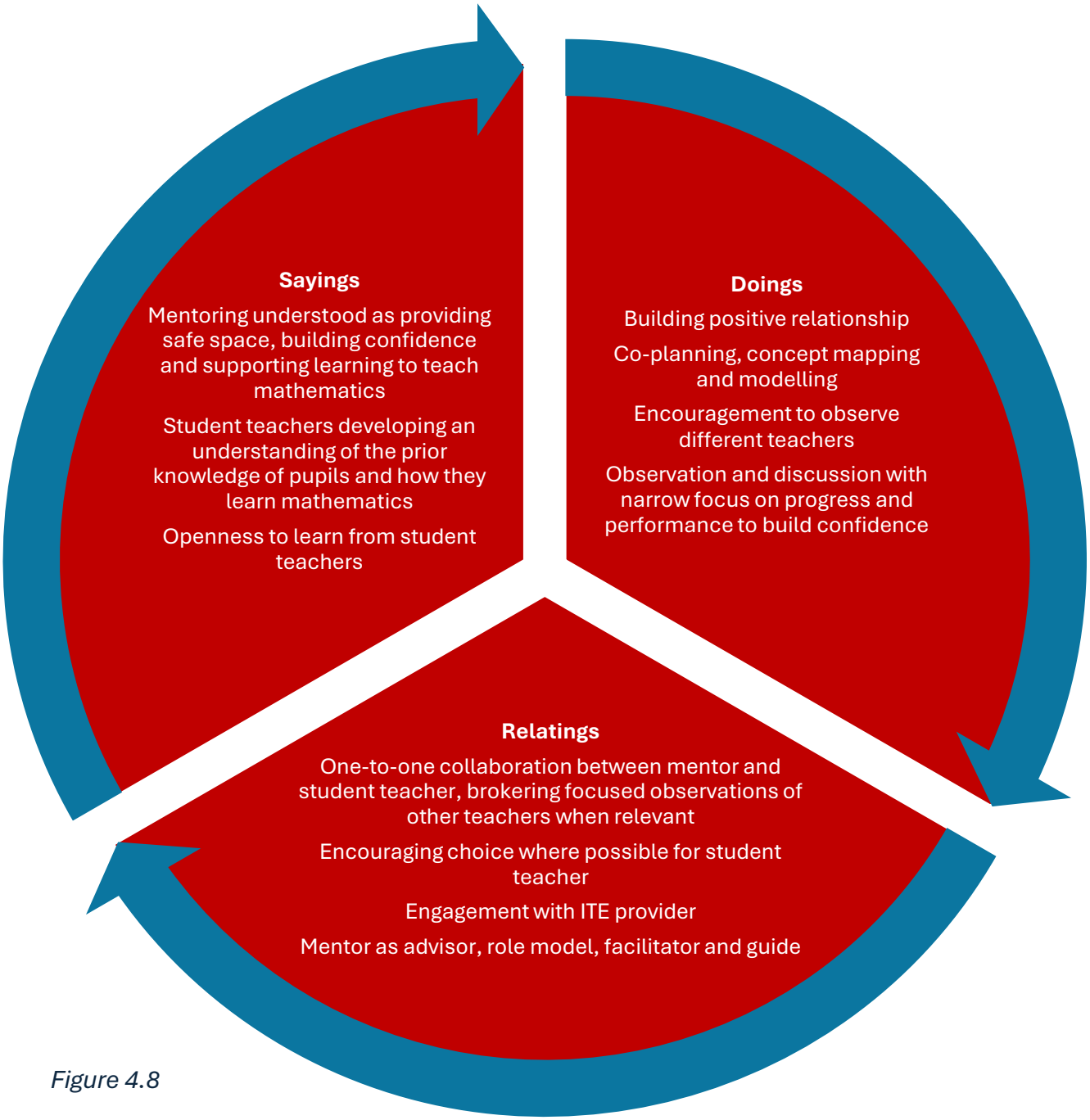


Figure 4.8

Adam's project of mentoring

Being a mentor

Like all mentors in this research, the relationship between mentor and student teachers is pivotal for Adam. He aims to create one that is open, trusting, collaborative and supportive, listening carefully to their perspective, providing guidance as needed, aiming to enable the student teacher to grow in confidence over time. When student teachers are observing lessons, Adam provides focused opportunities to observe other teachers to see different approaches in the classroom.

> I guide, you know, "Have you thought about this? Have you thought about trying this? Miss H, she does that really well, watch her."

> I think that when it comes to who to observe, it's often more useful for them to see someone who is in the early stages of their career, because if you say, "Go and see X who's brilliant at behaviour management." I think sometimes they come out and think "I'll never get to that" which is less helpful.

He also encourages them to see him teach classes with more challenging behaviour so that they are aware of the realities of the job. Whilst focused observations of other teachers were encouraged when needed, Adam did not mention student teachers working with other teachers beyond this.

Adam sees himself as an advocate for student teachers within the school and department, understanding their wider learning context and sticking up for them when needed. During his own ITE placements, Adam felt the need to fit in with different teacher's ways of working, recognising a lack of choice in how he taught as a student teacher; he had to replicate their approaches instead. Despite current constraints on his own practice as a teacher, as a mentor, Adam is keen that student teachers are

supported to find their own way of being a teacher, acknowledging that there are many ways to teach mathematics.

> I say it at the start, whenever new teachers come "You'll see how I teach, but I do not expect you to teach the way I teach. There are lots of ways to do this job."

This is something that has developed over time. As described earlier, when he started to mentor, he guided student teachers more towards classroom approaches that he found effective in his own teaching. Now, whilst he models his own ways of teaching and articulates his decision making when planning collaboratively with them, he encourages student teachers to try new ideas where possible.

The level of direction he provides is tailored to individuals, stepping in to provide more support and guidance when needed. Mindful of the value of noticing progress when learning to teach, he tries to provide parallel teaching groups on the student teacher's timetable so that they can act on feedback given from the first experience of teaching and see the impact of changes made. He also tries to replicate the narrow focus for development that was helpful for him in his recent professional development, describing the need to "focus on one aspect with the highest leverage where they can see impact straight away."

When learning to teach, Adam describes having lots of positive mentoring during his placements, getting good feedback and clear targets from mentors that he could immediately address and see an impact in his teaching.

> The things I had to work on were small enough so I could try and put them right.

Reflecting on the development of his own mathematical knowledge for teaching, Adam admitted that as he started his PGCE course, he thought he knew all the mathematics he would need already but was

> caught out a few times.... you realise "Actually, I need to go away, and I've got to look at things more deeply."

He described not wanting to show any weaknesses as a new teacher and learning to consider mathematical ideas more deeply before teaching.

Working with the researcher's university as a mentor, Adam has valued the clear guidance given for mentors but also the agency to work in ways that suit him as a mentor. As an ECT mentor, he expressed frustration at the constraints on how he must support and set targets for ECTs.

Considering the development of subject knowledge for teaching, when planning collaboratively, Adam draws on approaches that were used during his ITE course to help student teachers think about mathematics from the pupils' perspective, challenging them to think about what they will need to know as a teacher to facilitate this learning.

> When I was a student I did concept mapping. I like working with a big piece of paper, and put 'fractions' in the middle or something and then you talk about "If you're teaching fractions to year 9, what do you need to know?" You start from that before looking at any scheme of work, just purely from their own recollection, their own knowledge of maths. "What do you think a pupil will know? How will we go about teaching it? How can we make connections between one thing and another?" That's a really powerful way.

He asks questions to help student teachers understand how they can then build on prior knowledge, making links between different mathematical ideas to inform a lesson plan. Adam thinks that spending time working in this way then helps student teachers make more sense of the structure set out in textbooks. The school also has standardised resources and guidance videos for teachers to work from which he encourages student teachers to draw on to develop their understanding of approaches used within the school.

4.53 Adam's summary as a teacher and mentor

Adam's projects of teaching and mentoring reveal the importance he places on establishing an environment where people feel safe and able to learn. As a teacher, Adam's openness to learn from others, including the student teachers he is working with, means that his identity and priorities as a teacher and mentor continue to change. When speaking about teaching mathematics, Adam uses language linked to cognitive science approaches, something that was not as evident in other mentor stories. Adam's focus on progress and performance when teaching and mentoring aims to build confidence something also reflected in Jessica's story.

Whilst Adam is currently constrained in his own practice as a teacher, he aims to provide some agency for student teachers to develop a wider understanding of approaches to teaching and learning mathematics, and a deeper, connected understanding of mathematics that enables student teachers to respond with confidence when teaching. Like Alice, the use of concept maps provides an effective way for him to do this. While Adam directs student teachers to observe other teachers when relevant, like Alice, he seems to take responsibility for the student teacher's wider professional development,

involving other teachers when needed rather than fostering the collective approach to mentoring that was evident in Sam's and Jessica's approach. This perhaps reflects the current working culture within his department where teachers do not have time to discuss teaching mathematics together.

4.6 Summary of approaches to mentoring across mentor stories

Across these mentor stories, some common themes emerge. Establishing a trusting relationship where student teachers can be open, share uncertainties and explore new ways of thinking about teaching and learning mathematics was a priority for all mentors. Educative approaches to mentoring (Feiman-Nemser, 2001a; Van Ginkel et al., 2016) were evident through a focus on learning through collaboration, discussion and the use of questions to develop reflective skills and a broader, deeper understanding of teaching and learning mathematics. However, collaboration with other teachers varied, with mentors in departments where a collaborative working culture was already established referencing this more. Student teachers in these departments were integrated into this working practice, creating a conception of teaching that involves ongoing collaborative learning about mathematics and teaching and learning mathematics.

Mentors were also open to learning from student teachers (Ambrosetti et al., 2014; Lejonberg et al. 2018), as evidenced by Adam's story of changing his own approach to teaching and Jessica's observation

> The trainees that I have had that have done really well have been those who have been really open to working together because actually, you learn loads from trainees

All mentors in this research experienced learning mathematics in traditional ways and their own ITE course was significant in developing their mathematical knowledge for teaching, opening up new ways to think about teaching and learning mathematics as well as developing an understanding of how others learn mathematics. University tutors, peers, mentors and other teachers at placement schools were all identified as significant

in this learning. Despite constraints on some of their practices as teachers, mentors aimed to provide agency for student teachers as they were learning to teach, replicating experiences that they found valuable as student teachers such as ensuring opportunities to learn from different teachers, through observation and collaboration, and encouragement to try out different approaches within the classroom when teaching. For some, the development of reflection was central to their role as a mentor, something Harrison et al. (2006) suggested would facilitate greater learning for student teachers. Mentors were aware of the need to provide greater support and direction to student teachers at times and adapted their practice to suit the needs of individuals, blending showing and telling with asking and questioning (Feiman-Nemser, 2001b). They understood the learning journey for student teachers, with more guidance provided towards the start of the ITE year and when student teachers were struggling, aiming for greater independence over time.

4.7 Conclusion

The stories in this chapter, and the projects of teaching and mentoring identified, give a rich account of how mentors perceive their role as they support student mathematics teachers during their teaching placement, with educative approaches evident across their practice. Similarities and differences across the mentor stories related to approaches to mentoring have been identified, with mentors developing considerable understanding of the subject knowledge development needs of student teachers and their role in supporting this within their school context, which I will now go on to consider further in Chapter 5.

Chapter 5: Mentors' views on mathematical knowledge for teaching

5.1 Introduction

The previous chapter gave an account of the individual experienced mathematics mentors' stories as they work with student mathematics teachers during their teaching placements. Through considering the aims, actions and ends identified within their individual projects of teaching and mentoring (Kemmis et al., 2014) similarities and differences in their approach to mentoring were identified.

In this chapter, I provide a cross-case analysis of my case studies, focusing primarily on mentors' understanding of mathematics and the subject knowledge development of student teachers in their working context, to explore my first two research questions:

- How do mentors understand the subject knowledge development needs of secondary mathematics student teachers during their PGCE year?
- How do mentors understand their role in the subject knowledge development of secondary mathematics student teachers?

This cross-case analysis aims to explore the commonalities and differences between the mentors in relation to mathematics, identifying patterns, relationships between teaching and mentoring, and variations across the mentors' stories. In doing so, I aim to synthesise my findings and move towards more widely applicable conclusions about mentors and subject knowledge development which are considered further in Chapter 6. For ease of comparison, Tables 5.1 and 5.2 set out the projects of teaching and mentoring from Chapter 4.

The chapter is structured by considering my first two research questions in turn. My findings about mentors' conceptions of subject knowledge required to be a good mathematics teacher and what it means to learn to teach mathematics are considered, before moving on to examine how mentors conceive their role in subject knowledge development. In Chapter 6, I develop these ideas further, exploring how the dispositional themes identified in this research may provide potential causal mechanisms which influence mentors' perceptions and practices related to the subject knowledge development of student teachers.

Table 5.1

Projects of teaching comparison

	Sam	Alice	Jessica	Adam
Sayings	• Social constructivist approach to teaching and learning mathematics • Aims to develop relational understanding in pupils when teaching mathematics • Developing relational understanding of mathematics as a teacher and an understanding of how pupils learn- focus on misconceptions • Open to learning from pupils and colleagues	• Teaching mathematics involves breaking down concepts and presenting them in accessible ways • Focus on understanding how pupils learn mathematics • Developing relational understanding of mathematics as a teacher	• Teaching involves using a wide range of approaches • Focus on understanding how pupils learn mathematics • Developing a relational understanding of mathematics as a teacher	• Continually changing beliefs about teaching and learning mathematics • Focus on understanding how pupils learn mathematics • Developing relational understanding of mathematics as a teacher • Language of cognitive science when discussing teaching
Doings	• Creating interactive classroom environment • Use of collaborative tools when teaching • Discussing mathematics and approaches to learning and teaching with colleagues • Adapting standardised KS3 resources created by department or developing own resources	• Discussing teaching with colleagues when needed • Designing own lessons drawing on departmental scheme of work • Developing creative lessons when there is time	• Building positive relationships with pupils, building confidence • Discussing mathematics and approaches to learning and teaching with colleagues • Adapting bought-in KS3 resources or developing own resources • Whole school policies influencing teaching	• Building positive relationships with pupils, developing love of mathematics • Using bought-in KS3 resources for teaching • Creating booklets for use when teaching
Relatings	• Some autonomy and agency for planning and teaching as teacher and as a department • Culture of informal collaboration to support ongoing learning as teachers in department • Formal collaboration - school meetings • Learning opportunities brokered by MAT	• Autonomy and agency as a teacher • Informal on-to-one collaboration with colleagues to support ongoing learning as a teacher • Engagement in formal training courses within school and outside of school (e.g., Embedding Formative Assessment, NPQ)	• Culture of informal collaboration to support ongoing learning as teachers in department • Formal collaboration - school meetings • Engagement with professional communities beyond school (e.g., online, Maths Hubs)	• MAT and SLT as decision makers; lack of agency as a teacher currently • Engagement with popular mathematics education books and wider professional development opportunities (e.g., Ambition Institute coaching)

Table 5.2

Projects of mentoring comparison

	Sam	Alice	Jessica	Adam
Sayings	• Social constructivist approach to mentoring, sensitively challenging assumptions • Student teachers developing a relational understanding of mathematics, focus on understanding how others learn mathematics and how to structure mathematical ideas • Focus on professionalism, well-being and emotional support	• Mentoring understood as supporting, guiding and advising student teachers in their role as a professional and as a maths teacher. • Student teachers developing a relational understanding of mathematics, focus on understanding how others learn mathematics and how to structure mathematical ideas	• Mentoring understood as providing emotional support, building confidence and supporting learning to teach mathematics • Student teachers focusing on understanding how pupils learn and developing a range of different approaches when teaching mathematics • Openness to learn from student teachers	• Mentoring understood as providing safe space, building confidence and supporting learning to teach mathematics • Student teachers developing an understanding of the prior knowledge of pupils and how they learn mathematics • Openness to learn from student teachers
Doings	• Building positive relationship • Co-planning, observation and post-lesson discussion to develop teaching and reflection • Discussion of pre-planned lessons, misconceptions and how pupils learn mathematics • Encouraging increasing independence • Guidance to learn to be a professional	• Building positive relationship • Co-planning, observations, working collaboratively on concept mapping to develop lesson planning • Informal and formal meetings • Inquiry approach- asking questions to develop reflection • Guidance to learn to be a professional	• Building positive relationship • Co planning, rehearsal and modelling • Observation and discussion • Informal and formal meetings • Guiding and advising • Providing opportunities to see a variety of approaches to teaching mathematics • Encouragement to try different ideas out and learn from them	• Building positive relationship • Co-planning, concept mapping and modelling • Encouragement to observe different teachers • Observation and discussion with narrow focus on progress and performance to build confidence
Relatings	• Student teachers integrated into collaborative working culture in department • Mentor brokers opportunities for student teachers to work with others • Openness to learn from student teachers • Mentor as guide, facilitator, advisor and coach	• One-to-one collaboration between mentor and student teacher. • Encouraging choice for student teachers • Mentor as facilitator, role model, advisor and guide	• Student teachers integrated into collaborative working culture in department • Mentor brokers opportunities to work with others • Mentor as advocator, advisor, coach and assessor • Support from senior colleagues for mentor role • Partnership with ITE provider	• One-to-one collaboration between mentor and student teacher • Brokering focused observations of other teachers when relevant • Encouraging choice where possible for student teacher • Engagement with ITE provider • Mentor as advisor, role model, facilitator and guide

5.2 Research question 1: How do mentors understand the subject knowledge development needs of secondary mathematics student teachers during their PGCE year?

Mentors within this research demonstrate an understanding of the complexities of teaching and learning mathematics. As established in the projects of teaching in Chapter 4 (see Table 5.1 for summary), the experienced mathematics mentors believe that to support the learning of pupils, all teachers need to develop a rich, connected understanding of mathematics and an awareness of how pupils learn mathematics (Ball et al., 2008; Shulman, 1987). This provides a focus for mentors as they work with student teachers during their placement. The mentors' experiences during their ITE year were significant in establishing expectations about subject knowledge development for teaching which continue to influence their perceptions and practice as teachers and mentors many years later (Klieger & Oster-Levinz, 2015). This was evident in:

- Expectations about the mathematical knowledge a teacher needs
- Expectations about drawing on mathematical knowledge for teaching in the classroom

5.21 Expectations about the mathematical knowledge a teacher needs

In common with previous research (Davis & Simmt, 2006; Gess-Newsome, 1999; Hill et al., 2005; Kinach, 2002), within this study, the mentors' own starting points as student teachers revealed that their initial mathematical understanding, despite good mathematical qualifications, was instrumental and fragmented in nature. For example, Sam's story highlights that he initially saw mathematics as a set of standalone topics but came to understand that as a teacher, he needed to know the connections between different mathematical ideas. In a similar way, Alice reflected that as a pupil, she was

not interested in understanding “Why?”, but this developed later as a teacher. The mentor stories in Chapter 4 suggest that mentors also have a pedagogic focus for subject knowledge development, considering how others might learn a topic and what teachers need to know and understand to facilitate this, such as knowledge of misconceptions and alternative approaches to teaching and learning. The need to develop their mathematical knowledge in this way became evident during their ITE year through working with pupils and teachers. Sam and Adam both reference experiences of not being able to help pupils as a catalyst for developing their own understanding as teachers.

Mentors do not mention PCK specifically (Shulman, 1986) but their frequent reference to developing a student teacher’s understanding of mathematics and how others learn mathematics reflect this dual focus on content and pedagogy. Their insights align with elements of Ball et al.’s (2008) *Domains of mathematical knowledge for teaching*, in particular a relational understanding of mathematics (specialised content knowledge), an understanding of how pupils learn mathematics and the challenges involved (knowledge of content and students), and an understanding of how to teach, with knowledge of alternative approaches and an ability to structure ideas coherently (knowledge of content and teaching). Just as the mentors’ own beliefs about mathematical knowledge for teaching, tacitly held, are influential in their classroom practice as teachers (Ernest, 1989; Fennema & Franke, 1992; Lannin et al., 2013), this research, in common with Kemmis et al. (2014), finds that they are also influential in the early development of their student teacher’s mathematical knowledge for teaching. For example, whilst all mentors in this research focus on developing an understanding of how pupils learn, they emphasise developing different aspects of knowledge which

align with their own priorities and thought processes as teachers, such as understanding prior knowledge (Adam), common misconceptions (Sam), mathematical structure (Alice) and different approaches to draw on when teaching (Jessica). The role of context is also significant (Ernest, 1989) as the mentors' own beliefs will be influenced by the priorities for the department (Rowland & Ruthven, 2010; Van Driel & Berry, 2010), with the use of standardised resources for Sam, Jessica and Adam, providing a structure for the content of lessons that student teachers will use when teaching.

5.22 Expectations about drawing on mathematical knowledge for teaching in the classroom

Whilst experienced mathematics mentors sought to support student teachers to develop mathematical knowledge for teaching that was similar to their own, they did not prescribe *how* student teachers should use this when teaching, acknowledging frequently that learning to teach and knowing how to draw on mathematical knowledge for teaching requires more than copying others (Darling-Hammond, 2006; Lofthouse, 2018; Rowland et al., 2014). Experiences during their own ITE year established the mentors' expectation that the ITE year was a time to open up and develop wider understanding of teaching and learning mathematics and of how pupils learn and that student teachers should be encouraged to find their own way of teaching, despite current constraints on their own teaching. This included having some agency to learn to make professional decisions about how best to teach through collaboration with more experienced colleagues, something that Darling-Hammond (2006) suggested was an essential part of initial teacher education in the twenty first century. From the mentors' perspectives, the purpose of ITE included a focus on developing student teachers'

professional identity (Biesta, 2012) to learn how to make professional judgements in the classroom to support the learning of a diverse group of pupils (Feiman-Nemser, 2001a; Van Driel & Berry, 2017). The projects of teaching in Table 5.1 show that as teachers, the mentors within this research had different beliefs about teaching and learning mathematics and had different approaches in the classroom. However, where possible, they sought to encourage student teachers to learn from a wide range of practices and to develop their own beliefs about teaching and learning mathematics and approaches that suited them as mathematics teachers. For Sam and Jessica, working in departments where a collaborative working environment was already in place, this included opportunities to work with and learn from a range of different teachers.

Whilst all mentors expressed the view that teachers needed to develop a relational understanding of mathematics as a teacher (Ball et al., 2008; Shulman, 1987; Skemp, 1976), Sam was the only mentor who also stated that this was also his intention when working with pupils. The other mentors adopted a wide range of approaches when teaching mathematics, focusing on the progress and performance of pupils, and whilst they felt teachers needed a relational understanding of mathematics in order to support pupils, the nature of the mathematical knowledge they were seeking to develop when working with pupils was not stated within this research. As student teachers observed Sam teaching, this relational understanding of mathematics may have been more obvious as he sought to make it explicit for pupils as well, but with other mentors, their own relational understanding as teachers may have been more tacitly held, used to inform their decision-making during teaching but not overtly discussed with pupils.

Whilst my first research question provides some insight into mentors' understanding of mathematical knowledge for teaching, it does not consider how mentors perceive their role in this development, which I now move on to consider.

5.3 Research question 2: How do mentors understand their role in the subject knowledge development of secondary mathematics student teachers?

Whilst mentors are clear about the type of mathematical knowledge for teaching that student teachers need to develop, they are not always aware of their role in subject knowledge development (Bullough, 2012; Lejonberg et al., 2018). In the third research interview, when asked "How do you work with student teachers to develop their subject knowledge?", some mentors first stated that they did not do this, before going on to describe a wide range of ways in which they *do* seek to support student teachers to develop mathematical knowledge for teaching and mathematical thinking to support the learning of all pupils, highlighting the implicit nature of their practice in this area. The mentors' stories in Chapter 4 demonstrate that they have considerable insight into what it means to learn to teach mathematics which is evident through their understanding of the:

- **nature of initial content knowledge** that student teachers bring to the ITE course (Davis & Simmt, 2006; Gess-Newsome, 1999; Hill et al., 2005; Kinach, 2002)
- **subject-specific assumptions** about teaching and learning mathematics that student teachers often bring to their ITE course (Ernest, 1989; Petrou & Golding, 2011; Schoenfeld, 2012)

- **challenges** faced by student teachers as they try to develop their own mathematical knowledge for teaching (Berliner, 2004; Darling-Hammond, 2006; Van Driel & Berry, 2010)
- **strategies** mentors draw on to support student teachers to develop this mathematical understanding (Darling-Hammond, 2006; Depaepe et al., 2013)

Mentors also understand the importance of creating relationships of trust (Hobson et al., 2009; Lofthouse & Thomas, 2014) and a supportive learning environment where assumptions can be addressed, new understanding developed and challenges of learning to teach mathematics overcome through working collaboratively.

Mentors' awareness of the student teachers' starting points and the nature of their initial content knowledge has been discussed already, therefore in the following sections, I explore the potential assumptions and challenges faced by student teachers that mentors identify and the strategies that mentors draw on contingently to develop student teachers' mathematical understanding.

5.31 Common assumptions and challenges when learning to teach mathematics

Teacher education has an important role to play in challenging initial beliefs about teaching and learning, pupils and how they learn best (Darling-Hammond, 2006) as their beliefs go on to support or hinder the development of effective teaching approaches. This research with experienced mathematics mentors identified three assumptions that student teachers have about learning to teach mathematics:

- They already have all the mathematical knowledge they will need to be a teacher

- They think that learning mathematics is easy and that pupils will remember everything they are taught
- They think all pupils will learn in the way that they learnt

In common with Davis and Renert (2013a), drawing on their own experiences of learning to teach, or from working with student teachers, mentors recognise that student teachers with strong qualifications can assume they have no more maths to learn. This is exemplified in Jessica's story in Chapter 4 where she highlights that those with strong qualifications may not be as open to learning more mathematics as others who are less certain about their own mathematical knowledge. As discussed above, Sam and Adam recognised this in their own development as teachers. In addition, Sam and Jessica both acknowledge that the importance of developing mathematical knowledge for teaching only becomes clear following classroom experiences when student teachers realise that are not able to support pupils' learning.

The mentors in this research understand that student teachers often have assumptions about what it means to learn mathematics, thinking it is easy. They do not realise that pupils may find learning mathematics challenging and that they will not retain everything they are taught. Their awareness of mathematical misconceptions will be limited if their own experience of learning mathematics has been straightforward, as acknowledged in Sam's initial struggle to understand misconceptions when he was learning to teach. Student teachers can also bring with them assumptions about teaching mathematics (Ernest, 1989; Petrou & Golding, 2011; Schoenfeld, 2012), not recognising the role that contexts have played in shaping their current perspectives. In particular, they assume that they will just need to teach how they were taught or that

teaching is simple and is the same as telling, as reflected in Sam's observation that student teachers can initially take over the lesson and present ideas, rather than engage with pupils' learning, and Jessica's quote below:

> It's understanding that there is more to it than just "This is what you do, this is how you get the answer, off you go and do some questions."

Overcoming these initial assumptions as a student teacher can be hard. For those who have found mathematics easy to learn, gaining insight into the learning of others is difficult and takes time. The compressible nature of learning mathematics (Davis & Renert, 2013a) means that student teachers don't remember how they learnt mathematical concepts themselves as described in Sam's story related to solving quadratic equations in Chapter 4. When learning mathematics themselves, they are less likely to have encountered misconceptions that are common for others. Within this research, all the mentors had had experiences of struggling to learn mathematics which had been pivotal for their learning as a teacher, but not all student teachers have had this experience. Accepting that they have more mathematics to learn can be a knock to their early confidence as a student teacher, hence the need for strong relationships of trust and supportive learning environments (Hobson et al., 2009; Lofthouse & Thomas, 2014). Further challenges arise due to the busy nature of schools (Hobson et al., 2009), so that opportunities to discuss, use, and refine newly gained mathematical knowledge for teaching a topic are reduced or delayed by the need to move on to the next topic on the curriculum (Maud et al., 2024). If initial assumptions are not challenged, this will impact the learning and development of the student teacher, who may continue to teach like they were taught rather than integrate and adapt new knowledge to develop a

wider range of approaches, and consequently, better support the learning of the pupils they are working with (Darling-Hammond, 2006; Ernest, 1989).

5.32 Strategies used by mentors to develop mathematical knowledge for teaching

Irrespective of the working cultures within a department, mentors draw on a range of collaborative strategies to support the development of mathematical knowledge for teaching, with some aiming to expose student teachers to a wide range of approaches through brokering opportunities to work with other teachers. As outlined in the mentors' stories in Chapter 4, they draw on their own ITE experiences and aim to replicate strategies that had supported their own subject knowledge development, such as observation, co-planning, co-creating concept maps, pre- and post-lesson discussions and rehearsal of explanations, providing ways to learn from experienced mentors and teachers.

However, challenges arise within these collaborations due to the difference in what experienced and new teachers know and how they think (Berliner, 2001). This is exemplified in Sam's reflection below on the process of sharing lesson plans in advance.

> On the face of it, their lesson plan looks really good, and you're like, "Yes, this is good. This is fine." And then when you're in the lesson watching it, you're like, "Well, they have mentioned this about subject knowledge and haven't mentioned this about subject knowledge" .... I think that ultimately comes from the fact that if I'm planning a lesson, my lesson plan would probably look exactly the same as theirs would, but the extra things I would say, and the extra things I might do, would look very different.

As already highlighted, the value of particular mathematical knowledge may not be understood by student teachers until after they have taught a lesson, when a student teacher finds they cannot think on their feet and respond to pupils, something previously highlighted as important for teachers when supporting the learning of a diverse groups of pupils (Mason & Davis, 2013; Rowland et al., 2014). Sam continues:

> I don't know how to reveal that knowledge in advance .... with all the will in the world, I've explained, I've looked at a lesson plan when I've gone "It's really important that you talk about these three things for this topic." And then in the lesson, they don't talk about any of them. And then we do come to the post-lesson conversation, and they go "I needed to talk about this. I needed to talk about this. I needed to talk about this." and it's only through them doing, that they understood the importance of those three things.

This is perhaps unsurprising as learning to teach is a complex process as student teachers develop their mathematical knowledge for teaching alongside a wide range of other types of knowledge and skills (Darling-Hammond, 2006; Feiman-Nemser, 2001a; Shulman, 1987). Berliner (2001) highlighted that subject-specific knowledge becomes structured more effectively with greater experience in the classroom so experienced teachers can draw on it more flexibly than new teachers, but that this takes years to develop.

Opportunities to explore the student teachers' developing understanding and share the tacitly held knowledge of experienced teachers can arise in post-lesson discussions (Rowland et al., 2014), but again, a lack of time in school can constrain the chance to do this in depth (Hobson et al., 2009; Maud et al., 2024).

5.4 Conclusion

In this chapter I set out my cross-case analysis of my case studies, exploring my first two research questions. These focused on developing insight into experienced mathematics mentors' understanding of mathematical knowledge for teaching and the subject knowledge development needs of student teachers as well as their perceptions of their role and their practices. In doing so, I identified that experienced mathematics mentors develop knowledge of what it means to learn to teach mathematics, including an understanding of the nature of their initial mathematical knowledge; common subject-specific assumptions about teaching and learning mathematics; the challenges faced by student teachers in developing their mathematical knowledge for teaching and the range of strategies mentors draw upon to support the development of this knowledge.

As my research is set within a critical realist paradigm, I am also interested in understanding the underlying factors and structures influencing mentors' perceptions and practices around subject knowledge development as they support student teachers on placement. My analysis of their research interviews identified four dispositional themes which propose potential causal mechanisms influencing this. These are explored further in Chapter 6 as I turn my attention to my final research question:

- What personal, structural, and contextual factors influence mentors' perceptions and practice?

Chapter 6: Factors influencing mentors' perceptions and practice

6.1 Introduction

As set out in Chapter 1, my research aims were:

- to understand mathematics mentors' perspectives on the subject knowledge that teachers need, and to find out how they work with student teachers to support this development
- to understand mathematics mentors' working contexts and the factors that influence their practice as a teacher and mentor

Chapters 4 and 5 together considered the findings related to the first research aim and my first two research questions:

- How do mentors understand the subject knowledge development needs of secondary mathematics student teachers during their PGCE year?
- How do mentors understand their role in the subject knowledge development of secondary mathematics student teachers?

Through the mentors' individual stories and projects of teaching and mentoring (Kemmis et al., 2013) and cross-case analysis, I identified that mentors believe student teachers need to develop a rich, connected understanding of mathematics and an understanding of how pupils learn mathematics. I also established that experienced mathematics mentors develop knowledge of what it means to learn to teach that is mathematical and pedagogical in nature.

As my research is located within a critical realist paradigm, in this chapter I move on to explore my second research aim, the underlying reasons influencing mentors' perceptions and practice, considering my final research question:

- What personal, structural, and contextual factors influence mentors' perceptions and practice?

In doing so, I draw on the dispositional themes identified at the end of Chapter 3.5 These are:

- the existence of *specialised mathematical knowledge for teaching and mentoring*
- the impact of educative ITE experiences on conceptions of teaching and mentoring that shape mentors' initial and ongoing practice and perceptions
- the role that collaborative working cultures in schools play in enhancing mathematical learning opportunities for student teachers and mentors
- the impact of wider structural contexts in school and educational policy creating arrangements that enable or constrain subject-specific teaching and mentoring approaches

A range of theories about mathematical knowledge for teaching inform discussion about mathematical knowledge for teaching and mentoring (e.g., Ball et al., 2008; Rowland et al., 2014). The theory of practice architectures (Kemmis et al., 2013) is used to develop an understanding of the cultural-discursive, material-economic and socio-political arrangements in schools and wider educational policy that enable and constrain the development of mentors' perceptions and practice within their school contexts. In addition, I draw on the typology of structures identified by Scott (2010)

which informed my interview questions, with particular focus on the following structures:

- **embodied objects**-structures that restrict the potential for actions or change, the curriculum, use of standardised resources, exam processes, lack of time, performativity measures, Teachers Standards
- **social discourses**- structures that can effect change but may not e.g., ideas, values and attitudes about mathematics, teaching and learning, or mentoring
- **modes of agency**- structures linked to personal identity e.g., background, past experiences of teaching, learning to teach or being mentored, professional relationships and role within school/MAT
- **institutional and systemic norms**- social norms and accepted ways of working within a school or MAT or ITE programme e.g., roles, hierarchy, relationships, use of standardised resources, use of meeting time, time for mentoring, access to professional development

The chapter is structured using the dispositional themes identified, starting with the *specialised mathematical knowledge for teaching and mentoring* that experienced mathematics mentors develop. Following this, I focus on the potential influence of wider structures and working contexts on mentors' perceptions and practice, drawing on the remaining dispositional themes. The chapter concludes with a diagram (Figure 6.2) summarising influences on the development of mentor's perceptions and practices related to subject knowledge development of student teachers.

6.2 Mentors' specialised mathematical knowledge for teaching and mentoring

Drawing together the findings from my first two research questions in Chapters 4 and 5, in this section I set out my conception of *specialised mathematical knowledge for teaching and mentoring*, subject-specific knowledge developed by experienced mathematics mentors supporting the development of student teachers. This is summarised in Figure 6.1 below. It comprises of mentors':

- initial content knowledge
- mathematical knowledge for teaching
- mathematical knowledge of learning to teach

The proposed model is dynamic in nature, influenced by early experiences of learning to teach as well as ongoing experiences of being a teacher and a mentor.

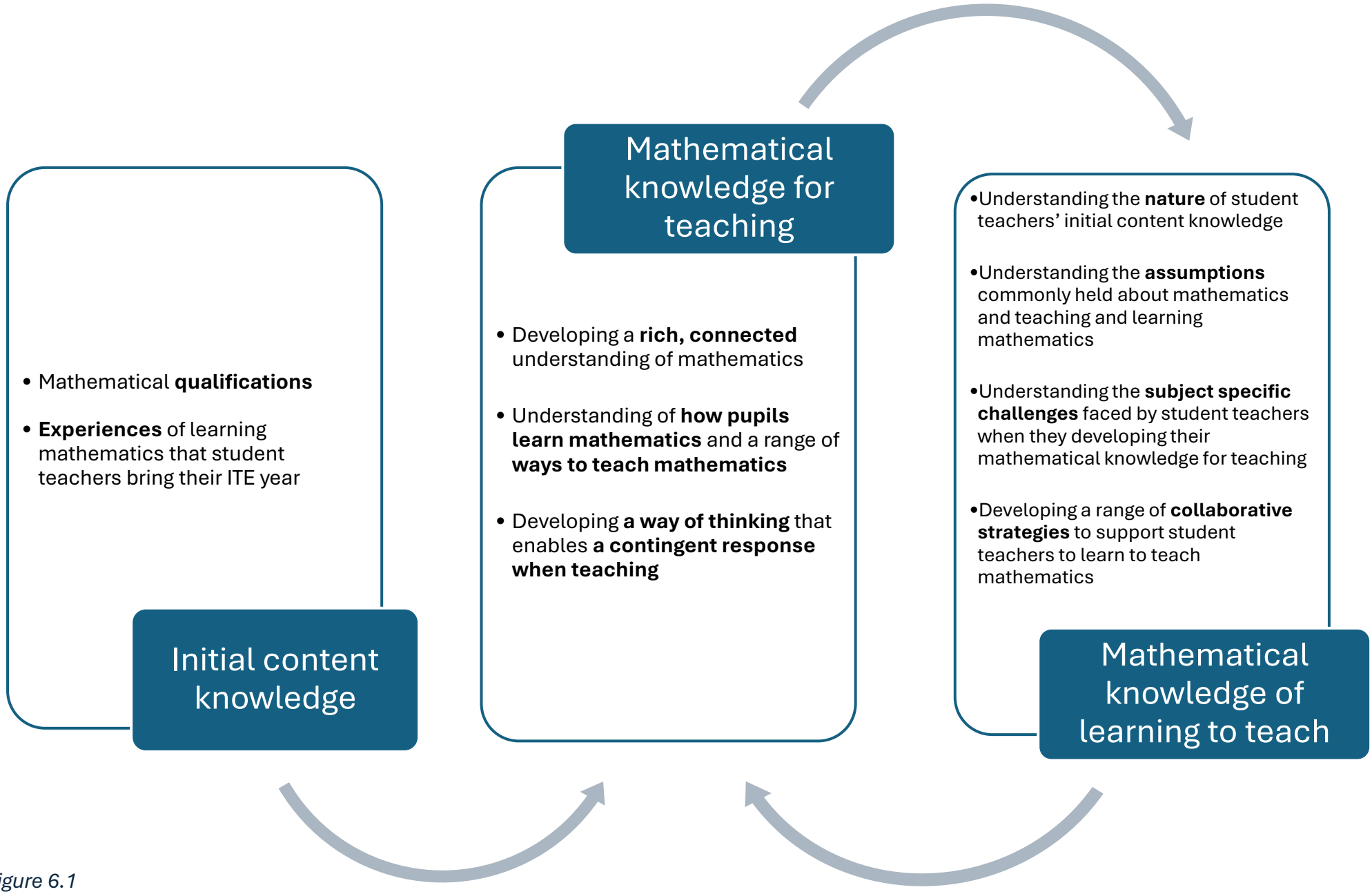


Figure 6.1

Model of Mathematical knowledge for teaching and mentoring

In Chapter 4, this research demonstrated that as teachers, mentors' initial content knowledge developed from something that was fragmented and instrumental to a richer, connected understanding to enable them to understand and support the mathematical learning of pupils (Ball et al., 2008; Fennema & Franke, 1992). As teachers, mentors developed their own subject-specific modes of agency (Scott, 2010), structures linked to their personal identity born out of their own experiences; their mathematical knowledge for teaching influenced by their own beliefs about teaching and learning, their ITE year and their experiences of teaching in schools (Darling-Hammond, 2006; Kelchtermans, 2017; Petrou & Golding, 2011). Over time, they learned to draw on this knowledge flexibly to support the learning of all pupils (Berliner, 2001; Fennema & Franke, 1992). Through the mentor stories set out in Chapter 4, and the cross-case analysis in Chapter 5, it is evident that as mentors gain experience of working with student teachers, they also develop mathematical knowledge of learning to teach, demonstrating insight into the nature of student teachers' initial content knowledge and the assumptions, challenges and strategies involved in working with student teachers as they learn to teach mathematics. The stories show that through working collaboratively with student teachers and being open to learning themselves, this mathematical knowledge of learning to teach further informs the mentor's mathematical knowledge for teaching as they gain further insight into how others view mathematics.

Whilst Shulman (1986, 1987) was criticised for not considering the role of beliefs in his taxonomy of teacher knowledge (Ernest, 1989; Fennema & Franke, 1992; Lannin et al., 2013), my conception of *specialised mathematical knowledge for teaching and mentoring* has this as a focus. Mentors acknowledge the importance of addressing

initial assumptions and misconceptions about mathematics and teaching and learning held by student teachers, something considered essential in research about teacher education (e.g., Darling-Hammond, 2006). Rowland et al.'s (2014) knowledge quartet also has relevance here. As discussed in Chapter 2.4, their work focused on student teachers' subject knowledge development in four areas related to the teaching of pupils (foundation; transformation; connection; contingency), encompassing the need for a rich, connected understanding of mathematics and the ability to know how to respond in the moment when teaching. There are parallels when considering the mathematical knowledge that mentors develop about their student teachers and their learning. When considering their mathematical knowledge of learning to teach, mentors develop *foundational* knowledge about student teachers' beliefs and assumptions about mathematics that informs their *contingency* to understand and know how to respond to student teachers when working with them in different ways. Their understanding of student teachers' starting points also informs how to support student teachers to *transform* their content knowledge and develop *connections* when planning, teaching and reflecting on lessons, the final two categories identified by Rowland et al. (2014). This is exemplified by Sam's observation that student teachers often only see the relevance of mathematical knowledge for teaching once they have taught a lesson. Therefore, Sam prioritises post-lesson discussions with student teachers to explore subject knowledge development.

Mentors also recognise the need to create an environment where student teachers are able to learn, something highlighted in all of their projects of mentoring (see Chapter 5, Table 5.2). They are aware of the vulnerable nature of learning to teach (Kelchtermans, 2017; Lofthouse, 2018; Shanks, 2014) and the tensions involved (Pillen et al., 2013).

Navigating the conflict and challenge of re-thinking previously held beliefs (Steadman, 2021) and dealing with uncertainty (Flores, 2020) as student teachers try to fit into a new working environment requires the establishment of a trusting relationship which all mentors recognise as essential (Hobson & van Nieuwerburgh, 2022).

Having considered the specialised knowledge that experienced mathematics mentors develop as they support the subject knowledge development of student teachers, in the following sections I consider in more depth the role that wider structures and working contexts might play in shaping mentors' perceptions and practice.

6.3 How contexts and structures shape mentors' perceptions and practice

Teaching and mentoring are social practices that are not just shaped by the aims, intentions and actions of individuals; they are also shaped and pre-figured by the cultural-discursive, material-economic and social-political arrangements that exist within or are brought to a school context (Mahon et al., 2016). As such, the theory of practice architectures recognises that practice is both socially and historically constituted and reconstituted over time. This theory also recognises that teaching and mentoring are networked practices, or ecologies of practices, with changes in one practice affecting the other (Kemmis et al., 2013).

As my research is located within a critical realist paradigm, I wanted to consider the arrangements that are brought to, or in place at, the contexts where student teachers and mentors are working together. I start with consideration of the influence that the mentors' own ITE experiences play in shaping their perceptions and practice as mentors. Next, with recent changes to the school landscape and the increase in

standardised approaches to teaching and learning mathematics evident in secondary schools in England, I turn to focus on the contexts within which mentors and student teachers are currently working together and how this continues to shape their perceptions and enable and constrain their practice as mentors. I use the theory of practice architectures as an analytical resource, to reveal how teaching and mentoring practices are enabled and constrained, and as a transformational resource to consider ways to change educational practice (Mahon et al., 2016).

6.31 The significance of the ITE year on mentors' future perceptions and practices

Just as student teachers often start their career teaching as they were taught (Darling-Hammond, 2006; Lortie, 1975), the same is true for the approaches to mentoring that mentors in this research initially adopted. In the mentors' stories in Chapter 4, it is evident that prior experiences of learning to teach, and the practice architectures in place during the ITE year, such as the sayings, doings and relatings in their placement schools, shape the future perceptions and practice of mentors.

The ITE year develops practice traditions (Kemmis et al., 2013) that new teachers take with them into their early career; inherited ways of thinking, acting and relating that are brought to or developed within school placements that formed part of their ITE course. When learning to teach themselves, the mentors within this research developed a conception of the purpose and practice of teaching and mentoring as they worked with more experienced teachers (Richter et al., 2013). All mentors within this research had positive experiences of being mentored during their ITE course which provided a starting point for their own practice as mentors. As new mentors, they sought to replicate the social discourses and institutional norms (Scott, 2010), and sayings, doings and

relatings (Kemmis et al., 2013), which had been beneficial to them when they were being mentored. Looking at the comparison of projects of mentoring set out in Chapter 5 (Table 5.2), educative approaches to mentoring are evident (Feiman-Nemser, 2001a) as they all aimed to foster relationships of trust and develop opportunities for student teachers to learn, through observation, discussion of mathematics (e.g., use of concept maps by Adam and Alice) and discussion of planning and teaching. Sam and Jessica, in particular, also prioritised promoting opportunities to learn from a wide range of teachers, practices that had been significant in broadening and deepening their understanding of mathematics and approaches to teaching and learning as student teachers. During his own ITE placements, a focused approach to feedback and target setting was beneficial for Adam, building his confidence as a student teacher when targets were met. This focused approach is now part of his way of working as a mentor. For Sam, his experience of a culture of experienced teachers regularly discussing teaching and learning mathematics and considering how all pupils could make progress established a perception that teaching and mentoring are strongly collaborative projects (Kemmis et al., 2014; Scott, 2010). The solidarity that existed within those departments created an expectation that part of the role of the teacher was to work with colleagues to continue to develop their mathematical understanding and practice as a teacher. This is evident in his social constructivist approach to mentoring where there is a strong focus on learning through discussion with more experienced teachers and also being open to learning from student teachers themselves (Aderibigbe et al., 2018; Ambrosetti et al., 2014; Lejonberg et al., 2018).

Whilst the mentors in this research initially sought to replicate strategies that had been beneficial when they were learning to teach and share their own ways of teaching, over

time, their approach to mentoring became more contingent in nature, seeking to work in ways that suited the student teacher and their development needs (Feiman-Nemser, 2001b). For example, despite currently working in a department where he has little agency as a teacher, Adam describes how during his seventeen years as a mentor, he has moved away from encouraging student teachers to teach as he taught, instead providing, where possible, opportunities and freedom for student teachers to become their own type of teacher. In common with other mentors in this research, he continues to act as role model and share his ways of thinking and working, but his aim is to encourage student teachers to find what works for them, enabling the development of their own identity as a teacher, identified as central to high-quality teacher education (Darling-Hammond et al., 2017). Similarly, Sam describes relying less on his own experiences of being mentored over time, instead learning from the student teachers he is working with and adapting to what they need.

Richter et al.'s (2013) research with student mathematics teachers highlights that adopting social constructivist approaches when mentoring, evident in Sam's approach in particular, increases the efficacy, enthusiasm and job satisfaction of student teachers, and can aid retention. However, this conception of the role of the mentor to guide and facilitate is at odds with the focus within the ITTECF (DfE, 2024b) where mentors are conceived as experts to be copied. It is evident from this research that the experienced mathematics mentors valued their ITE year as a time to develop a broad and deep understanding of teaching, which supported the development of their professional identity. However, the socio-political arrangements currently in place (Kemmis et al., 2013), as reflected in ITE policy, create a different conception of what it means to be a good teacher. It promotes a particular ideology of teaching and learning,

based on cognitive science (DfE, 2024b; Hordern & Brooks, 2023), potentially narrowing opportunities for student teachers and creating superficial learning about teaching that de-professionalises the role of the teacher (Traianou et al., 2025). A good teacher is seen as a deliverer, following set guidance about what to teach and how, rather than developing the critical reflection and agency that develops a strong professional identity (Beijaard et al., 2023). Mentors are conceived in a supervisory role, positioned as experts who can model good practice and be copied by student teachers. Reducing the role of learning to teach as imitating others neglects the development of an individual teacher's subject identity which is significant in their development and retention as teachers (Brooks, 2016; Richter et al., 2013; Thompson, 2023). The mentors in this research, whilst seeking to model and explain good practice, had a broader understanding of their role as a mentor, with all mentors seeing themselves as a facilitator and guide, adapting their practice to meet the needs of individuals and their stage of development. Mentors all recognised the importance of providing some freedom for student teachers to try out new ideas, develop critical reflection and understand the value of different approaches to teaching and learning mathematics when working with pupils.

The development of mathematical knowledge for teaching during the ITE year, identified by Darling-Hammond et al. (2017) as a feature of strong mentoring programmes in countries with high retention rates for teachers, was a significant focus for discussion with student teachers for the mentors in this research. Currently the ITTECF (DfE, 2024b) recognises the importance of student teachers developing knowledge and skills to teach but its statement that it is "a shared body of knowledge and skills, irrespective of subject or phase" (DfE, 2024b, p.4) demonstrates a generic approach to learning to

teach. This potentially neglects the development of student teachers' subject-specific thinking and reflection (Hordern & Brook, 2025) that would enable to them to develop the professional judgements needed to become excellent mathematics teachers. ITE quality requirement guidance for mentors (DfE, 2025b), whilst identifying the need for student teachers to have mentors with subject expertise, focuses attention on mentors understanding the ITE curriculum and ensuring guidance through this curriculum. Without developing the student teachers' mathematical knowledge and thinking in a way that enables them to learn to notice and respond to the needs of pupils in the classroom, their teaching will not be as effective (Darling- Hammond, 2006; Mason & Davis, 2013).

Having considered the influence that mentors' own ITE experiences play in their perceptions and practices, I now move on to consider my next dispositional theme, the potential impact of collaborative working cultures in enhancing the mathematical learning opportunities for student teachers and mentors.

6.32 Working cultures for teachers create practice architectures for mentoring

The working contexts for mentors within this research were different in nature, enabling different professional learning for mentors as teachers, and different opportunities for student teachers learning to teach mathematics. Below, Table 6.1 summarises key extracts from the mentors' projects of teaching and mentoring relevant to teaching and learning and the working culture established in their departments (See Tables 5.1 and 5.2 in Chapter 5 for full comparison).

Table 6.1

Summary of approaches to teaching and learning and working culture from projects of teaching and mentoring

Name	Sam	Alice	Jessica	Adam
Current school context	11-18 school in small MAT	11-18 school, local authority	11-18 school in small MAT	11-16 school in large MAT
Approach to teaching and learning	Adapting standardised KS3 resources created by department or using own resources	Designing own lessons, drawing on departmental scheme of work	Adapting bought-in KS3 resources or developing own resources	Using bought-in KS3 resources for teaching, no flexibility
Discussion of teaching and learning with colleagues	Discussing mathematics and approaches to learning and teaching with colleagues, informally, meeting time, MAT PD opportunities	Discussing teaching with colleagues when needed	Discussing mathematics and approaches to learning and teaching with colleagues, informally, meeting time	None as a department, despite a lot of department time, time used to create booklets for teaching
Department approach to mentoring	Student teachers integrated into collaborative working culture in department Mentor brokers opportunities for student teachers to work with others	One-to-one collaboration between mentor and student teacher	Student teachers integrated into collaborative working culture in department Mentor brokers opportunities for student teachers to work with others	One-to-one collaboration between mentor and student teacher Brokering focused observations of other teachers when relevant

Approaches to teaching and learning within the school contexts varied in the mentors' stories in Chapter 4 but the nature of the professional learning community and working culture established appeared to be more significant when considering the practice of mentors as they supported the development of student teachers' understanding of teaching and learning mathematics. Sam and Jessica, working in schools where standardised resources were used flexibly and where a collaborative working culture

was established, integrated student teachers into this way of being as a teacher. The student teachers became part of a mentoring department. However, for Alice, working in an environment where she had complete freedom to plan and teach how she wanted, and Adam, with no flexibility to deviate from standardised KS3 resources, it seemed that while teachers collaborated when necessary, it was not part of the established working culture within the department. In both cases, the mentoring of student teachers seemed to be mostly facilitated by them.

Collaborative working cultures in mathematics departments provide teachers with greater access to opportunities to learn from others (Sjølie et al., 2019) and consequently, enhance learning opportunities for student teachers as they are mentored within these environments. It also supports mentors by creating an environment where everyone is involved in mentoring student teachers, addressing persistent concerns within research about the additional workload of mentoring, lack of time and isolation in the role (Hobson et al., 2009; Maud et al., 2024). Thompson (2023, p.38) recognises that "collaborative subject departments play a particular role in teachers' identity development and their relationship with the subject, particularly the acquisition of subject- specific pedagogical knowledge" suggesting the significance of institutional norms (Scott, 2010) when considering the learning opportunities for student teachers. Within collaborative departments, an expectation is established that being a teacher involves ongoing learning from others, fostering a curiosity about how pupils learn and how best to teach. This is exemplified in Sam and Jessica's stories where teachers regularly work together to further develop their mathematical knowledge for teaching, meeting to discuss misconceptions and ways to address them and discussing how to use standardised KS3 resources. The cultural-discursive

arrangements within these departments (Kemmis et al., 2013; Mahon et al., 2016) suggests that being a teacher means that it is ok to ask questions, admit that you don't know something, that you can learn from teachers, and reciprocally, contribute to the learning of other teachers. It also creates an environment where problem-solving and innovation about teaching and learning mathematics are seen to be part of the work that teachers do together (Kemmis et al., 2014). Discussion of approaches to teaching and learning considers the pupils they are teaching, acknowledging that different ideas may need to be drawn upon in different ways, addressing a concern raised that standardised resources do not engage and motivate pupils or meet the needs of pupils with special educational needs and disabilities (Traianou et al., 2025). This collaborative approach has the potential to develop a sense of belonging, professional autonomy and agency for teachers in departments (Kelchtermans, 2017; Shields & Murray, 2017), something observed in teacher education in higher performing countries (Darling-Hammond et al., 2017; OECD, 2020), and to provide transformative professional development opportunities for teachers (Boylan et al., 2023; Sjølie et al., 2019). However, in the most recent TALIS survey that they were involved in, England has one of the lowest ratings for teacher autonomy and collaborative working cultures (OECD, 2020).

Such approaches to working together are shaped by the institutional structures and social discourses (Scott, 2010) within the school context. These establish social norms and ways of working within schools and MATs, determining the use of time, beliefs about teaching and learning mathematics and access to professional development (Kelchtermans, 2017). Ofsted's (2024b) review highlighted that schools with strong professional development opportunities for staff provide a range of formal and informal

ways for teachers to work together, considering the wider context and individual teacher goals. For Sam and Jessica, their collaboration with colleagues was part of their way of being as a teacher that was facilitated by the institutional structures in place at a department and trust level. For example, for Jessica, planned discussions during scheduled department meeting time enabled new ideas from the Maths Hub to be explored by the department, with time and space given for teachers to understand and question these ideas and consider how they could be used in a range of ways to support pupils' learning. At a trust level, whilst Traianou et al. (2025) report the increase in top-down approaches where teachers are told what to teach and how, the director of mathematics role has the potential to support professional development in a way that provides greater professional autonomy, as was the case in Sam's school. In addition to sharing good practice across schools, the director actively sought out what teachers wanted to learn about, creating a collaborative working culture that extended beyond the department, ensuring that professional development was designed to meet the needs of teachers, not just about implementing school or MAT policies. The socio-political arrangements within the MAT and in the approaches adopted by the director of mathematics ensured that the teachers had power to effect change within their department, again promoting their professional autonomy and sense of belonging (Kelchtermans, 2017; Sjølie et al., 2019) within the MAT.

The cultural-discursive arrangements within a department reflect the ways in which teaching mathematics is understood and discussed, which enables teachers to develop a shared view of the purpose and practice of the teaching of their subject, something that can create a sense of belonging for teachers (Kelchtermans, 2017). In creating institutional structures where there is an expectation and time to collaborate

and discuss teaching and learning together, individual teachers can become influential in facilitating a space for others to work and learn together providing student teachers with opportunities to be part of this learning environment. Again, in Sam's school, one teacher who worked on different projects within the department was the driving force in gathering interested teachers together to discuss approaches to teaching and learning mathematics, aiming to develop wider and deeper understanding, albeit in their own time. This also led to newer teachers asking more experienced staff for advice to develop their subject knowledge at different points, evidence that a culture where teachers felt safe and able to admit weaknesses/areas for development had been established. Considering Scott's (2010) modes of agency, linked to personal identity, whilst individual teachers bring with them practice traditions from learning to teach and other experiences of teaching, a shared understanding of what it means to teach mathematics can be developed through strong collaborative professional relationships and working cultures (Kelchtermans, 2017), creating new practice traditions within the current context. When considering the development of mathematical knowledge for teaching, Scheiner (2022, p.9) states that

> The capacity of transformation of subject matter content… is not a property of an individual teacher but of social and cultural systems that organise ways of preparing subject matter content for students, in which certain kinds and forms of knowing are valued based on history and tradition as well as on societal needs and cultural practices

It is interesting to note that both Jessica and Sam spent their teaching careers so far in one school, choosing to stay in an environment that enabled them to teach and mentor

in ways that suited them, a place where social discourses within their department aligned with their own views about mathematics. For Jessica and Sam, the development of their mathematical knowledge for teaching and mentoring was not an individual, cognitive pursuit but one firmly embedded in the educational goals and working practices within their schools (Kelchtermans, 2017). However, for Alice and Adam, opportunities to do this collaboratively were not necessarily part of the established culture but were sought out through their own motivation to learn as teachers.

Considering the practice of mentors, a collaborative working culture within a department provides a practice architecture that facilitates an educative approach to mentoring (Feiman-Nemser, 2001a). Drawing on social constructivist approaches to learning, this approach sees mentoring as a reflective, reciprocal opportunity to develop understanding of teaching and learning and classroom practice. Within an environment where dialogue between teachers is part of their day-to-day practice, a mentor can integrate student teachers into this way of working in the department, helping them to develop their understanding of what it means to be a teacher from different people. Student teachers then have access to a wider range of opportunities to learn from experienced teachers, more formally, through working with them, and informally, being in the department and observing and being part of what happens day to day. Through discussing teaching and learning mathematics together, experienced teachers model subject-specific professional dialogue and make external their thinking and decision making that may otherwise be tacitly held.

If a student teacher does not see and hear this happening, they will not have access to the mathematical knowledge that an experienced teacher draws upon contingently to

know how to act in the moment, or be able to develop an understanding of how teachers decide what to give attention to, what to emphasise, connect or ignore to support the learning of pupils (Mason & Davis, 2013). Consequently, it may be more challenging to develop an understanding of how experienced teachers think and why they act in certain ways. Observing teaching without understanding why a teacher makes decisions or adopting approaches to teaching and learning mathematics without understanding why they have been selected, may result in superficial learning. This may make the development of student teachers' intelligent action that would enable them to know how to meet the needs of a diverse group of pupils more challenging (Darling-Hammond, 2006; Feiman-Nemser, 2001a).

So far, I have considered how mentors' own ITE experiences brought to the department and the collaborative working practices found in the mentors' current department shape the perceptions and practices of mentors and the potential learning of student teachers. Next, I move on to consider the potential influence of wider educational structures currently in place.

6.33 The impact of wider structural contexts on mentoring

Wider structural contexts create arrangements that influence the teaching and learning of mathematics and approaches to mentoring during school placements (Kemmis et al., 2014), enabling or constraining a mentor's practice.

Within schools and MATs, performativity and accountability structures remain significant (Brown et al., 2015; DfE, 2025d), providing measures of success that are interpreted by others. As explored in Chapter 1, increasing prescription of how to teach mathematics (Ofsted, 2021) and how to learn to teach (DfE, 2024b; DfE, 2025b) are

evident within current education and ITE policy and guidance. Within MATs, there has been an increase in the use of standardised approaches to teaching and learning, particularly in mathematics (Greany & McGinity, 2021; Traianou et al., 2025). Within ITE, the demands on mentors working with student teachers has increased (DfE, 2025b) with little provision for this within policy changes. In this section, I explore the impact of these embodied structures (Scott, 2010) on the mentoring of student teachers. I start by considering the wider educational policy structures in place before moving on to consider structural practices in schools and MATs and approaches to teaching and learning mathematics.

Wider educational structures

Performativity and accountability measures currently in place in England can create conditions in school which are focused on pupil outcomes at the expense of teacher autonomy and agency (Voisin & Dumay, 2020; Parcerisa et al., 2022). When considering the learning of student teachers, this may reduce opportunities to learn, creating an environment which is risk averse.

High workload for teachers has been a persistent issue in schools in England, and a reason why many leave the profession (DfE, 2024f). The pressures created by this undoubtedly have an impact on mentors and student teachers as they work together with a lack of time having an impact on the quality of mentoring (Hobson et al., 2009; Maud et al., 2024). This is evident in two ways related to curriculum. Firstly, as mentioned by Sam, the volume of the mathematics curriculum means that teachers need to move on quickly to ensure that they cover everything required, reducing opportunities to revisit new mathematical ideas with student teachers. Secondly, when considering the ITE curriculum, Alice mentions that with so much to do during an ITE

course, there is a pressure to get the student teachers teaching quickly, rather than taking time to learn from others.

Despite recent policy guidance which recognise the importance of the role of the ITE mentor, a lack of time and funding for the mentoring role and a lack of status in schools (Hobson & Malderez, 2013) means wider support networks for mentoring within schools varies widely, with ITE mentors reporting that they feel undervalued in their role (Maud et al., 2024). Sam suggests that as the progress of student teachers is not linked to the performance measures of the schools in which they are placed, mentors do not often have protected time to work with student teachers. Whilst schools may value working with student teachers and want to support the development of the next generation of teachers, the outcomes for ECTs and pupils, significant in accountability measures, understandably may take priority in terms of time and focus. Sam recognises how busy senior leaders are, instead relying on departmental colleagues and the collaborative working culture in place to collectively support the student teacher, and his work as a mentor as a result. The need for a collaborative approach is recognised as significant in reducing the isolation felt by many ITE mentors (Maud et al., 2024). Jessica was the only mentor to comment on the good support in place from senior leaders within school, providing an important reflective space to develop her practice and confidence as a mentor.

Whilst limited funding was provided to secure time for mentor training to meet new DfE requirements (DfE, 2025d), staff shortages, teacher workload and exam pressures may encroach on time allocated for this as happens for other professional learning (Ofsted, 2024b). Time to work together within the school day is not funded and often, mentors

sacrifice their own time to provide the support and guidance their student teacher requires (Maud et al., 2024). Whilst mentors develop expertise about teaching their subject and what it means to learn to teach and consequently are well placed to support the development of student teachers, the potential of this role will not be realised within these current systems (Hobson et al., 2009).

Whole school approaches

Within MATs, implementing trust-wide approaches, often adopted in response to Ofsted reports, requires teachers to develop ways to accommodate these approaches and ensure that the teaching of their subject is enhanced, rather than restricted. This was true for all mentors within this research, despite different working cultures and differing levels of individual teacher agency. Even within contexts where a collaborative working culture is established, as was the case for Jessica and Sam, teachers must find ways to negotiate the implementation of whole school policies, to be able to make them work for the mathematics classroom.

As well as standardised teaching and learning resources that teachers may need to use, teachers may also be required to have standardised lesson structures or practices that need to be integrated into all lessons. For example, Sam was currently learning to incorporate whole school lesson structure into his own classroom approaches, describing how he had to "get round the edges" to make it work for teaching mathematics. A similar, standardised approach to lesson structure was one of the reasons Alice left her previous school, when she felt that the whole school approach adopted did not work for mathematics, particularly in relation to discussion, and she did not feel listened to as a teacher when this was raised. She moved school to seek a

working environment where she had greater autonomy and agency in her classroom practice.

With whole school approaches often linked to Ofsted reports, it is understandable that schools need to ensure consistent implementation of these approaches, resulting in close monitoring described by Jessica in Chapter 4.4 where senior leaders did lesson observations to ensure the new school wide approach to develop reading was embedded in all classrooms. Whilst such standardised approaches may bring benefits, such as establishing expectations and routines that pupils become familiar with, they can also restrict classroom practice, limit creativity (Parcerisa et al., 2022) and may create tension when the social discourses within school are not aligned with teachers' espoused values and beliefs about teaching and mentoring. Teachers are required to navigate such practices and adapt them to ensure high quality teaching of their subject is maintained. Sjølie and Østern (2021) suggest that rather than expecting harmony or coherence across practices in schools, the role of teacher education should be to support student teachers to learn how to navigate differences and tensions that arise. However, current socio-political arrangements in schools mean that this ability to innovate and adapt is something that is in danger of being neglected in the development of student teachers who learn to teach in environments where many of the decisions about their lessons have been made by others.

Approaches to teaching and learning mathematics

Approaches to teaching and learning mathematics varied for mentors in this research, particularly at Key Stage Three. Alice was the only mentor who had autonomy and agency to plan and teach as she wanted to. Sam and Jessica could work flexibly from

shared resources, whilst Adam was restricted to using pre-planned booklets in Key Stage Three (See Chapter 6, Table 6.1).

Alongside collaborative working cultures, TALIS 2018 identified that strong professional autonomy was significant in the outcomes for pupils and in the retention of teachers (OECD, 2019). However, the practice architectures currently in place in England do not always create arrangements where individual or collective teacher autonomy is prioritised. This may compromise the development of student teachers' mathematical knowledge for teaching, especially when time is not provided for collaboration with more experienced teachers.

A centralised approach to teaching and learning mathematics standardises the educational experience across a school or MAT but it may reduce the professional autonomy of teachers (Parcerisa et al., 2022; Traianou et al., 2025) and create a reliance on others for subject-specific decisions about teaching methods, materials and assessment processes. Coupled with competing time pressures and low levels of professional development for teachers which has a subject-specific focus (Ofsted, 2024b), this raises concerns about the development of student teachers' understanding of teaching and learning mathematics.

Part of this research aimed to understand the potential impact of standardised approaches for teaching and learning on the practice of mentors working with student teachers. Whilst there was some evidence of a reduction in professional autonomy within the mentor's stories in Chapter 4, in departments where standardised resources were used flexibly, with some agency for teachers to adapt resources or use them selectively, an established collaborative working environment provided opportunities

for teachers to discuss how best to use these shared resources when teaching, allowing student teachers to be part of these discussions. This was the case for Sam and Jessica, providing valuable opportunities for student teachers to gain further insight into how pupils learn mathematics and to develop critical engagement with chosen teaching materials and approaches.

However, even within collaborative working environments, there can be challenges for student teachers as they try to understand how to use standardised resources that have been planned by experienced teachers. Berliner (2001) highlights that experienced and novice teachers think differently, with knowledge structured more effectively over time, experienced teachers can draw on this knowledge more flexibly. Sam's story highlights these challenges.

> We have pre-prepared resources. We obviously showed them to the student teachers, and I tried to make it very, very, very clear that they are a guide. They are a basis, and they are a starting point. They are something good to look at because ...the person that prepares them has excellent subject knowledge and really understands where the misconceptions are. As they look through them, we talk through them as well. And the bits that they see as the important parts of the lesson and of the pre prepared resources aren't necessarily what I would see as the important parts. And usually, the bits that they want to either skip over or quickly deal with are the ones that would bring the most challenge to the pupils and the ones that would be the most valuable for them. And I think that it it's again a massive learning curve about misconceptions and teaching in general, and why those conversations are what they are.

Providing a particular example about teaching about triangles

> Often student teachers are just like “Angles in a triangle they have 180 degrees, so the slide on this and the two examples on that are really important.” The three other examples after it that are about finding misconceptions, finding the errors. They'll quickly go over but won't actually have a large conversation with the kids about because they don't understand how important they are, their significance, and that actually that's way more important, I think. Before they got into that room, they all knew that angles in the triangle add to 180, you’ve not added any value to that, it’s about spotting in different situations with it.

Despite trying to highlight the importance in advance, understanding of this knowledge is only developed through the experience of teaching, highlighting the significance of reflective post-lesson discussions to ensure student teachers can plan and teach lessons that enable all pupils to make progress, and the development of reflective skills that will enable the student teacher’s ongoing learning (Aberibigbe et al., 2018; Harrison et al., 2006).

As already discussed, the mentors in this research valued learning from a wide range of colleagues when they were learning to teach themselves, but current practice architectures in place in school and within ITE policy potentially compromise this. Whilst mentors espouse a continued belief that student teachers need to see a wide range of practice, this is perhaps becoming more difficult to facilitate due to the use of standardised resources, as student teachers will see different teachers using the same resource for teaching. Whilst undoubtedly this will support them to learn from experienced teachers, it does not provide access to a wider range of effective

approaches that formed part of the development of mentors when they were learning to teach. For example, a student teacher may see a particular approach being used, without understanding possible alternatives and reasons why this choice has been made, creating an impression that there is one way to teach something and limiting the development of their mathematical knowledge for teaching. A lack of time to discuss this with experienced teachers further adds to the challenge of making sense of these decisions. Working from standardised resources potentially reduces opportunities to develop a breadth and depth of understanding and critical reflection that would come from observing a wide range of practice or being part of discussions where teachers are weighing up the right approach to choose for the class they are working with. Being able to critically evaluate different approaches to teaching and learning mathematics and develop their reflective skills in this way may happen less as student teachers focus on making sense of and understanding approaches selected by others. In some contexts, teachers do not have the agency to use standardised resources flexibly, potentially reducing further the opportunities to learn from others.

Not all schools adopt standardised approaches for teaching and learning mathematics, and this was the case for Alice. As a teacher, she had freedom to plan and teach in ways that suited her, but this did not always mean that student teachers had access to a wide range of opportunities to learn from others. Wider professional development priorities set within the school, whilst recognised as valuable learning experiences, had squeezed out opportunities for teachers to work together on subject-specific areas of professional development, something that had previously been in place. Without the use of shared resources to work from, there was perhaps less need and/or opportunity to discuss approaches to teaching day to day.

With claims that the current market model of education in place in England (Voisin & Dumay, 2020) has led to the disappearance of collaborative practices in schools (Parcerisa et al., 2022; Traianou et al., 2025), student teachers may have fewer opportunities to learn from experienced teachers in a meaningful way. Consequently, student teachers may not develop the depth and breadth of understanding of their subject to be able to respond contingently and confidently when working with pupils in the classroom. The type of teacher developed may be more restricted in their classroom practice as the material economic arrangements currently in place in many schools suggest that teaching is about following pre-prepared material, that teachers do not have meaningful control over their own work and are restricted to following guidance set out by others, de-skilling teachers over time and further reducing their professional status.

6.4 Conclusion

In this chapter, I explored the four dispositional themes identified within my research. These were:

- the existence of *specialised mathematical knowledge for teaching and mentoring*
- the impact of educative ITE experiences on conceptions of teaching and mentoring that shape mentors' initial and ongoing practice and perceptions
- the role that collaborative working cultures in schools play in enhancing mathematical learning opportunities for student teachers and mentors

- the impact of wider structural contexts in school and educational policy creating arrangements that enable or constrain subject-specific teaching and mentoring approaches

In Figure 6.2 below, the main findings from my research are drawn together, setting out how the cultural-discursive, material-economic and socio-political arrangements (Kemmis et al., 2013) brought to or found in the site of practice, through ITE experiences, previous and current school contexts and wider educational policy contexts, shape the projects of teaching and mentoring of individual teachers. These projects set out their evolving aims, actions and ends as teachers and mentors, encompassing their motivations and beliefs about teaching mathematics and mentoring student mathematics teachers. Together, these influences shape the perceptions and practices of mentors as they support the subject knowledge development of student teachers, developing *specialised mathematical knowledge of teaching and mentoring* that includes an understanding of how to support others to learn to teach mathematics.

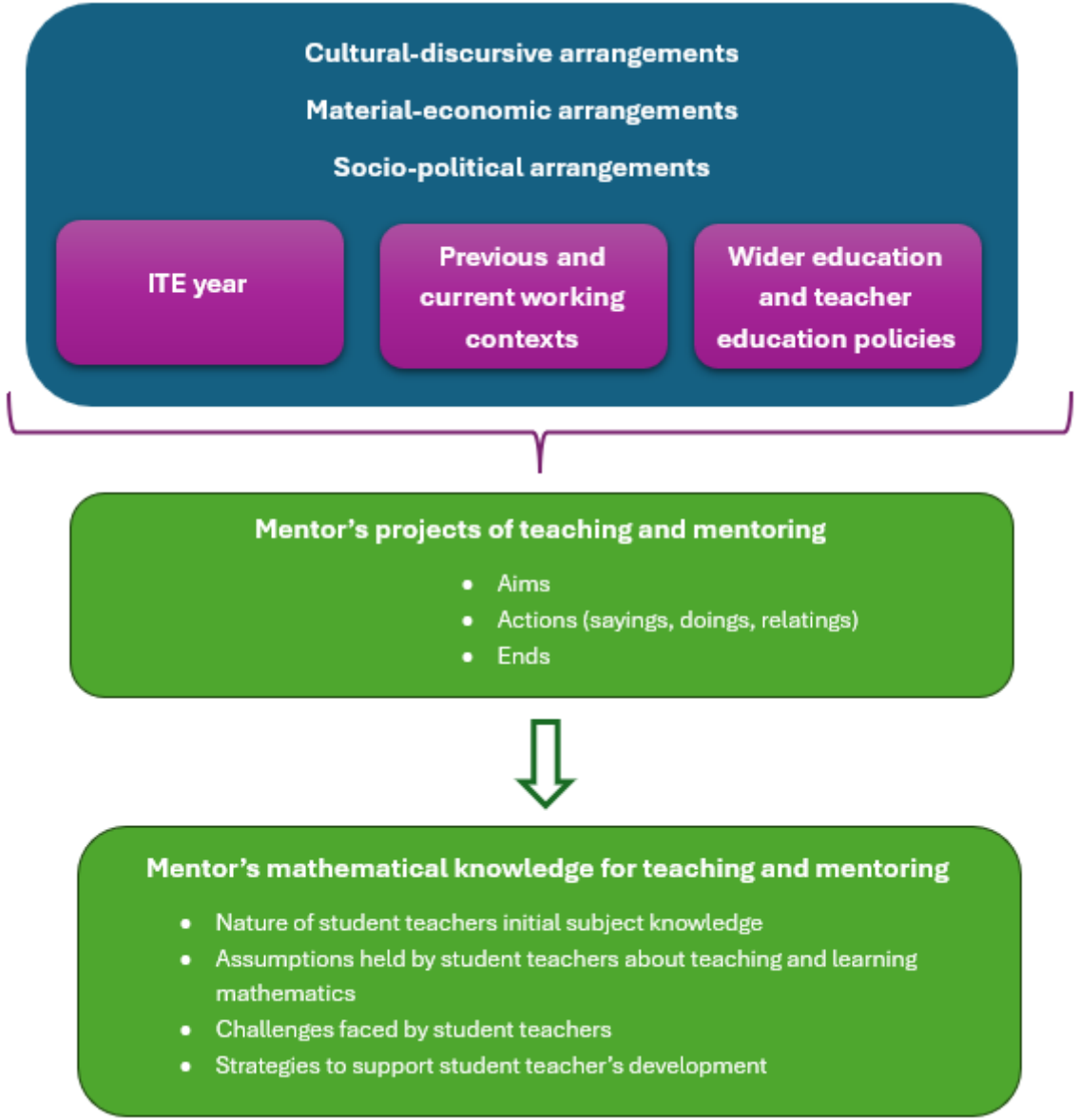


Figure 6.2

Influences on mentors' perceptions and practices of subject knowledge development of student teachers

Chapter 7: Conclusion

7.1 Introduction

In this final chapter, I summarise the key findings of my research. Following this, I outline my contribution to knowledge identified from my work with the experienced mathematics mentors involved and consider the wider implications and significance of my work for the field of teacher education. The limitations of this research are considered and recommendations for future policy and research that could build on my findings are outlined. I finish with a reflection on myself as a researcher and how this study has informed my professional practice.

7.2 Changing landscapes

In Chapter 1, I set out how changing landscapes in schools and teacher education in England had created a market model of education (Voisin & Dumay, 2020) where increasing control was exerted through educational policy related to schools and ITE. A narrowing conception of what it means to be a good teacher is evident across these contexts. Academies and MATs, created with the aim of improving educational outcomes, are now the dominant model for secondary schools in England (DfE, 2022). Initially intended to provide greater freedom for schools and more autonomy for teachers, something observed in the international comparisons of higher performing countries (OECD, 2007), this has not been realised for individual teachers (OECD, 2020; Ofsted, 2019). Instead, there has been:

- greater prescription of how to teach mathematics at a policy level (DfE, 2021b; Ofsted, 2021)

- an increase in the use of standardised approaches to teaching and learning across schools and MATs, particularly in mathematics (Traianou et al., 2025)
- less access to subject-specific professional development for teachers in England compared to those in high performing countries (Cordingley et al., 2019; OECD, 2019)
- a decrease in collaborative working cultures which would provide informal, context-specific professional development (OECD, 2020)

At the same time, increasing control over and standardisation of the content and structure of ITE courses has been exerted through recent policy changes (DfE, 2024b; 2025b) that has a generic, rather than subject-specific focus.

7.3 Summary of findings

Situated within a critical realist paradigm, this research aimed to understand the subjective reality of experienced mathematics mentors working in different school contexts as they supported the subject knowledge development of student teachers during their school placements, and to gain insight into the factors that shape their perceptions and practice. My research aims set out in Chapter 1 were:

- to understand mathematics mentors' perspectives on the subject knowledge that teachers need, and to find out how they work with student teachers to support this development
- to understand mathematics mentors' working contexts and the factors that influence their practice as a teacher and mentor

Through a sequence of semi-structured interviews, I explored the mentors' experiences as a learner of mathematics, becoming and being a teacher and being a mentor. I have

argued throughout this work that school-based mentors are well placed to support the subject-specific development of student teachers. In this research, I identified that experienced mathematics mentors develop a *specialised mathematical knowledge for teaching and mentoring*, knowledge that is mathematical and pedagogical in nature. This encompasses a mentor's own mathematical knowledge for teaching and mathematical knowledge of learning to teach. The practice architectures (Kemmis et al., 2013) across a range of contexts (mentors' ITE experiences, previous and current working environments, wider educational policy) are significant in creating cultural-discursive, material-economic and socio-political arrangements that shape this knowledge, the perceptions and practice of mentors and as a result, the learning opportunities for student teachers.

7.4 Contribution to knowledge

This research contributes to our understanding of the role of mentors in supporting student mathematics teachers as they develop their mathematical knowledge for teaching in two main ways, by identifying the:

- specialised knowledge developed by experienced mathematics mentors
- potential influences on the development of this knowledge

Since Shulman's seminal work in the 1980s, the nature of the specialised knowledge that teachers need to develop to become effective in the classroom has been conceptualised by researchers in different ways (Ball et al., 2008; Fennema & Franke, 1992; Rowland et al., 2014; Shulman, 1986,1987). A common thread across these conceptions is the importance of teachers understanding how pupils learn mathematics and how to overcome some of the challenges that are inherent in learning.

Other researchers have focused on how subject-specific knowledge for teaching can be developed by teachers (e.g., Depaepe et al., 2013; Horn, 2009; Kinach, 2002).

My research drew on this vast body of literature, but examined it through a different lens, focusing on the perceptions and practice of mentors to identify the specialised mathematical knowledge that they develop through working with student teachers, *mathematical knowledge of learning to teach*. My model of *mathematical knowledge for teaching and mentoring*, found in Chapter 6 Figure 6.1, encompasses:

- Mentor's initial content knowledge
- Mentor's mathematical knowledge for teaching
- Mentor's mathematical knowledge of learning to teach, including an understanding of the:
    - nature of initial content knowledge that student teachers bring to their ITE course
    - assumptions commonly held by student teachers about mathematics and teaching and learning mathematics
    - challenges faced by student teachers as they try to develop their own mathematical knowledge for teaching
    - strategies mentors draw on to support student teachers to develop mathematical knowledge for teaching

All student teachers, irrespective of their subject or phase, start their career as a teacher with a set of beliefs and assumptions about teaching; opportunities to analyse motivations, assumptions and beliefs to form new understanding of what it means to be a teacher are essential (Claxton, 1984; Darling-Hammond, 2006; Ernest, 1989).

Therefore, this understanding developed from working with mathematics mentors may be applicable more widely. In other subject areas, experienced mentors may also develop a specialised, subject-specific understanding of what it means to learn to teach their subject. Whilst this knowledge and understanding may be different in nature, the structure developed here for mathematics may provide a helpful framework to begin to consider the specialised subject-specific knowledge developed by mentors working in other subject areas. At a time when there is increasing use of standardised resources across all subjects and increasing time pressures for all teachers coupled with reduced opportunities to collaborate in schools, this also raises a question about the cumulative impact of these changing landscapes on the subject-specific learning of all student teachers as they work with their mentors. This warrants further research and consideration by education and ITE policymakers and ITE providers.

This study also contributes further to this field of research by identifying potential influences on the development of specialised subject-specific knowledge of teaching and mentoring. As set out in Chapter 6 Figure 6.2, the importance of the cultural-discursive, material-economic and socio-political arrangements in place in the mentor's ITE year, their previous and current working contexts and educational policy (Kemmis et al., 2013; Kemmis et al., 2014) are all significant in shaping the perceptions and practice of mentors and the subject-specific knowledge for teaching and mentoring that they develop. In particular, it highlights the importance of collaborative working environments as a rich source of subject-specific informal professional development, providing student teachers with a wider range of opportunities to learn from experienced teachers. With the use of standardised resources reducing the range of approaches a student teacher is likely to observe, integrating student teachers into

collaborative working environments provides essential opportunities to discuss the teaching and learning of mathematics more broadly, for example, exploring the reasons behind the teaching approaches chosen to develop a more critical and informed understanding of mathematical knowledge for teaching. Such environments provide access to tacitly held knowledge that informs experienced teachers' actions and decision making when teaching, developing a student teacher's capacity to know how to act in the moment to support pupils in the classroom (Mason & Davis, 2013). They also promote a conception of teaching as a profession that involves ongoing collaborative learning about mathematics and teaching and learning mathematics.

Alongside this, my research highlights the importance of ITE as a time to explore and develop a critical understanding of teaching and learning mathematics, in line with Lofthouse's (2023, para 6) assertion that universities should hold a space for professional learning "a space to think, articulate, share practice, experience dissonance, engage with alternatives, be curious, developed shared language, connect ideas and conceptual understanding and to elicit feedback." The practice architectures in place in schools and ITE when mentors were learning to teach provided experiences which enabled them to broaden their understanding, becoming open to new ways of thinkings about mathematics, develop critical reflection and curiosity that has become part of their way of being as teachers and mentors. This research finds that to continue to develop high quality mathematics teachers who can respond contingently to the pupils that they work with, it is essential that their ITE year provides opportunities to do this.

7.5 Limitations

This research set out the stories of four experienced school-based mathematics mentors working in different contexts in secondary schools in England. Whilst it is representative of a range of working contexts within our ITE partnership, it does not and did not seek to represent all contexts in schools. Similar research that focuses on the perceptions and practices of mentors about the subject knowledge development of student mathematics teachers, and in other subject areas, would continue to add to the knowledge generated from this research, to develop and refine my initial conception of *specialised mathematical knowledge for teaching and mentoring* presented here and perhaps develop similar insight in other subject areas.

Whilst in recent years there has been an increase in standardised approaches to teaching and learning mathematics, only one of the mentors in this research worked within a highly constrained school environment where decisions about teaching and learning were made by senior leaders in the school, rather than the department. As they had only been at this school for a year, I gained limited insight into the potential impact of a more rigid approach to teaching and learning mathematics on this mentor's perceptions and practice as he drew on a wide range of experiences across different schools.

This research was completed with mentors during 2022-23 and 2023-24 and since then, the use of standardised resources has continued to increase; it is now even more prevalent for mathematics teaching within schools in our ITE partnership. Ongoing research is needed to better understand the cumulative impact of the use of

standardised resources, and changes in working environments in schools on the learning opportunities of student mathematics teachers.

A final limitation is that the use of the theory of practice architectures as a theoretical, analytical and transformative lens (Mahon et al., 2016) through which to consider this research was not part of initial planning of my research design and therefore did not inform the decisions made at that point. Research involving the theory of practice architectures often captures practice in the moment through a mixed methods approach. Adopting a mixed method approach, perhaps through the use of video diaries which would enable the mentor's perceptions and their view of their practice to be captured at the time rather than solely accessed through reflection, may provide further insight in this area.

7.6 Recommendations

This research has significance for education and ITE policymakers, ITE providers and schools and makes the following three recommendations:

***Recommendation 1**: Education and ITE policy and school leaders should prioritise developing collaborative working environments to support the subject-specific professional development of teachers, mentors and student teachers*

Collaborative working environments for teachers are identified as significant for the development of good teaching within high performing countries (OECD, 2019, 2020). This research finds that collaborative working environments are also significant for the subject-specific learning of student teachers and recommends that they should be a priority with education and ITE policy. Without opportunities to develop this understanding and learn from experienced teachers, student teachers may develop approaches to teaching and learning mathematics that are superficial in nature,

restricted to teaching how they were taught or only using approaches that have been selected by others, without knowing why or having access to alternatives. This potentially restricts student teachers' capacity to support the learning of pupils in the future. Collaborative working environments enable student teachers to go beyond *Learning that…* and *Learning how to…* as set out in the ITTECF (DfE, 2024b) but also *Learning why…..,* by providing greater opportunities to explore and discuss teaching mathematics with experienced colleagues. Doing so enables the development of a deeper understanding of mathematics that equips student teachers to respond more contingently to the pupils they are working with.

In addition to this, education and ITE policy should ensure that mentors have time provided to collaborate with student teachers to realise the potential of working together. The need for more time for mentors to support student teachers is a persistent refrain throughout the research of others (e.g., Bullough, 2005; Hobson et al., 2009; Lee & Feng, 2007; Maud et al., 2024). Time is needed to provide opportunities for assumptions held by student teachers to be sensitively challenged, their challenges when learning to teach understood, and for mentors work with student teachers to support the development of a broad and deep understanding of mathematical knowledge for teaching.

***Recommendation 2**: ITE policy should include a focus on the subject-specific learning of student teachers*

Current ITE policy has a strong focus on the learning outcomes for student teachers, but not the subject-specific learning process of student teachers as they learn to teach their subject (DFE, 2024b). The current priority set, to develop an understanding of pupils' learning in the classroom, goes some way to recognising the mathematical

knowledge that student mathematics teachers need to develop; an understanding of the prior knowledge and misconceptions of pupils in order to address these and support their subsequent learning. However, the need to understand student teachers' own subject-specific starting points, the assumptions they bring about teaching and learning mathematics and how these can be addressed to enable further development that will benefit pupils in the classrooms, is absent. Leaving these assumptions and potential misconceptions unchallenged could limit the learning of student teachers and their effectiveness as mathematics teachers. This research provides insight into what this could look like for those supporting the learning of student teachers, enabling the knowledge and strategies developed by experienced mentors to be shared more widely. It may also provide a helpful starting point to consider the subject-specific knowledge developed by mentors in other subject areas which could inform future ITE policy.

***Recommendation 3**: ITE providers' secondary mentor curriculum should include a subject-specific focus*

In the absence of subject-specific guidance for mentors within the ITTECF (DfE, 2024b), the insight developed from listening to experienced mathematics mentors is valuable for ITE providers as they develop their own secondary mentor curriculum. Adopting a generic approach to mentor development neglects this important focus on the content of what student teachers are learning to teach. A subject-specific focus within a mentor curriculum provides the opportunity for mentors to develop an understanding of the known starting points, assumptions and challenges student teachers may face when learning to teach their subject, equipping them to understand and support student teachers more effectively. A focus solely on the competencies set out in the ITTECF framework (DfE, 2024b) potentially neglects the purpose, content and relationships that

characterise education (Biesta, 2012), when what is needed is the development of teachers who can make situated judgements that support the learning of all pupils. Teachers need access to a diversity of approaches to support learning, irrespective of the teaching and learning approaches adopted within school, whether standardised across a school or MAT or individual to the teacher. For mathematics mentors, a focus on *mathematical knowledge of teaching and mentoring* may enable ITE providers and mentors to develop an understanding of the tacitly held subject-specific knowledge that they have about teaching and mentoring, which would enhance their work with student teachers; this may also be applicable in other subject areas. In doing so, the role of the mentor would be expanded, moving from a role that is supervisory in nature, ensuring that standards are understood and met, to one that has the potential to ensure transformative professional development learning opportunities for student teachers to develop a deep understanding of the teaching and learning of their subject.

7.7 Reflection and implications for my professional practice

I started my part-time Professional Doctorate in Education in 2019 with an intention to better understand the impact that changes to school practices at that time, such as the adoption of standardised approaches to teaching mathematics, might be having on the subject specific development of student teachers and mentors as they worked together during placements. Over six years later, there has been a continued move towards more standardised approaches to planning and teaching within mathematics and across other subjects.

Initially, as an ITE tutor, I was frustrated that these approaches to teaching and learning mathematics may be reducing the professional autonomy of teachers and restricting

the learning opportunities of student teachers. Completing this research required me to set aside my initial assumptions and be open to developing a new understanding of the potential impact of these changes. My research provided me with an opportunity to hear directly from the mentors involved in supporting student teachers and to learn from their experiences and perspectives. Whilst I have always sought to listen to and learn from the student teachers and mentors that I work with, this research has allowed for a more structured, and sustained engagement with their experiences and perspectives.

The research process enabled me to gain a more balanced, contextually sensitive understanding of how mentors and student teachers work together during school placements, and some insight into the factors influencing this. In particular, I developed an understanding of the existence of mathematical knowledge for teaching and mentoring, an insight with implications for my practice that I had not originally anticipated. Integrating this understanding into future work with mathematics mentors is a priority for development within our mentor curriculum. When I started this research, I was the PGCE mathematics subject lead tutor, but for the past three years, I have been the PGCE secondary course leader with oversight across six different subject areas. As such, I can also see scope for the development of these ideas within our mentor curriculum on a broader scale than I had first anticipated.

Engaging with the experiences and perspectives of mentors challenged my initial assumptions about the impact of new approaches to teaching and learning in schools. In doing so, I discovered that collaborative professional relationships, rather than specific approaches to teaching and learning, play the most crucial role in developing student teachers' subject knowledge. Promoting opportunities for mentors and student

teachers to discuss the teaching of their subject has been an established part of the course for several years. However, my next steps are to use these insights to consider how to develop further collaboration between student teachers and mentors which focus on subject knowledge development, and to advocate for practices during school placements that provide greater opportunity for student teachers to learn from their experienced colleagues.

As I complete this thesis, the Curriculum and Assessment Review (2025) has just been published. Its call for an inclusive, evidence-informed curriculum shaped by teachers recognises the importance of professional autonomy, collaboration and the expertise already within the profession, which has parallels to the findings of my research. This stands in contrast to recent policy directions, which have not always fully supported or enabled these principles to flourish, but perhaps provides hope for changes ahead within schools that will enable a more collaborative approach to professional learning and development in the future.

However, a high turnover of mentors is evident in our ITE partnership, especially in mathematics, and this is born out in the mentors involved in this research. Since the completion of my research, one mentor has left teaching, one is no longer mentoring PGCE students, one is now working with a different ITE provider, meaning that just one mentor is still involved in our ITE partnership. The departure of two of these experienced mentors reinforces the importance of capturing and embedding their insights into our ways of working across our course and more widely. Doing so will ensure that future mentors, and the student teachers that they work with, and ultimately, the pupils that they teach, can benefit from the wisdom of practice they developed over time.

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Appendices

Appendix 1: Information sheet and consent form

Information sheet

Mentors and the subject knowledge development needs of student mathematics teachers: developing an understanding of perceptions and practice in schools.

Researcher: Claire Clemmet

Institution: School of Education

Programme: EdD

Supervisors: Information redacted

You have been invited to take part in a research study for my Doctorate in Education (EdD). Before you decide to take part in this study it is important to understand why the research is being done and what it will involve.

Please take time to read the following information carefully and discuss it with others if you wish. Please ask if there is anything that is not clear, or if you would like more information.

Research context

This research aims to understand how PGCE mathematics mentors work with student teachers to develop their subject knowledge. With a range of changes currently taking place in school structures and educational policy, the research will explore the influences on mentor perceptions and practices. This research will inform how we work in our ITE partnership to support student teachers with their subject knowledge development in the future.

Your opportunity to be involved

The research will involve 4-6 mentors who have recently or are currently working with the University of Nottingham PGCE secondary mathematics course.

You will be asked to participate in three one-hour interviews with the researcher. These are planned to take place during the Spring term with around two weeks between each interview. The interviews will involve discussing your educational history as a learner of mathematics; your transition into the teaching profession; your views of mathematics and teaching and learning mathematics and your perception of your role as a mentor of student mathematics teachers.

Interviews will take place at a time and location to suit participants. They will be recorded using a digital recording device and then transcribed. Transcriptions will be shared with participants via a secure link to check for accuracy. A request for amendments will be made, but there will be flexibility offered to suit the needs of the participant.

Anonymity and confidentiality

Recorded and transcribed interviews will be stored securely on the University of Nottingham SharePoint to guarantee confidentiality in line with UK GDPR guidance (data privacy notice attached). Only my supervisors and I will have access to this data. Your data will be anonymised, as well as the name and any identifying features of your school, and your name will not appear on any stored documentation, or subsequent writing. A pseudonym will be used for all data associated with you and in any reporting of the research.

Do I have to take part?

Participation is entirely voluntary. It is important that you understand that you do not have to participate in the research at all, and even if you decide to take part you are free to stop at any time and without giving a reason. Doing so will have no impact on your role as a mentor with student teachers on the PGCE mathematics course. You may have participated in mentor training events in the past, but you should feel free to comment on whether or how these have prepared you for your role.

Are there possible disadvantages and/or risks of taking part?

Three one-hour long interviews are planned for this research with will take up your time. Some people might find this difficult or tiring. You will be asked to reflect on your school context, teaching and mentoring and this might cause feelings of discomfort or anxiety. Otherwise, there are no substantive risks or disadvantages to taking part.

What are the possible benefits of taking part?

It is highly likely that the process of reflecting on your own experiences of education, teaching and mentoring will be professionally enriching. Furthermore, it is hoped that your views, and the views of others, will be used to develop the PGCE mathematics course and the ways on which mentors and university tutors can work together to support student teachers with their subject knowledge development.

Ethical review of the study

This research has been approved by the School of Education Research Ethics Committee. The University of Nottingham Code of research Conduct and Research Ethics (2019) and the ethical guidelines of the British Educational Research Association (2018) will be adhered to throughout all stages of the research process. A separate GDPR compliance notice will be sent.

What will happen to the results of the research?

Data will be deposited in the University of Nottingham research data archive for a minimum of 7 years unless a participant asks for their data to be withdrawn from the research.

This research is for my Doctorate in Education (EdD) which will be made available online following the completion of the programme. I also expect to present my research at conferences and academic and professional journals.

Contact details

If you want to know more about taking part, or have any questions, please contact me or my supervisor.

Researcher: Claire Clemmet

Supervisors:

School of Education Research Ethics Coordinator:

Participant consent form

Mentors and the subject knowledge development needs of student mathematics teachers: developing an understanding of perceptions and practice in schools.

Researcher: Claire Clemmet

Institution: School of Education

Programme: EdD

Supervisors: Information redacted

	Yes	No
I have read the Participant Information Sheet and the nature, and purpose of the research project has been explained to me. I understand and agree to take part.		
I have read the project's Privacy Notice		
I understand the purpose of the research project and my involvement in it.		
I understand that I may withdraw from the research project at any stage during the interview process and that this will not affect my status as a mentor now or in the future. I may also withdraw any data related to me at this point so that it is not included in the thesis. I understand that it will not be possible to withdraw my data after the interview process has been completed.		
I understand that while information gained during the study may be published, I will not be identified, and my personal results will remain confidential. I understand that the school and Multi-Academy Trust will also not be identified.		
I understand that I will be audio recorded during the interview.		
I understand that data will be stored on a University of Nottingham SharePoint site that only the research and supervisors have access to. Digital audio recordings will be stored separately from anonymised transcripts.		
I understand that all anonymised research data created by the project will be deposited in the University of Nottingham research data archive (https://rdmc.nottingham.ac.uk). University of Nottingham will retain and preserve research data in line with university requirements for a minimum of 7 years unless a participant asks for their data to be withdrawn from the research.		
I understand that I may contact the researcher or supervisor if I require further information about the research, and that I may contact the Research Ethics Coordinator of the School of Education, if I wish to make a complaint relating to my involvement in the research.		

Signed ..... (research participant)

Print name ..... **Date** .....

Contact details

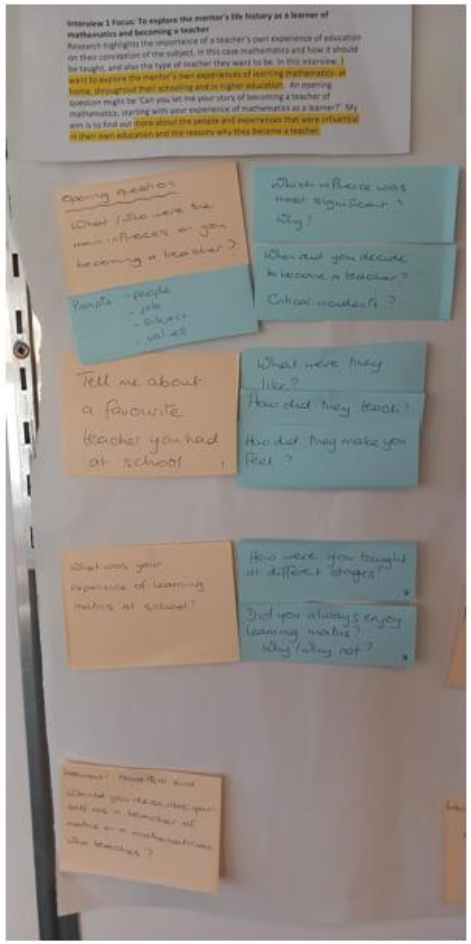
Researcher: Claire Clemmet

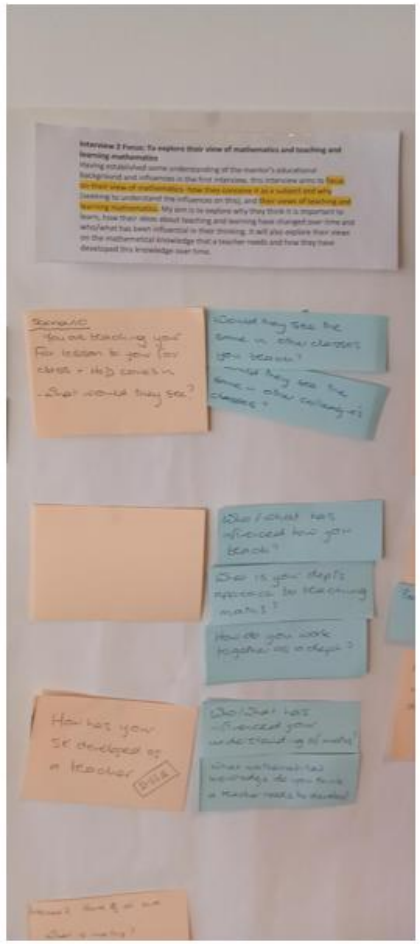
Supervisors:

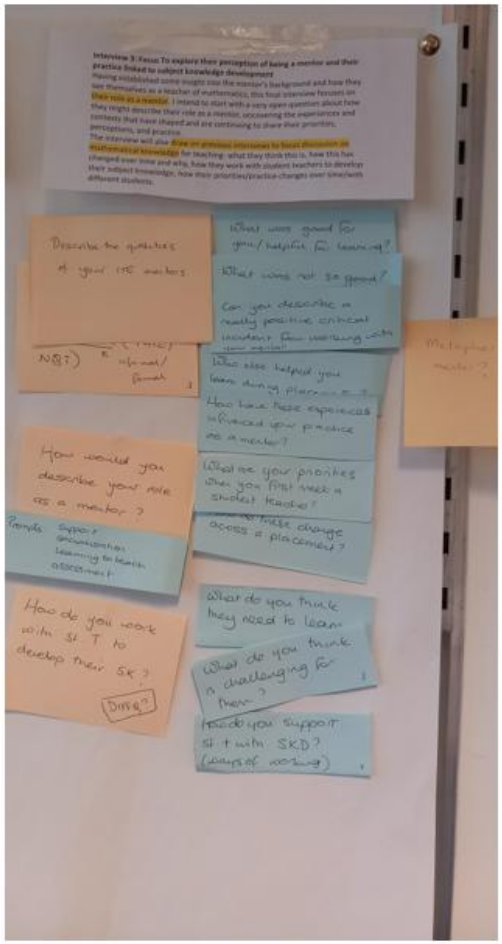
School of Education Research Ethics Coordinator:

Appendix 2: Interview resources

Appendix 2a: Development of interview questions mapped against interview focus







Appendix 2b: Interview questions mapped to research questions

Title: Mentors and the subject knowledge development needs of student mathematics teachers: developing an understanding of perceptions and influences on mentor practice in schools						
RQs	Int 1	RQs	Int 2	RQs	Int 3	
1. How do mentors understand the subject knowledge development **needs** of secondary mathematics student teachers during their PGCE year? 2. How do mentors understand **their role** in the subject knowledge development of secondary mathematics student teachers? 3. What **personal, structural, and contextual factors** influence this?	1.Why did you want to become a teacher? What/who do you think were the main influences on you becoming a teacher? ○ People ○ Nature of job ○ Subject ○ Motivation ○ Opportunities 2.Tell me about a favourite teacher you had at school ○ What they were like ○ How they taught ○ How they made you feel 3. What was your experience of learning maths? ○ Different stages ○ Enjoyment or not 4. Would you describe yourself as a mathematician who teaches or a teachers of maths? ○ Reason why ○ Change over time	RQ3 RQ3 RQ3 RQ2 RQ3 RQ2 RQ1 RQ1 RQ2 RQ3	1.Scenario: **Priorities as a teacher of maths** You are teaching your favourite lesson to your favourite class. Imagine there is a fly on the wall. What would they see/hear? ○ Tasks ○ Discussion ○ Role of T 2.Who/what influenced how you teach? ○ Teachers ○ Exp of learning ○ Other people ○ Experience of learning to teach ○ Experience of teaching 3.In what ways do you think your understanding of maths has developed as a teacher since you started your career? ○ Influences (who/what) ○ Experiences ○ School structures	RQ1 RQ3 RQ2	1.Scenario: Think back to your experiences of **being mentored**. Describe a significant critical incident from work with your mentor on one of your placements. If positive one, is there a less positive significant moment (or via versa)? 2.Card sort How would you describe the different aspects of your **role as a mentor**? Choose up to 5 words from the card sort that describe how you see your role as a mentor Areas of focus ○ socialisation into profession ○ emotional support ○ learning to teach ○ assessment 3.How do you work with student teachers to develop their subject knowledge? ○ Mentor role ○ Strategies ○ Influence of structures	RQ3 RQ3 RQ2 RQ1

Appendix 2c: Example of Pre-amble before starting interview

Interview 1

Preamble:

- Purpose of research overall- to find out more about mentors' perspectives on SK that student teachers need and how they work with student teachers. Also, to understand what influences this and which influences are most significant.
- **This first interview is about finding out more about experiences that were influential in your own education**
- Confirm consent. This is the first of three interviews hopefully. Remind that it is ok to withdraw at any time and with no reason given. I am going to record this on a voice recorder, and it will later be transcribed. The recording will only be heard by me. Both the recording and the transcription will be held securely on OneDrive under a pseudonym and will be destroyed when the research is complete. Anything you say here will be confidential.
- I would like you to feel able to talk freely- there are no right answers here- please try to say as much as possible in response to each question. I will be asking you to reflect on your own experiences and am interested in gaining insight into your 'lived experience' as a teacher and mentor.
- If we need to pause at any time, just let me know. We will take no more than an hour.
- Any questions before we start?

Appendix 2d: Interview Schedules

Interview 1

Opening question	Possible areas to explore	Further prompts
In this interview I am interested in finding out more about the people and experiences who were most influential in your education and why you decided to become a teacher		
Q1: Why did you want to become a maths teacher? What/who do you think were the **main influences** on you becoming a teacher?	Which **people** were influential?	Which of these **influences** was most significant for you? Why were they significant?
	What attracted you about the **nature** of the job of a teacher? (holidays/flexibility/working with young people)	
	Why did you want to teach **maths**?	
	What was your **main motivation** for wanting to teach? (**values**/social conscience/making a difference)	When did you decide to become a teacher? Describe any critical moments that informed this decision or was it something that evolved over time?
	What **practical** considerations influenced you? (bursary/location/university)	
	What '**push'** and **'pull'** factors were most significant for you?	
Q2: Tell me about a **favourite teacher** you had at school (does not need to be a maths teacher)	What were they like?	If not maths teacher, why this subject?
	How did they teach?	
	How did they make you feel?	
Q3: What was your **experience of learning** maths [at school]?	How were you taught at different stages? (early life/pre-school/primary/secondary/university)	
	Did you always enjoy learning maths? Why/why not?	
Q4: Would you describe yourself as a teacher of maths or a mathematician who teaches?	Why do you think this?	
	Has this changed over time?	

Finally: Today we have focused on your:	
• Main influences on becoming a teacher • Favourite teacher • Experience of learning of maths	Is there anything else arising from our conversation that you would like to add?

Debrief and next steps

Interview 2

Opening question	Possible areas to explore	Further prompts
In this interview I am interested in finding out more about your views of mathematics and teaching and learning mathematics		
Q1: Scenario: **Priorities as a teacher of maths** Tell me about a favourite lesson you teach. What is it like? What would you see/hear in the lesson?	What type of tasks would pupils be doing?	Would they see the same approach in other classes you teach? Would it be typical?
	How would the pupils be working? (individually/groups/noisy/quiet)	What sort of culture do you aim to create in your classrooms?
	What would your role be as a teacher?	Would they see the same in other colleagues' classes?
	What would be your intended outcome of the lesson?	What freedom/agency do you have as a teacher in your department/school/MAT?
	What type of teacher would pupils say you are?	
Q2: Who/what has influenced **how you teach**? • Historically • Currently	What role did your favourite teacher play (Interview 1)?	How has your approach to teaching changed over time?
	How did your **experience** of learning at school influence you (refer to Interview 1)?	
	Which other **people** were influential (mentor/tutor/peers/pupils/colleagues)?	How do you think your **values**/motivation to teach influence the type of teacher you are?
	How did your experience of learning to teach influence you?	What role did your peers/mentors/placements play?
	How has your experience of teaching influenced you (different schools/MATs?)	What is your department's approach to teaching maths?
		How do you work together as a department?
		If applicable, was it the same/different in other schools?
Q3: In what ways do you think your **understanding of maths** has developed as a teacher since you started your career?	**Who/what** has had an influence? (peers/mentor/colleagues/department/ school/MAT/PD)	Who/what do you think was most influential?
	Are there any particular **experiences** of planning/teaching/observing that have been significant in shaping your understanding of maths as a teacher?	What strategies/experiences have helped you to learn?
	What role have the **ways of working** within your department/school/MAT played in influencing your understanding?	Does everyone in your department have the same understanding of mathematical knowledge for teaching?

Q4: Reflecting on our conversation so far, how would you answer these questions? • What is maths? • How would you describe the 'mathematical knowledge for teaching' that a teacher needs to develop?	
Finally: Today we have focused on your:	
• Priorities as a teacher • Influences on how you teach. • View of mathematical knowledge for teaching	Is there anything else arising from our conversation that you would like to add?

Debrief and next steps

Interview 3

Opening question	Possible areas to explore	Further prompts
In this interview I am interested in finding out more about your role as a mentor and the experiences that have shaped your priorities, perceptions and practice		
Q1: Scenario: Think back to your experiences of **being mentored**. Describe a significant critical incident from work with your mentor on one of your placements (could be positive or negative). If positive one, is there a less positive significant moment (or via versa)?	How did your mentor help you to develop **your subject knowledge for teaching**?	What **approaches** did they take that were helpful for your learning? What was good? What was not so good?
	What **qualities** did you mentors have?	What did you want from your mentor?
		What role did **other colleagues** in the department play?
		Who else helped you learn during your placement?
	How have your **experiences** of being mentored influenced your practice as a mentor?	What do you think **currently influences** your practice as a mentor- **values/colleagues/department/school/MAT**
Q2: I want to explore how you would describe the different aspects of your **role as a mentor**? Choose up to 5 words from the card sort that describe how you see your role as a mentor Areas of focus • socialisation into profession • emotional support • learning to teach • assessment	Explain why you have chosen these. Are there any that you would reject? Which role is most important to you? Which role do you most frequently adopt?	How did you learn to mentor?
		What are your **priorities** when you first meet a student teacher?
		How do these **change** across a **placement**?
		How do these **change** with **different student** teachers?
		What **agency/freedom** do you have as a mentor (if not asked above)
		How has your **practice** as a mentor **changed** over time?

Opening question	Possible areas to explore	Further prompts
Q3: How do you work with **student teachers to develop their subject knowledge**?	What do you think **your role** is in supporting this development?	What do you think **students need to learn**?
		How does this change across a placement?
		What **strategies do you use** to support their learning in this area?
		What do you think is **more challenging** for students to learn?
	How does **your department/school/MAT influence** how you work as a mentor in this area	
Finally: Today we have focused on your:		
• Experience of being mentored • View of your role as a mentor • Approach to developing SK of student teacher	Is there anything else arising from our conversation that you would like to add?	

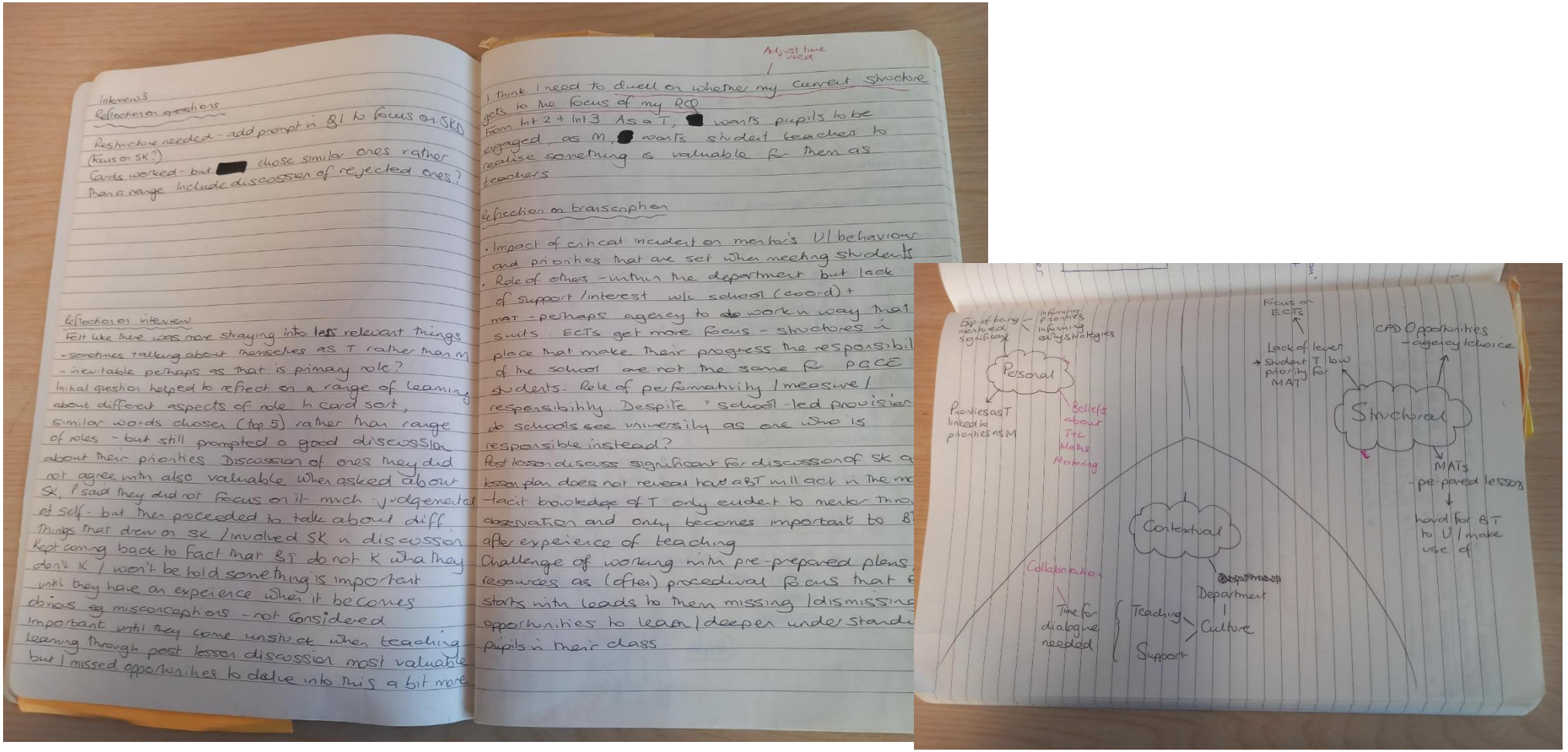
Debrief and next steps

Interview 3: card sort of mentor roles (Ambrosetti et al., 2014; Brondyk & Searby, 2013)

Counsellor	**Advocate**	**Supervisor**
Advisor	**Coach**	**Teacher**
Guide	**Facilitator**	**Trainer**
Collaborator	**Evaluator**	**Colleague**
Helper	**Assessor**	**Role model**
Instructor		

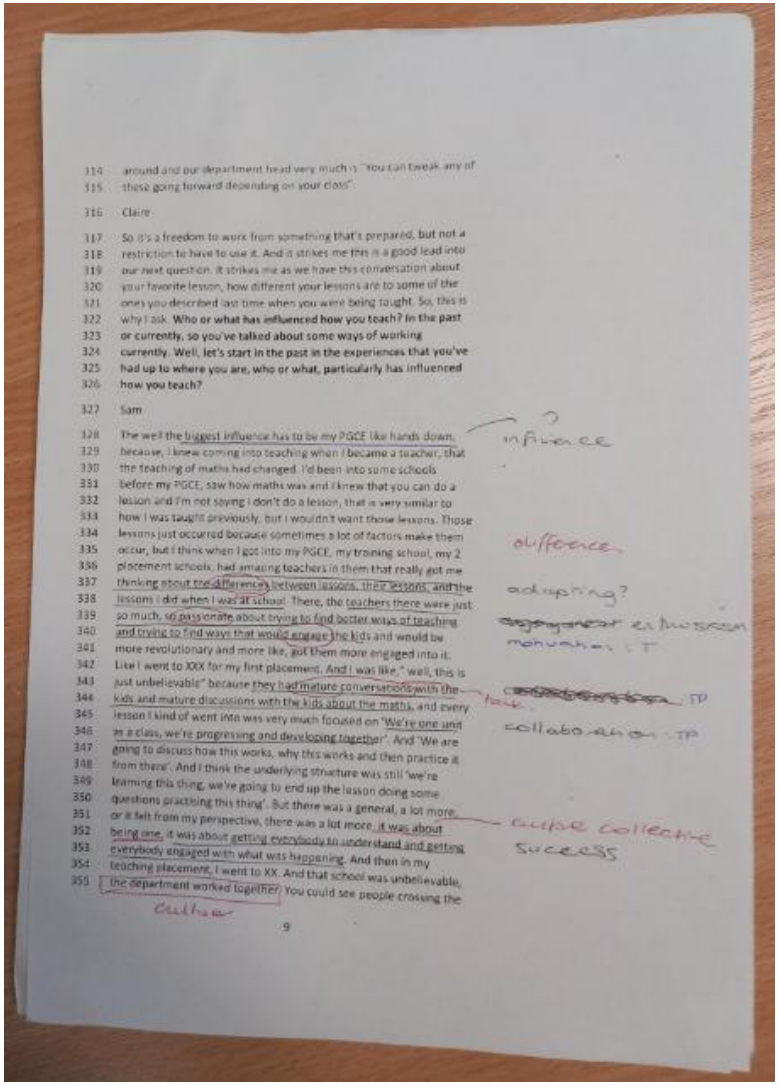
Appendix 3: Notes made after interview/transcription

Initial reflections on Interview 3, Sam: after interview and after transcription



Appendix 4: Samples of coding process to arrive at experiential themes

Initial descriptive coding on script (Interview 2, Q2, Sam)



around and our department head very much is "you can tweak any of these going forward depending on your class".

Claire

So it's a freedom to work from something that's prepared, but not a restriction to have to use it. And it strikes me this is a good lead into our next question. It strikes me as we have this conversation about your favorite lesson, how different your lessons are to some of the ones you described last time when you were being taught. So, this is why I ask. **Who or what has influenced how you teach? In the past or currently, so you've talked about some ways of working currently. Well, let's start in the past in the experiences that you've had up to where you are, who or what, particularly has influenced how you teach?**

Sam

The well the biggest influence has to be my PGCE like hands down, because, I knew coming into teaching when I became a teacher, that the teaching of maths had changed. I'd been into some schools before my PGCE, saw how maths was and I knew that you can do a lesson and I'm not saying I don't do a lesson, that is very similar to how I was taught previously, but I wouldn't want those lessons. Those lessons just occurred because sometimes a lot of factors make them occur, but I think when I got into my PGCE, my training school, my 2 placement schools, had amazing teachers in them that really got me thinking about the differences between lessons, their lessons, and the lessons I did when I was at school. There, the teachers there were just so much, so passionate about trying to find better ways of teaching and trying to find ways that would engage the kids and would be more revolutionary and more like, got them more engaged into it. Like I went to XXX for my first placement. And I was like," well, this is just unbelievable" because they had mature conversations with the kids and mature discussions with the kids about the maths, and every lesson I kind of went into was very much focused on "We're one unit as a class, we're progressing and developing together". And 'We are going to discuss how this works, why this works and then practice it from there'. And I think the underlying structure was still 'we're learning this thing, we're going to end up the lesson doing some questions practising this thing'. But there was a general, a lot more, or it felt from my perspective, there was a lot more, it was about being one, it was about getting everybody to understand and getting everybody engaged with what was happening. And then in my teaching placement, I went to XX. And that school was unbelievable, the department worked together. You could see people crossing the

9

influence

difference

adapting?

enthusiasm

motivation

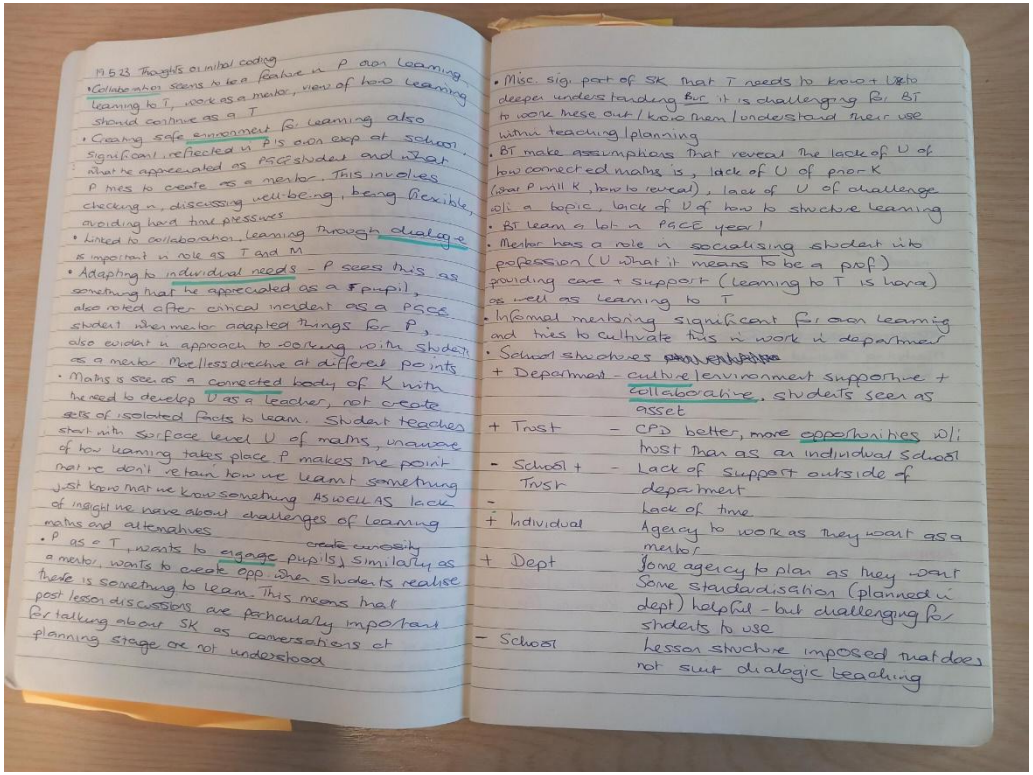
TP

collaboration TP

culture collective success

culture

Notes made following transcription of all three interviews, Sam

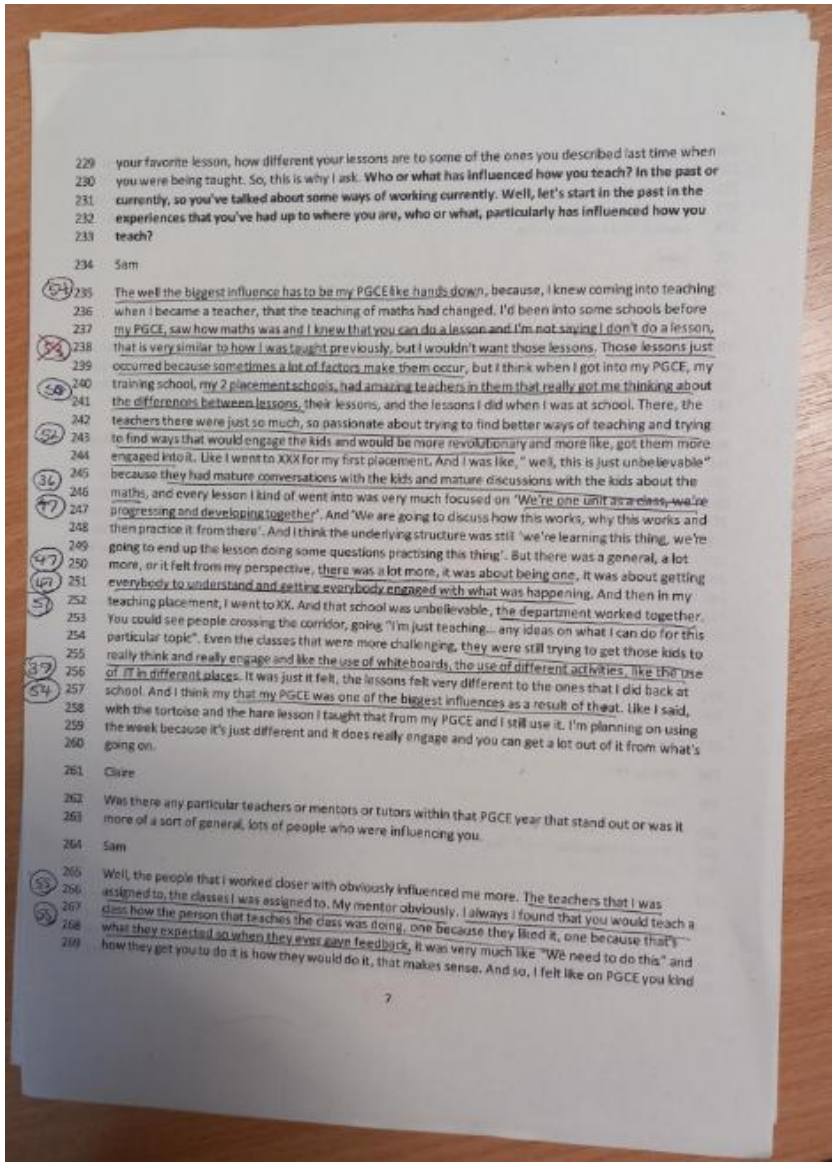


19.5.23 Thoughts on initial coding

- Collaboration seems to be a feature in P own learning
- learning to T, work as a mentor, view of how learning should continue as a T
- Creating safe environment for learning also significant, reflected in P's own exp at school, what he appreciated as PGCE student and what P tries to create as a mentor. This involves checking in, discussing well-being, being flexible, avoiding hard time pressures
- Linked to collaboration. Learning through dialogue is important in role as T and M
- Adapting to individual needs - P sees this as something that he appreciated as a pupil, also noted after critical incident as a PGCE student when mentor adapted things for P, also evident in approach to working with students as a mentor. More/less directive at different points
- Maths is seen as a connected body of K with the need to develop U as a teacher, not create sets of isolated facts to learn. Student teachers start with surface level U of maths, unaware of how learning takes place P makes the point that we don't retain how we learnt something just know that we know something AS WELL AS lack of insight we have about challenges of learning maths and alternatives
- P as a T, wants to engage pupils, similarly as a mentor, wants to create opp when students realise there is something to learn. This means that post lesson discussions are particularly important for talking about SK as conversations at planning stage are not understood

- Misc. sig. part of SK that T needs to know + U to deepen understanding but it is challenging for BT to work these out / know them / understand their use within teaching / planning
- BT make assumptions that reveal the lack of U of how connected maths is, lack of U of pnor K (your P will K, how to reveal), lack of U of challenge w/i a topic, lack of U of how to structure learning
- BT learn a lot in PGCE year!
- Mentor has a role in socialising student into profession (U what it means to be a prof) providing care + support (learning to T is hard) as well as learning to T
- Informal mentoring significant for own learning and tries to cultivate this in work in department
- School structures ~~non-existent~~
  + Department - culture/environment supportive + collaborative, students seen as asset
  + Trust - CPD better, more opportunities w/i trust than as an individual school
  - School + Trust - Lack of support outside of department
  - Lack of time
  + Individual Agency to work as they want as a mentor
  + Dept Some agency to plan as they want Some standardisation (planned in dept) helpful - but challenging for students to use
  - School lesson structure imposed that does not suit dialogic teaching

Codes developed (Interview 2, Q2, Sam)



your favorite lesson, how different your lessons are to some of the ones you described last time when you were being taught. So, this is why I ask. **Who or what has influenced how you teach? In the past or currently, so you've talked about some ways of working currently. Well, let's start in the past in the experiences that you've had up to where you are, who or what, particularly has influenced how you teach?**

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Claire

Was there any particular teachers or mentors or tutors within that PGCE year that stand out or was it more of a sort of general, lots of people who were influencing you

Sam

Well, the people that I worked closer with obviously influenced me more. The teachers that I was assigned to, the classes I was assigned to. My mentor obviously. I always I found that you would teach a class how the person that teaches the class was doing, one because they liked it, one because that's what they expected so when they ever gave feedback, it was very much like "We need to do this" and how they get you to do it is how they would do it, that makes sense. And so, I felt like on PGCE you kind

7

Code	Initial descriptive codes	Refined experiential codes
36	Importance of collaboration: pupil teacher	Later combined: A collaborative approach important when learning maths
39	Importance of collaboration: pupil-pupil	
47	Classroom culture as a teacher: collaborative	
51	Collaboration with colleagues	Importance of collaboration with colleagues about teaching and learning mathematics
52	Importance of ownership/choice as a teacher	Retained language but later combined with code 66: Importance of providing choice for student teacher
54	Influence of PGCE course/peers	Later combined: ITE course had a positive impact on learning to teach
55	Influences of mentors/teachers on teaching as a student teacher	

Extract from spreadsheet to show development of sample of experiential themes related to teaching with frequency recorded.
(Yellow highlights are examples of codes developed above from Interview 2, Q2, Sam)

			Sam	Alice	Jessica	Adam
	All nascent experiential themes "Data show that..."	Initial codes "The participant expressed that ..."	Frequency	Frequency	Frequency	Frequency
Teaching	all mentors wanted to develop a deeper understanding of maths when teaching	01. Aim to develop deeper/connected understanding of maths when teaching pupils	8	1	4	4
Teaching	all mentors expressed a need to understand and adapt to pupils you area working with	03, 49, 58. need to understand and adapt to pupils you are working with when teaching	16	5	18	4
Teaching	most mentors expressed the importance of understanding misconceptions as a teacher	05. Understanding misconceptions and difficulty points important as a teacher of maths	8	4	5	
Teaching	all mentors expressed the importance of pupil teacher relationship	31 and 31 a. The teacher-pupil relationship in the classroom is important	12	3	12	3
Teaching	most mentors expressed the need for a collaborative approach in the classroom when teaching and learning maths	36, 39, 47. A collaborative approach is best for learning maths	4	4	6	
Teaching	most mentor expressed a love of maths as a motivation for teaching	44. They felt inspired to teach by their love of maths	3		1	4
Teaching	all mentors expressed the need to create a culture when pupils want to learn	46. Importance of creating a classroom culture where pupils want to learn and 46a. And 48	9	3	2	1
Teaching	most mentors expressed a wish to create an environment where it was ok to make mistakes	50 and 79a. Importance of creating an environment where it is ok to make mistakes, good to learn from mistakes	4	1		1
Teaching	all mentors expressed the importance of having choice/ownership as a teacher	52. annd 66. Importance of having choice/ownership as a teacher	7	4	7	3
Teaching	all mentors expressed the need to navigate whole school policies to make them work for maths	53. Need to work around school policies to make it work for maths	5	2	6	7
Teaching	most mentors expressed how their ITE course had been influential in deepening their understanding of teaching maths	54.and 55. ITE course/peers had a positive impact on learning to teach	4		2	2
Teaching	all mentors expressed the importance of collaborating with colleagues about teaching and learning maths	55a and 51. Importance of collaboration with colleagues about T&L maths	10	7	9	3
Teaching	some mentors valued the support from wider trust colleagues in their role as a maths teacher	59a. wider trust roles provide support for learning as a teacher	4			2

Appendix 5: Development of inferential themes

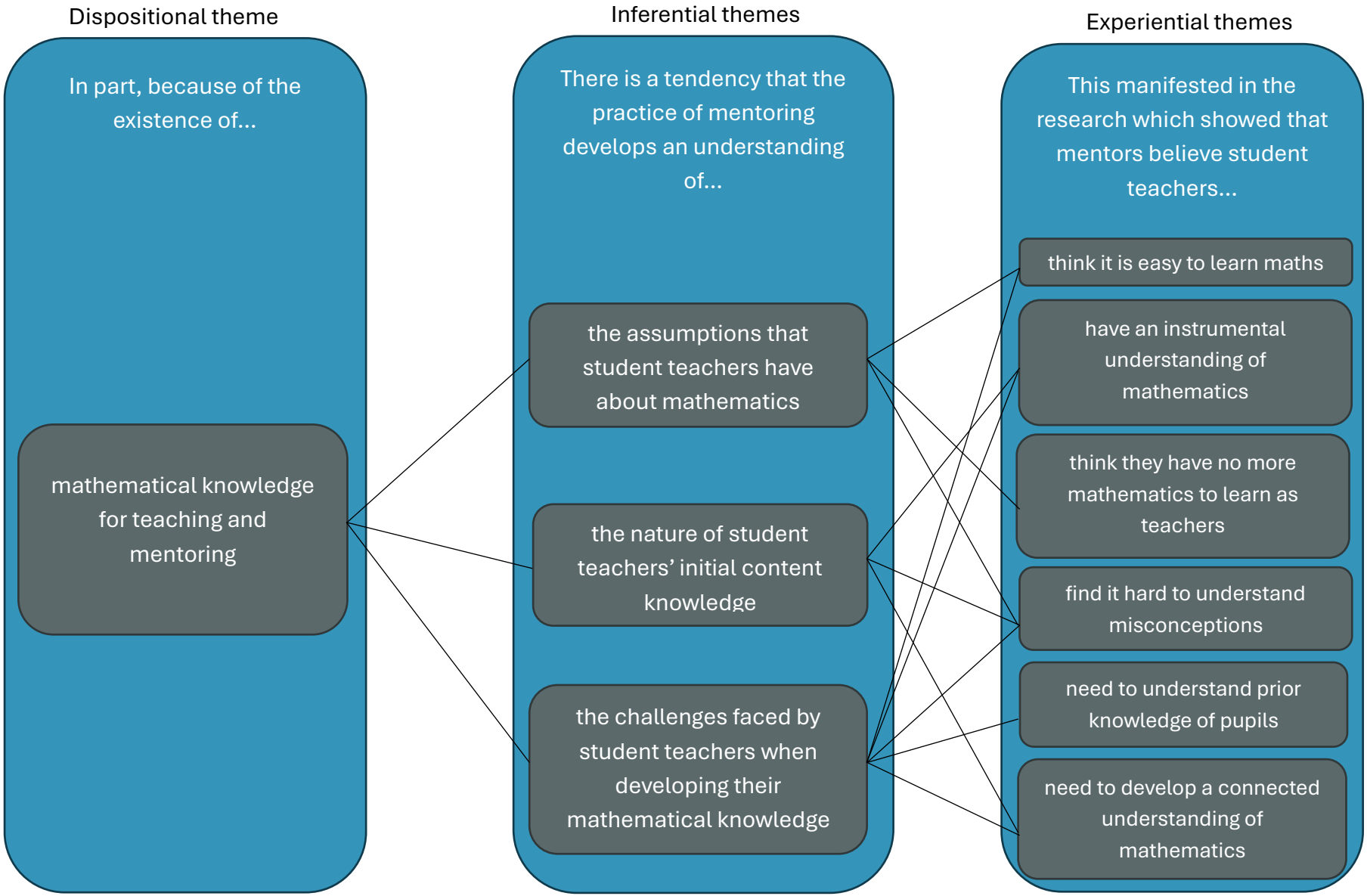
Extract from spreadsheet to show to development of inferential themes

(Yellow highlights are examples of codes developed in Appendix 2 from Interview 2, Q2, Sam)

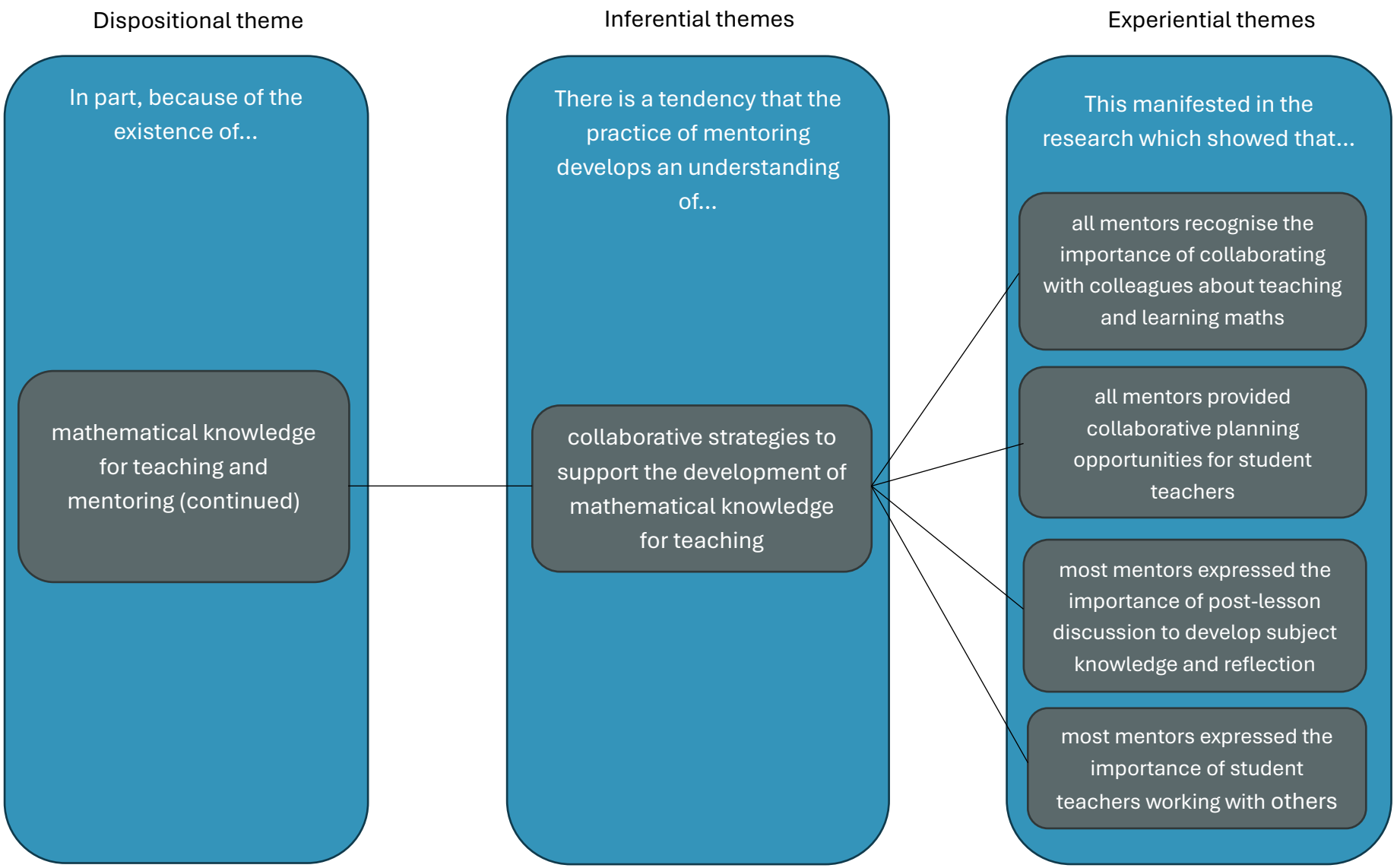
	All nascent experiential themes "Data show that..."	Initial codes "The participant expressed that ..."	Nascent Inferential themes	Inferential themes It is plausible to claim....	Inferential themes use may/could/often/likely to
Teaching	all mentors wanted to develop a deeper understanding of maths when teaching	01. Aim to develop deeper/connected understanding of maths when teaching pupils	Deeper understanding of mathematics needed as a teacher	experienced mentors recognise the need for teachers to develop a deep, connected understanding of mathematics	Mentors are likely to recognise the need for teachers to develop a relational understanding of mathematics
Teaching	all mentors expressed a need to understand and adapt to pupils you are working with	03, 49, 58. need to understand and adapt to pupils you are working with when teaching	Adaptive approaches when working with pupils	supporting the learning of others requires an adaptive, contingent approach	Mentors are likely to to recognise that supporting the learning of others requires an adaptive contingent approach as a teacher
Teaching	most mentors expressed the importance of understanding misconceptions as a teacher	05. Understanding misconceptions and difficulty points important as a teacher of maths	Importance of understanding how pupils learn: misconceptions	experienced mentors recognise the need for teachers to develop a deep, connected understanding of the challenges pupils face when learning mathematics	The practice of mentoring often involves helping student teachers understand how pupils learn mathematics (misconceptions)
Teaching	all mentors expressed the importance of pupil teacher relationship	31 and 31 a. The teacher-pupil relationship in the classroom is important	Importance of relationships when learning maths (teacher)	experienced mentors recognise the importance of open, trusting relationshps when supporting the learning of others	Mentors are likely to recognise the importance of building open, trusting relationships when learning
Teaching	most mentors expressed the need for a collaborative approach in the classroom when teaching and learning maths	36, 39, 47. A collaborative approach is best for learning maths	Collaborative approaches to T&L maths	experienced mentors often value collaborative approaches to T&L mathematics	Mentors often create collaborative classroom cultures to learn mathematics
Teaching	all mentors expressed the need to create a culture when pupils want to learn	46. Importance of creating a classroom culture where pupils want to learn and 46a. And 48	Creating motivating environments for learning	experienced mentors recognise the importance of open, trusting relationshps when supporting the learning of others	Mentors are likely to recognise need to build positive learning environments to motivate pupils to learn
Teaching	most mentors expressed a wish to create an environment where it was ok to make mistakes	50 and 79a. Importance of creating an environment where it is ok to make mistakes, good to learn from mistakes	Creating environments where we learn from mistakes	experienced mentors recognise the importance of open, trusting relationshps when supporting the learning of others	Mentors often create a culture where mistakes are seen as an opportunity to learn
Teaching	all mentors expressed the importance of having choice/ownership as a teacher	52. annd 66. Importance of having choice/ownership as a teacher	Importance of agency as a teacher	experienced mentors recognise the importance of agency as a teacher when teaching and learning mathematics	Mentors are likely to value a working culture where they have agency as teachers
Teaching	all mentors expressed the need to navigate whole school policies to make them work for maths	53. Need to work around school policies to make it work for maths	Navigating whole school policies as subject specialist	contextual factors enable/constrain practice as a mentor and teacher	Mentors are likely to need to navigate contextual factors such as whole school policies when teaching mathematics
Teaching	most mentors expressed how their ITE course had been influential in deepening their understanding of teaching maths	54 and 55. ITE course/peers had a positive impact on learning to teach	ITE course developing understanding of maths	the practice of mentoring and teaching is shaped by prior experiences of learning during ITE year	Mentors approaches to teaching and mentoring are often influenced by their ITE experience
Teaching	all mentors expressed the importance of collaborating with colleagues about teaching and learning maths	51. Importance of collaboration with colleagues about T&L maths	Collaboration with colleages as a teacher important	collaborative learning environments enable mentors and teachers to engage in informal subject speicfic professional development	Collaborative learning environments enable mentors and teachers to engage in informal subject speicfic professional development
Teaching	some mentors valued the support from wider trust colleagues in their role as a maths teacher	59a. wider trust roles provide support for learning as a teacher	Support from Trust as a teacher	contextual factors enable/constrain practice as a mentor and teacher	Mentors may experience support from leadership in school (contextual/structural factors)

Appendix 6: Examples of forming dispositional themes from analysis.

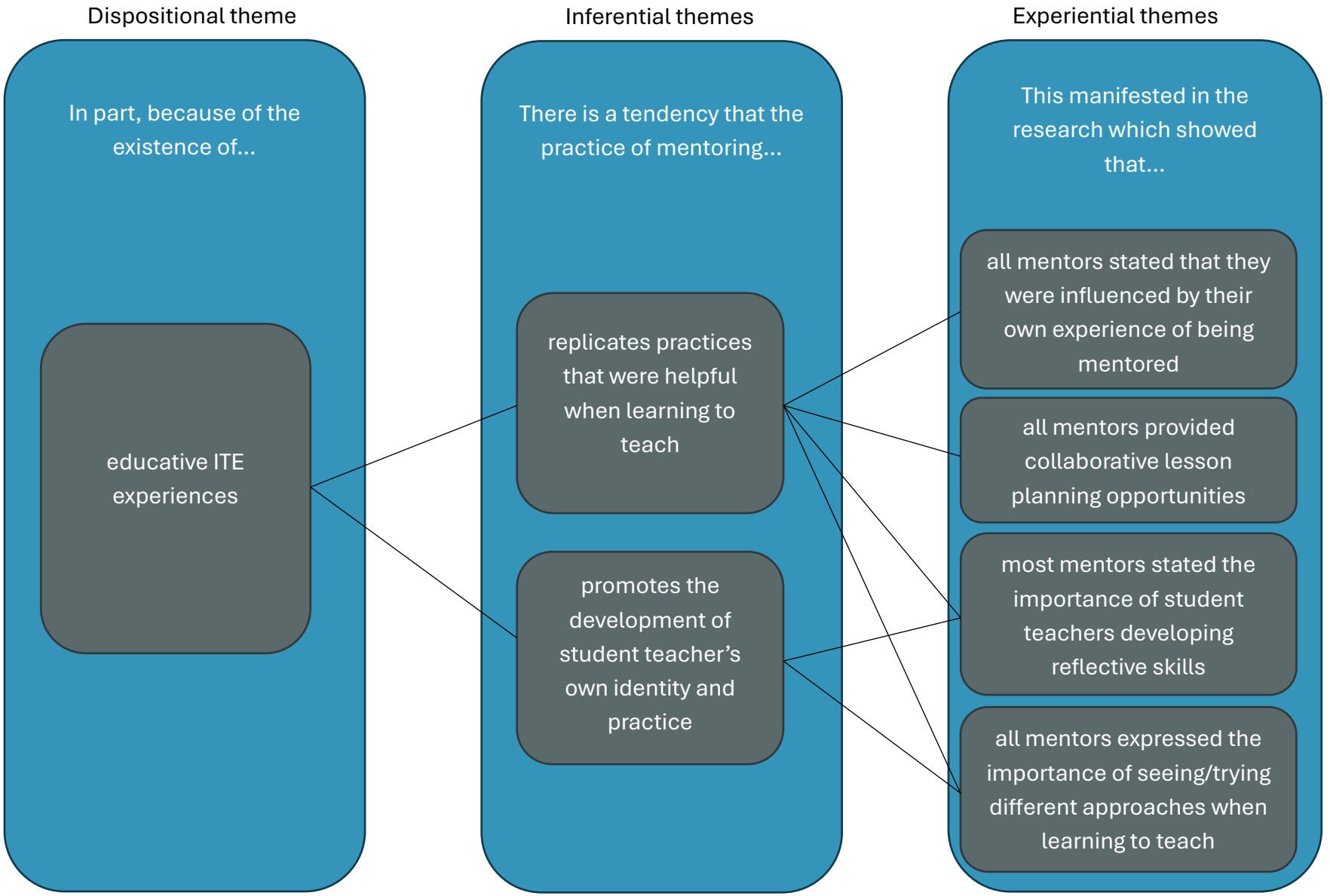
Development of dispositional theme 1: The existence of *specialised mathematical knowledge for teaching and mentoring*



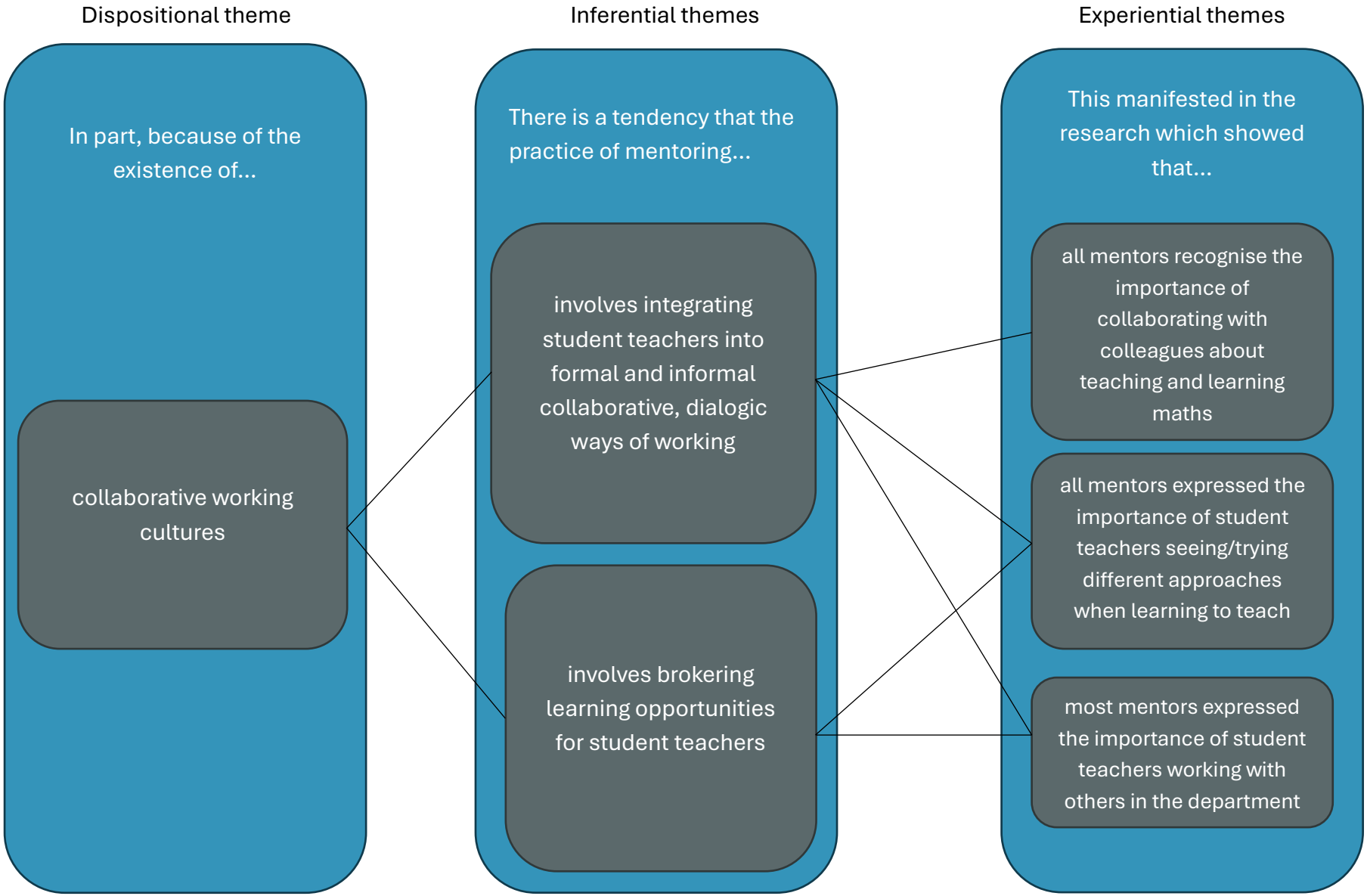
Development of dispositional theme 1 (continued): The existence of *specialised mathematical knowledge for teaching and mentoring*



Development of dispositional theme 2: The impact of educative ITE experiences on conceptions of teaching and mentoring that shape mentors' initial and ongoing practice and perceptions



Development of dispositional theme 3: The role that collaborative working cultures play in enhancing mathematical learning opportunities for student teachers and mentors.



Development of dispositional theme 4: The impact of wider structural contexts in school and educational policy creating arrangements that enable or constrain subject-specific teaching and mentoring approaches.